Cycling Infrastructure and Its Relationship to Residential Property Prices

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Abstract

There is a commonly-held myth that bike lanes will reduce local property values. This myth is part of an often vocal 'bikelash' – resistance to cycling infrastructure. However, as with many other issues pertaining to cycling, there is little evidence to support this claim. This report explicitly seeks to understand to what extent cycling infrastructure impacts residential property values. Our case study examines the cities of Kitchener, Waterloo and Cambridge, situated within the Region of Waterloo. All four local governments have been active in developing new cycling infrastructure, and they have also seen resistance to new infrastructure by some segments of the local community. While these cities do not have an abundance of separated cycling infrastructure, new bike lanes are added each year, and cycling is one of the most contentious local issues.

We employ a mixed method approach that includes both hedonic modelling and interviews with realtors and developers. We find no evidence that bike lanes have a significant negative impact on property values. Among realtors and developers there are perceived differences in how bike lanes are valued by potential home buyers that depend on both their demographics and the type of neighbourhood, with specific differences between denser, core neighbourhoods and automobile-oriented suburbs. Quantitatively, we find cycling infrastructure associations with single-family residential homes are largely neutral. We do find positive associations between cycling infrastructure and condo values. In both cases, there are no significant differences in property value associations between core areas and the suburbs.

We recommend that cities continue to invest in cycling infrastructure across the region in order to meet growing demands for cycling and provide equitable access to active transportation in both urban and suburban neighbourhoods.

Executive Summary

Transportation conversations are changing, and although cycling is not necessarily a high priority for everyone, it is increasingly factoring into the home buying decision. This point was clear in many of our qualitative interviews with realtors and developers and can also be seen in media reports in the Region of Waterloo and beyond.

No participants argued that cycling infrastructure directly lowered a dwelling's value. From the perspective of realtors and developers, there is a noticeable divide in urban and suburban cycling cultures that relates to the degree to which cycling amenities are sought-after by potential home buyers. Some respondents (realtors and developers) argued that there is little value placed on cycling specific infrastructure in suburban cores, while others believed that suburban areas lack safe and connected infrastructure. Many respondents perceived the urban lifestyle as more conducive to cycling, both from the availability of infrastructure and from the lifestyle that the core areas offer. Increasingly, as seen through changing parking ratios in core developments, this shift to alternative modes of travel is becoming a necessity. Four main factors can be attributed: accessibility, affordability, sustainability and the lack of automobile infrastructure.

Almost all participants were hesitant to attribute property value increases to cycling infrastructure specifically, because they felt it was very difficult to separate it from the overall changes in the Region that are driving the housing market (with the exclusion of greenspace and trails). However, they did agree that cycling infrastructure is not currently negatively impacting property value.

Given the current political shifts towards sustainability and active forms of transportation, most agents and developers believed that the market demand for cycling would grow. However, they stressed safe and connected infrastructure, as well as the need for greater transparency regarding new cycling projects, and continued education for citizens looking to take up cycling.

Our quantitative research estimated hedonic models to explore the relationship between proximity to cycling facilities and residential sales prices while controlling for the other confounding factors, such as green space, transit facilities, and urban core. In particular, we considered three major types of cycling infrastructures: (1) on-road bike lanes (or painted bike lanes, excluding sharrows); (2) multi-use trails (or multi-purpose trails); and (3) separated or protected bike lanes. For each cycling facility, three proximity buffers were calculated: 0-100 meters; 100-200 meters; 200-400 meters. We then determined whether each property was within the proximity buffers of cycling facilities at the sales time. By adding these variables to hedonic models, we were able to isolate the associations of different cycling facilities with property prices.

Condo prices are positively correlated with on-road bike lanes and multi-use trails nearby. On average, condo values are higher within 100 metres (7%), between 100-200 metres (5.8%) and between 200-400 metres (7.7%). Multi-use trails are also associated with higher values: 5.5% within 100 metres, 4.1% between 100-200 metres, and 3.6% for 200-400 metres. However, separated bike lanes are associated with lower condo prices: 9.7% less within 100 metres, 7.3% less between 100-200 metres, and 7.6% less between 200-400 metres. Discussed in more detail below, the few separated bike lanes with substantial numbers of condo sales nearby are now in rail underpasses and on busier roads or on higher-traffic regional roads. Further, as

noted by developers, condos on roads with separated bike lanes may not have pull in drop-off spots. For selected other locational factors of interest, we find that being within the downtown core is associated with 13% higher condo prices; access to the iXpress bus transit at the nearest bus stop is associated with 7.1% higher values, and an additional bus transit route with an additional 1.5%. Access to open space is a less important factor influencing condo prices than for single family residential properties, but trees matter. A 10% increase of the tree canopy within 100 meters is associated with 1.2% higher condo prices; and every 10 additional trees within 100 meters another 0.8%.

For single-family houses (including duplexes and semi-detached), most cycling facilities have no significant associations with sales prices; however, on-road bike lanes within 200-400 meters are associated with 1% higher house prices. Access to open space positively impact house prices, where every 1 km^2 of open space within 800 meters is associated with 2% higher prices, and being adjacent to open space is associated with a further 1% increase. A 10% increase of the tree canopy within 100 meters is associated with 1.4% high home prices, and every 10 additional trees within 100 meters with another 0.2%.

We do not report results for townhouses, as the majority of townhouses in Kitchener are proximate to cycling facilities, with only three complexes not having good cycling access. Thus, there was insufficient variation in cycling access to apply our statistical models. However, the results for semi-detached and duplexes should have relevance for townhouses.

Introduction

Cycling infrastructure has become an important consideration for the Waterloo Region. Population growth and increasing density, particularly in downtown cores, combined with concerns about the environment, public health, traffic congestion, and affordability, have motivated more people to engage in cycling for recreational purposes and daily commuting. As a response, cities across Canada have begun to make important changes to their cycling infrastructure, with notable examples in Vancouver, Montreal and Calgary.

The Region of Waterloo is currently undergoing widespread transportation change. With the integration of phase 1 of the ION light rail transit and plans for phase two currently under development, the question of how we move around the region has become an important consideration for residents. With increasing congestion, the growth of public transportation and active forms of movement are working to combat this issue. In Waterloo Region, the local municipalities of Cambridge, Kitchener and Waterloo and the Region have been developing transportation and trails master plans to guide future cycling planning and investment. Kitchener, Waterloo and the Region of Waterloo have also developed separated and protected bike lane pilots, which will run for eighteen months. These lanes will cater to cyclists commuting to and from work and recreational cyclists, but will also function to connect to the ION to promote accessible ridership.

However, while the economic, social, health and environmental benefits of cycling are well-established in the literature[1], there are concerns among some segments of the population that new cycling infrastructure may have a negative impact on residential property values. To investigate this question, the Region of Waterloo, and the cities of Kitchener, Waterloo and Cambridge have commissioned researchers at the University of Waterloo's School of Planning to investigate the relationship between cycling infrastructure and property values/neighbourhood desirability, using a combination of expert interviews (qualitative methods) and statistical analysis (quantitative methods). In this research, we are examining both trends across the region's urban areas, which we argue would be applicable to other mid-sized cities in Canada, and, where possible, the role of local contexts between cities.

It should be stressed that at present, there is very little on street, separated cycling infrastructure in the Region of Waterloo. There are also very few protected intersections that create the kind of seamless, safe network that can be found in other countries. The majority of bike routes consist of on-street painted bike lanes, or trails through parks or other off-road spaces. Separated infrastructure is relatively new to the Region, and there are few instances where the arrival of cycling infrastructure has coincided with an overall redesign of a street and sidewalk. Thus, our quantitative and qualitative analysis is limited both in terms of the spatial extent of cycling infrastructure and its overall impact on urban space. Having said that, cycling is one of the most hotly-debated urban topics, including intense debates in the media, local councils and within communities. Additionally, there have been several key pilot projects featuring separated and protected bike lanes that have been implemented in recent years. Therefore, trying

[1] Buehler et al., 2011; Cavill et al., 2008; Bassett et al., 2008; Karssenberg et al., 2016; Krizek, 2018; te Brömmelstroet et al., 2017; Reid, 2018.

to understand what role this limited infrastructure plays in impacting residential property prices can give much-needed rigour, clarity and evidence-based research to these debates.

This research is divided into two parts. The first engages with real estate agents and developers to better understand how these changes to cycling infrastructure are reflected in the residential real estate market and are considered by home buyers and in new residential developments. The second develops statistical models that distill correlations between housing sales values and property attributes to isolate associations between sales prices and cycling infrastructure. Our mixed methods approach to understanding the relationship between cycling infrastructure and residential property prices allows us to jointly consider both a statistical analysis of variables that influence this relationship, and the perceptions and experiences of individuals (realtors and developers) who have an intimate and detailed knowledge of what shapes residential property markets. This report will provide a brief review of relevant literature before turning to the mixed methods we have used in this study.

The main question guiding this report is: to what extent do different types of cycling infrastructure impact residential property values in different parts of Kitchener, Waterloo and Cambridge?

Literature review

As research continues to explore the relationship between housing costs, locational desirability and transportation infrastructure; cycling has become the next frontier of study. However, unlike other modes of travel, the purpose of cycling infrastructure can vary, catering to different types of traveling outcomes (i.e. commuting, exercise, leisure, etc.). Current available research draws important distinctions between the different infrastructures that can support cycling to achieve specific goals and outcomes[2].

It should be noted that, to date, there has been relatively little research into the impact of cycling infrastructure on residential property prices. Far more studies have examined the variety of health, social, safety and environmental benefits of promoting cycling. Emerging research is also examining many of the intangible benefits of cycling, such as its role in building a more trusting society and the positive experiences of travel time that cyclists enjoy[3]. In terms of measuring the impact of transportation investments on residential property prices, it should also be noted that there is a far larger body of literature that has examined the role of rail-based transit, rather than cycling. Here, the results tend to show a positive relationship[4].

A recent review of the academic literature on the economic impact of bike lanes in urban centres found five key benefits: they boost of retail sales; cyclists spend more in local areas than those using other forms of transport; they play a role in raising urban home values; bike lane projects create more jobs than traditional road projects; and bike lanes attract talented workers and tech companies[5]. To date, most of this research has been conducted in larger cities such as Portland, Toronto, or New York; very little work on the economic impacts of cycling has been done in small or medium-sized communities such as Waterloo Region. However, a recent liveability report by Remax listed "easy access to bike lanes and walking paths" as one of its key criteria in a range of cities across the country[6].

Just as cities are not all alike, the same is true with cycling infrastructure. In this section, we will examine the existing literature to assess what is already known about how different types of cycling infrastructure impact residential property prices. A review of existing literature also stresses the importance of dense urban areas, with a range of mobility options (walking, cycling, driving, transit) and automobile-oriented suburbs, where other forms of transportation beyond the automobile are less prevalent or convenient. Broadly speaking, we can categorize cycling infrastructure into three distinct forms[7]:

- Multi-use trails and paths primarily found in greenspace or parks
- On-road bike lanes

[2] Connolly et al., 2019; Krizek, 2006; Lindsey et al., 2004
[3] Krizek, 2018; Legrain et al, 2018; te Brömmelstroet et al., 2017
[4] Welch et al., 2016; Knaap et al., 2001; Huang 2020; Hess and Almeida, 2007
[5] Dunne, 2019
[6] Remax, 2020
[7] Mogush, Krizek & Levinson, 2005

- Separated, or protected bike lanes

1**. Multi-use trails (MUTs) and paths, primarily located within greenspaces or parks.** These trails can be cycling specific or they can be shared spaces for cycling, walking, jogging and other outdoor activities. Discussions of cycling trails are often associated with talk of "quality of life," looking at the way in which having access to trails and greenspaces to partaking in a cycling culture can be beneficial for an individual[8]. Because of this, research surrounding residential housing costs has explored the potential for this particular amenity to have a positive impact on housing prices in a given area. This research is very specific in separating trail-based cycling from other forms of cycling infrastructure that are more commonly used for commuting purposes because trails and paths position cycling primarily as a recreational activity and not as a means of commuting or a common replacement for cars or public transit travel[9]. Many trail users may be cycling on trails for recreation and leisure rather than as a form of transportation. Analyzing sales data alone, it is not possible to distinguish between leisure and transportation values. The literature does however suggest that housing values are higher in areas with abundant multi-use paths and trails[10]. These values include not just transportation value, but the aesthetic appeal of greenspace that supports cycling trails and the overall ease of access of an outdoor area for recreational purposes[11]. Empirical analysis in Indianapolis[12] and San Antonio[13] both emphasize the positive relationship between trails, or urban greenways, and increases in residential property values.

There is also a body of literature that suggests that these types of trails and paths can contribute to gentrification, with both rising property prices and the displacement (direct or indirect) of low-income communities[14]. A recent study of Atlanta's Beltline found that between 2011–2016, home values rose between 17.9% and 26.6% more within half a mile of trails than elsewhere[15]. Therefore, there is significant literature to suggest that trails and paths play a role in stimulating economic development within their vicinity.

2. On-road bike lanes. On-road bike lanes are a designated space on a roadway for exclusive use by cyclists, identified through paint and signage. In contrast to having shared roads with no cycling infrastructure, these on-road bike lanes attempt to cut down on accidents, decrease traffic and reduce conflicts between drivers and cyclists[16]. Reactions to bike lanes are both mixed and place specific. Many attempts to expand existing on-road biking networks are often hotly contested, with these divisions based around the pre-existing relationship between the different segments of the public and the idea of a cycling culture[17].

Much of the literature on property value impacts of on-road bike lanes is focused on larger urban centre. For instance, a 2011 study found that cycling lanes are better received due to

[8] Asabere & Huffman, 2009; Gnagey & Grijalva, 2018
[9] Lindsey et al., 2004; Gnagey & Grijalva, 2018
[10] Connolly et al., 2019; Lindsey et al., 2004; Parent & vorn Hofe, 2013; Welch et al., 2016
[11] Ohler & Blanco, 2017; Olivier et al., 2013; Sander & Height, 2012
[12] Lindsey et al., 2004
[13] Asabere & Huffman, 2009
[14] Immergluck, 2009; Harris et al., 2019; Riglon and Németh, 2020
[15] Immergluck & Balan, 2018
[16] Krizek, 2006
[17] Connolly et al., 2019

their existing biking culture[18]. Urban centres in general have seen a shift to more active forms of transportation to combat issues of congestion[19]. As on-road bike lanes offer the opportunity for a further means of commuting, they are relatively well received and have a positive impact on real estate prices[20]. For urban centres, the majority of cycling lanes are found in the city's core and most populous areas[21]. Bike lanes in less dense areas in particular face issues of being disconnected from the greater cycling network and disjointedness through their inconsistent placement, illustrating far less functionality than their downtown counterparts. However, in any instance, bike lanes that provide strong access with little disconnect are the most desirable[22].

In suburban areas, where cycling is often viewed as a form of recreation rather than transportation, there can be reluctance from the local population to support the growth of an on-road cycling network. The literature suggests that in suburban areas, the installation of on-road bike lanes can have a neutral or negative impact on real estate[23]. Yet, Li and Joh[24] have suggested that this response can change when bike lanes are presented through "the last mile" ideology, making direct connections with accessible public transit through the integration of spatially-joint cycling investment with public transit investment. Overall, the likelihood of cycling lanes impacting real estate prices increased when the neighbourhood already had a strong transit system in place[25].

3. Separated or protected bike lanes. The third form of cycling infrastructure, often referred to as separated or protected bike lanes, is dedicated bike infrastructure installed within the street right of way, but separated from motor vehicle traffic by some form of barrier or median. This category also includes multi-use trails located in the boulevard next to a roadway, as well as bike lanes directly adjacent to motor vehicle lanes that are separated with a barrier or median. Like on-street bike lanes, there is no consensus as to their impact on property values. Early research by Krizek, dating back to 2006, suggested they could have a negative impact on housing prices in both urban and suburban settings when these separated bike lane were built along streets with high levels of vehicular traffic. On the other end, Krizek found that when separated bike lanes were installed away from busy streets, property value was positively affected[26]. To understand these differences, Krizek articulated that housing markets were comprised of both structural (the characteristics of the house) and neighbourhood characteristics, and, importantly, an area's location within a city, or a suburb, arguing that this distinction between lifestyle, amenities, density, and car-dependency helped to explain the different impacts between core, urban areas, and automobile-oriented suburbs.

One of the most comprehensive studies of the impact of this type of cycling infrastructure was conducted in Portland, Oregon, by Liu and Shi[27]. They found that proximity to "advanced

[18] Stein, 2011
[19] Li & Joh, 2017
[20] Connolly et al., 2019
[21] Stein, 2011
[22] Buck & Buehler, 2012
[23] Krizek, 2006; Welch et al., 2016
[24] Li & Joh, 2017
[25] Sander & Haight, 2012; Welch et al., 2016
[26] Krizek et al., 2006
[27] Liu & Shi, 2017

bike facilities" (separated bike lanes, bike boulevards, buffered bike lanes) had a significant and positive effect on both single family and multi-family housing property values. The authors also noted that when a cycling network becomes denser, these values increase even more.

Much of the economic-based literature on the impact of cycling infrastructure has focused on its role in enhancing commercial or retail areas, rather than residential values. Despite often vocal protests from local business owners, studies show that overall impacts of cycling infrastructure on retail streets are positive for businesses and that cyclists spend more per person in these areas than those who arrive by car[28]. A recent analysis of the new separated bike lanes on Toronto's Bloor Street found similar results including greater foot traffic, increased spending in local businesses and a greater average spend by both those arriving by bike and by people living locally[29].

Broadly speaking, existing research on the relationship between cycling infrastructure and residential housing values highlights the importance of distinguishing the type of infrastructure, its intended use value and the neighbourhoods that they are being placed in. Urban areas that already engage in alternative forms of transportation appear to be more receptive to cycling infrastructure than their suburban car-centric counterparts (Connolly et al., 2019; Krizek, 2006). Scholars such as Pierre Filion note the entrenched durability of auto-dependency in many Canadian suburbs, as well as a shared culture of the car that transcends both ethnicity and class in neighbourhoods built after the Second World War, when the automobile replaced transit as the dominant transport mode that shaped urban and suburban space[30]. That is not to say that there is no value placed on cycling facilities in suburban areas; as several studies showed, multi-use trails and paths did have a positive correlation to property value uplift, also in suburban locations. At the same time, reactions to cycling infrastructure, in all its forms, are place specific (both between types of cities (e.g. large and small) and within different neighbourhood types and locations within an urban region, and can be influenced by a number of external factors, including proximity to other amenities, pre-existing perceptions of cycling and the length of time the infrastructure has been in place.

[28] Reid, 2018; Smith, 2017
[29] Smith, et al., 2017
[30] Filion, 2018

Table 1. Summary of hedonic studies on bicycle infrastructure and property values

Study	Location, data, accessibility measure	Type of bicycle infrastructure	Effect on property values
Lindsey, et al. (2004)	• Marion County, Indiana, USA • Residential property transactions in 1999 • **Distance buffer**: within ½ mile of greenway trail	**Off-street**: urban greenway trails	Positive significant: +11% for the most popular greenway; +26% for the conservation corridor Not significant for the other greenway corridors
Asabere and Huffman (2009)	• San Antonio, Texas, USA • Home sales from 2011 to 2012 • **Presence** of trail/greenbelt in the neighbourhood	**Off-street**: trails and greenbelts	Positive significant: +2% (or $2,350) for trails, +4% (or $5,900) for greenbelts, and +5% (or $4,700) for trails with greenbelts
Parent and vom Hofe (2013)	• Hamilton County, Ohio, USA • Single-family home assessment value in 2005 • **Network distance** between each property and the nearest trail entrance	**Off-street:** multi-purpose trail (Little Miami Scenic Trail)	Positive significant: +3.98 per foot closer to a trailhead
Krizek (2006)	• Twin Cities, Minnesota, USA • All home sales in 2001 • **Distance** to the nearest bike facility	**On-street:** bike lane	Not significant for City Negative significant for Suburbs: −$364 per 400m closer
		Off-street: roadside bicycle trails	Negative significant for City and Suburbs: −$2,271 and −$1,058 per 400m closer
		Off-street: non-roadside bicycle trails	Positive significant for City: +$510 per 400m closer Negative significant for Suburbs: −$239 per 400m closer
Welch, et al. (2016)	• Portland, Oregon, USA • Single and multi-family property sales from 2002 to 2013 • **Network distance** to the nearest bike facility	**On-street**: bike lane	Negative significant: −$2.47 in sales prices per foot closer
		Off-street: regional multi-use path	Positive significant: +$0.86 in sales prices per foot closer
		Off-street: local multi-use path	Not significant

Conrow, et al. (2020)	• Tempe, Arizona, USA • Single-family residential property sales from 2013 to 2016 • **Density**: bike facility length within a ½ - mile radius	**On-street** bicycle facility	Positive significant: +$619 per additional mile of on-street bicycle infrastructure within ½ mile of a property
		Off-street bicycle facility	Not significant
Connolly, et al. (2019)	• Franklin County, Ohio, USA • Single-family residential property sales from 2009 to 2013 • **Distance buffer**: 100m/500m/1000m • Presence of bike facility **connecting** to local land uses within 400m	**On-street** bike facility	Positive significant: + $6,952, $4,596, and $2,340 for facilities within 100m, 500m, and 100m from a home. For road bike facilities within 500m of a property, connectivity to open space increase prices by $8,572; but connectivity to bus stops decreases the prices by $5,412.
		Off-street bike facility	Not significant
Liu and Shi (2017)	• Portland, Oregon, USA • Single and multi-family property sales transactions from 2010 to 2013 • **Distance** to nearest bike facility (ease of access) • **Density**: bike facility length within a ½ - mile radius (extensiveness of bike network)	**On-street** bike facility (focusing on advanced bike lanes: bike-priority facilities and separated bike lanes)	Positive significant: - For single-family homes, +$1,571 each ¼ mile closer; +$1,399 each additional ¼ mile of bike lane density - For multi-family homes, + $211, + $3,683 for the increase in proximity and density, respectively.

Two key shortcomings of this existing literature will be addressed in this report. The first, as mentioned above, is a lack of research into mid-sized cities. While the presence of cycling cultures and communities has been well-documented in larger cities, the details and experiences around cycling have been much less studied in mid-sized communities such as Waterloo Region and its associated cities and townships[31]. Much of the existing literature suggests that attitudes towards cycling are less favourable in smaller communities; however, these tend to be assumptions, rather than comparative studies between big and small cities[32]. While it is true that automobile mode shares are higher in mid-size cities (including those in Waterloo Region) when compared to Toronto, Montreal, Ottawa or Vancouver, this is no guarantee that this will lead to different economic impacts when cycling infrastructure is built. It should also be noted that suburban neighbourhoods in these big cities, and suburban municipalities within their regions also display higher levels of automobility than their urban cores.

A second shortcoming of the existing literature that our report will address is the predominance of quantitative hedonic modelling to understand this relationship. We will perform this analysis for Waterloo Region, but additionally, we will include qualitative research, specifically interviews with local realtors, to gauge their impressions and understandings of how different types of cycling infrastructure impacts housing sales in different neighbourhood types and locations within Waterloo Region (i.e. the difference between urban and suburban home sales). As many scholars note, using a mixed-methods approach helps to paint a clearer picture of what is happening on the ground, allowing us to understand the "why" as well as the "what"[33]. Statistics can analyze complex relationships between different types of variables and can come up with models to assess these relationships, but these models miss many human aspects of how urban space operates and the detailed perspectives, experiences and ideas from people who are actively involved in shaping that urban space. Therefore, our mixed-methods analysis will provide a rich and detailed account that has hitherto been absent from studies of the relationship between cycling infrastructure and residential property prices.

[31] Pelzer, 2010; Mayers & Glover, 2019
[32] Stein, 2011
[33] See Loukaitou-Sideris et al., 2019; Chapple & Loukaitou-Sideris, 2019

Sustainable transportation profile for the Waterloo Region

Speaking to the Canadian population, the 2016 census found that almost 1 in 3 commuters engaged in sustainable transportation, which includes public transportation, carpooling, cycling and walking for commuting purposes. Of this third, almost 7% relied on cycling or walking. In 2016, the population of the Waterloo Region was 535, 154 with 24.2% of commuters engaging with some form of sustainable transportation. Of this, 6% were public transit users, 12.6% were carpoolers and 5.5% were active transportation users (walking or cycling). The region had 2,905 (1.1%) people listing cycling as their primary mode of commuting with only 700 female riders.

These numbers have likely increased substantially due to a number of factors including the ION, shifting focus on public health and sustainability, and an increase in active transportation infrastructure availability. The region has also experienced population growth and densification, seeing more and more people moving into Downtown areas where sustainable transportation is traditionally better utilized. With the growth of on-road, off-road and multi-use trails across the region, our understanding of the role of cycling is still developing.

Overall, the research findings below will explore how different forms of cycling infrastructure are impacting property values, the way in which properties are being developed and desirability for buyers in Cambridge, Kitchener and Waterloo.

It should be noted that the geography of cycling, as a means of getting to and from work, is highly uneven across the Region of Waterloo. Data analyzed from the 2016 Census shows that in some core Census Tracts, as many as 6% of people cycle to work. Broken down even further, in areas such as Uptown West, some areas see numbers of up to 12.8%. In general, the areas with higher journey to work by bicycle mode shares can be found along the Central Transit Corridor in Kitchener and Waterloo and around the universities[34]. However, it should be noted that measuring mode share to work is only one factor in determining bicycle use; as American scholar Julian Agyeman reminds us, there are many hidden aspects of bike use that are neither captured in official statistics, nor feature as central points in planning and policy discussions[35].

[34] See https://censusmapper.ca/maps/2397#13/43.4519/-80.5099
[35] Agyeman, 2020

Qualitative Research

Research methods

While quantitative analysis of sales transactions can tell us something about the relationship between different variables (such as cycling infrastructure and property prices) in different contexts, this method is unable to either fully analyze *why* these results are the way they are, or obtain perspectives about what this infrastructure means for people on the ground. Therefore, in order to help understand the role that cycling infrastructure plays in residential property markets, we utilized qualitative interviews to gain more in-depth insights. For the purposes of this study, we interviewed realtors and developers, people who have their fingers on the pulse of the property market. We should stress that while the cities and the region are actively constructing new cycling infrastructure (including new routes that were developed after our interviews were conducted), very little of this development has dramatically transformed the look and feel of streets; much of the region's cycling infrastructure is in the form of painted bike lanes.

We conducted 22 semi-structured interviews with realtors (agents) (17) and developers (5) in Cambridge, Kitchener and Waterloo, representing an even distribution between the three cities, with the purpose of understanding how cycling lanes are being discussed in the context of the current real estate market. Emphasising three different forms of cycling infrastructure (on-road lanes, separated cycling lanes and multi-purposes trails), the focus of these discussions is to understand if these key informants perceive cycling infrastructure as having an impact on property value. Participants were recruited via their professional profiles, through contacts provided by city representatives, or responses to a call for participants sent out by the Kitchener-Waterloo Realtors' Association. The interviews took place both in person and over the phone. Each interview was between thirty minutes and one hour in length. They were recorded using an audio recorder and subsequently transcribed for clarity. In this report, we will use direct, anonymous quotations, with participants' permission, from these interviews to illustrate and articulate our main findings.

Participants represented a wide experience sample, ranging from one year to 30+ years in their field. The only marker for participation was that the realtor or developer work primarily in Cambridge, Kitchener, or Waterloo. However, some participants also listed, or have current development projects in cities outside of the region. Many realtors were also willing to buy or sell in Guelph with one realtor reaching as far as Toronto. Developers also varied as well, with developments in the Townships, Guelph and one reaching as far as Barrie. Approximately 50% of participants expressed personal experience cycling in the Region.

Please see Appendix A for the semi-structured interview guide for both realtors and developers.

Findings

Realtors and developers

In our interviews with realtors and developers, no one conclusively stated that the presence of bike lanes detracted from a property's value. However, there were many different perspectives on the role and purpose of cycling infrastructure. These perspectives tended to revolve around both the type of property (single family home versus condominium), the financial position of clients and the type of neighbourhood. For the latter point, we found that perspectives about the impact of cycling infrastructure varied depending on whether a home was in an older, core urban area (i.e. downtown Kitchener or downtown Galt), versus suburban residential neighbourhoods that were designed and constructed with the automobile as the main form of transportation (i.e. areas developed after 1945). Existing literature on transportation and mobility divisions within metropolitan areas also points to these differences as being significant in understanding both transportation patterns among households and attitudes towards different forms of transport[36].

In our study, realtors who work primarily in suburban neighbourhoods were less likely to engage in discussion surrounding cycling with their clients, whereas realtors who focused on downtown areas were noticing the increase in desirability for a cycle friendly area. Importantly, some realtors noted the potential that cycling may have factored into the neighbourhood choice prior to the home buying discussion (in other words, people who wanted a lifestyle where cycling was accessible and convenient were searching in core urban areas). Similarly, for developers, the role of cycling came down to types of developments, location and personal perception. For condos/rental units, developers perceive that people are more willing to decrease vehicle usage, and developers are adapting development plans to meet this desire.

Background information

Many realtors had experience selling along streets with cycling infrastructure, but few could identify an increase in desirability along specific trails or paths. Realtors were more aware of available infrastructure in the core areas in relation to their listings.

Some agents we spoke with have had clients that expressed a desire to increase walking, cycling and transit use and decrease car use for a number of reasons:

- **Affordability**: This is primarily for individuals living in Condos, where each parking spot can cost over $30,000.
- **Accessibility**: Having proximity to important amenities means that two cars is unnecessary.
- **Sustainability**: This was less of a concern, but was still mentioned for some clients, who discussed walkability and cycling, and increasingly, car share services.
- **Lack of automobile infrastructure**. Many new developments do not have a 1:1 parking ratio, meaning having two cars is not always possible.

As one agent summarizes these points, specifically with reference to younger buyers:

[36] Filion, 2018

> "Honestly its mostly millennial buyers that are more interested in being so close to so many things. I think walking, biking, being able to be close without having to drive. That's just what a lot of them are talking about. Part of it is probably health, part is probably affordability and a lot of buyers are in the market for a condo, and it is very rare to have parking for more than one, unless you are talking about a townhouse, which would have a driveway and a garage. But, you know that almost has to be the reality, especially if you are talking about two people living in the house. You almost need to have one of them walk or take transit to work."

It was a common theme that agents believed such housing preferences were prevalent not only among young professional buyers, but also empty nesters. For both segments of the population, downtown cores in all three cities provide this kind of lifestyle. One agent noted that they had one young couple who were instead looking for transit access to the core that they could cycle or walk to because of the increasing cost of living in these areas. However, it should be noted that these geographic or demographic divides are not necessarily black and white; other agents believe that this desire to reduce car use can be found across all demographics and in some suburban areas. As one agent states:

> "…because in the suburbs most people have two cars … I do see one car families, though, but they are a rarity. You'll see them jumping on their bikes and you'll see them jumping on the buses. Especially near the university, like when you've got people who work at the universities you'll see that they'll be more open to jumping on their bike to get to work, or jumping on public transportation to get to work."

On the other hand, some agents noted that the majority of the home buyers they interact with are actually looking to increase car usage, linked to single family homes in areas less connected to the downtown core. This phenomenon was expressed mostly by agents who cater to larger families and more economically prosperous households. Agents articulated a very specific clientele (over 40, upper-middle class and heavily car reliant). These agents could be unaware of some key changes surrounding cycling desirability. Beyond this, agents noted that their perceived target market for a particular property impacts their marketing strategy for that property. Age, career, lifestyle and family are all important considerations for realtors in the way in which they tailor their advertisement of a property to their client. As one agent states:

> "It will depend on the client coming in. If I've got a 70-year-old client coming in to look at the house I'm not going to talk to him about cycling. But if I've got a family that walks in with three teenagers, I am going to really point out the cycling and all the good stuff around there for the kids, right?"

Developers noted that they are beginning to cater to less car centric culture in the downtown cores. Participants noted that some new developments in the Downtown cores are able to build with a .6-.65/unit ratio for parking. This leaves some units without parking, and the likelihood of obtaining two parking spots very low. While people are willing to buy these units, there is an increasing number of investors buying these units and renting them out, suggesting that renters might be willing to forfeit a vehicle. As one developer mentions:

> "Depending on the location, we hear some clients that wish they could have had two spots, but it wasn't an option. Or, certainly the urban ones we're now building buildings with a 0.6-0.65 to unit ratio. So not every unit gets a parking spot. So, we will have car share, certainly bike storage, access to LRT all those kinds of things. It seems to me when we launched [development] two years ago, at the time it felt like "is it going to work or not?" are people's behaviours changed yet or are we ten years ahead of our time? But it worked out and we sold out sin 2 days."

Developers are also using creative tactics to address a lack of cycling infrastructure in old refurbished buildings. As one developer mentions in response to a question about integrating cycling into their developments:

> Yeah! So, we run into some cycling issues with our older buildings. Our older buildings, like circa 1850 type of thing, they have zero cycling infrastructure in them. So, we have to get creative with trying to create spots for bike parking that doesn't involve residents taking the bikes into the hallways and basically damaging the insides of our buildings. So, we have in one of our buildings an old horse stable, and we've got a covered bike parking area that is available for them.

Overall, initial discussions with both realtors and developers illustrate that Downtown cores are currently making adaptations to cater to more sustainable modes of transportation, and are seeing a growth in less car centric lifestyles from their clients. Suburban residential areas are still seeing strong reliance on vehicular travel.

Conversations with clients and Current impact of cycling on location planning

In terms of home buying discussions with clients, there was some agreement amongst participants that transportation (in any form) was an important point of consideration in the home buying process. Those who disagreed believe that although transportation plays a role, it is not a large one.

For more residential areas, drivability and proximity to the 401 were positively viewed, and residential parking was essential. One agent noted that he had difficulties selling century homes that were without garages because of the car culture that exists in the area.

Speaking broadly about all three cities, some agents did find that cycling was mentioned as a desirable mode of travel, but only a few agents were able to recall a case where a client made cycling a top or even secondary priority. In these situations, the area of interest was the downtown core and proximity to a transit route was a must. But, as one agent explains:

> "I think it's, not that they are not asking about cycling, it's part of the mix when they are thinking about their lifestyle, but they're not specifically say 'I cycle, I bike to work, therefore I need X. But when you're taking about where they want to live the cycling would fall into that group of being close to different you know, parks. Recreation and having that ability to bike with their family and just enjoy their community."

Other agents note that cycling has yet to be mentioned by the clients themselves, and only comes up if the agent points out infrastructure in close proximity to the housing they are selling or showing.

This addresses the complexity of desirability discussions with potential buyers. Individuals or families come into the home buying process at different levels of preparedness, which could mean that desirability for cycling access is under discussed. Prior research into neighbourhoods and their accessibility could prevent buyers from mentioning cycling because they are already aware of their cycling options-especially as such information is now easily accessible for a given property on Realtor.Ca.

Access to multi-use trails and greenspaces does factor into decisions for many homebuyers, but the ability to cycle is viewed as a recreational "add on" rather than a driving factor to be close to green spaces. People prefer access for children to play, recreational activities, and increasingly space for dogs.

Overall, there was greater value placed on public transportation and walkability as they relate to home buying. Clients frequently mention access to public transportation (LRT specifically) and overall walkability. In this case, there are clients that see walkability, access to the LRT as an amenity in itself, meaning that they may not actually take advantage of it but would pay more for it. But, for the most part transportation is a more valuable factor for investors looking to purchase properties to rent in the Downtown cores.

Clients who mention cycling do make it clear if they want cycling for recreation versus commuting, and this does have an impact on how importantly they rank cycling infrastructure.

In discussions of cycling infrastructure having an impact on property value, agents were hesitant to give a definitive answer. Many of the interviewees agreed that roadside and off-road bike lanes do have a correlation to increased property values, but note that they are also prevalent in areas where value is already increasing due to other factors (LRT, tech industries, growth of downtown core, walkability etc.). As one agent states:

> "You get, you get number and property value because you are near the core, so whether cycling plays into that, I think it does, but I find it really difficult to extract data, specifically to cycling because you know it gets lumped into green space, lumped into near all the restaurants and shops and coffee shops. Near greenspace, near work so how you actually extract cycling, is not as clear cut as extracting the LRT routes."

A few agents did not think that cycling had an impact on property value (more common for agents listing in Cambridge or more residential areas). Further, some noted that it was simply too soon to tell.

Not a single realtor believed that cycling lanes have a negative impact on property value currently. However, from their professional and personal opinions, they did believe that the current (pre-pandemic) pilot projects in Uptown Waterloo and Downtown Kitchener were problematic for traffic congestion, and could deter clients in the future. These participants believe that cycling infrastructure should be made available off-road, believing that cycling infrastructure contributes to vehicle traffic congestion by taking away road space for cars. The limited amount of data on the impact of bike lanes on traffic congestion in the Region of

Waterloo does not indicate that separated cycling infrastructure has a negative impact on automobile travel times[37].

All participants agree that greenspace and off-road trails do increase value, or has the potential to increase value for the right buyer. For it to have a positive impact, they had to be within a block or two from the park, with the largest seen on property directly backing onto the area. As one agent mentions:

> "Oh, there is no question, people will [pay more for greenspace], and some people especially if they are second or third time home owners and they are looking to build their last house they will wait for something to come up that is going to be backing on greenspace or whatever and pay a premium for it. For sure."

A few participants mentioned specific cases of buyers not wanting to back onto greenspace due to safety concerns, but did not see this having an impact on the value of the home. As well, a few agents mentioned that backing onto a golf course or a cemetery was something clients were willing to pay a premium for.

For some developers, transportation plays a role when choosing a location, but not the most important one. In KW downtown cores, access to LRT, overall walkability and cycling infrastructure are all seen as highly marketable. Beyond this, depending on the location developers will integrate the infrastructure into their projects (via the inclusion of cycling parking, storage options, working areas etc.).

One developer who works with both suburban and urban developments noted that the current state of densification and growth in the Region has meant that availability of land is the number one consideration for developers, with everything else being an afterthought. As they state:

> "So, generally speaking, if there is land available people actually build. I would say from a development standpoint cycling infrastructure and those types of things are an afterthought, but they're nice to have obviously."

But building along cycling lanes can create issues for developers. A concern that was raised surrounds pick up/drop off points for condos and how cycling lanes can interfere with them. Buildings desire a pick up drop off point, but this is not always possible when there is cycling lane between the building and the road.

There is also a notable difference in cycling for residential versus commercial properties. Cycling can be even more beneficial for commercial properties. A participant noted that this was something to consider for Hespeler, as there is a lack of on road parking. Providing adequate cycling infrastructure and facilities, particularly in city centres, could encourage more people to integrate cycling into their daily lives.

There is agreement that cycling is a strong marketing tool, and can be used to attract buyers for both commuting and recreation (whether the buyers intends to use the facilities or not)

[37] Kinsella, 2020

in Downtown cores. As a Cambridge developer states in response to cycling infrastructure having value for buyers:

> "Yeah definitely. I think that from a recreational standpoint there is a ton of value in cycling infrastructure. People aspire to be close to that cycling infrastructure, from a work/ life balance standpoint."

A developer who works primarily in suburban developments, did not believe that cycling plays a large role in the way in which their projects are marketed, noting as many realtors did, that suburban areas, especially away from the Downtown core are more concerned with larger properties and in-home amenities.

In terms of incentives, Developers can use cycling facilities (bike parking, storage, etc.) to reduce the required number of parking spots for their developments, and those I spoke with have taken advantage of this. As this developer states:

> "When we talk about amenities, another one that that we've been thinking about doing, well I shouldn't say that we actually just did, is putting in a bike, toolkit- work area. So again, the idea is not so much to promote cycling it's to promote, or decrease parking ratios. Ultimately it costs me sometimes in the neighbourhood of 65-70 to build an underground parking spot and then we turn around and sell for 40, so the fewer I can build the better. And if I need to promote cycling and these types of things then we do."

Overall, both realtors and developers are slowly seeing cycling and other forms of transportation beginning to factor into the home buying decision and new development plans. Although buyers who prioritize cycling as a "must-have" are rare, buyers tend to respond positively to the addition of cycling infrastructure. Both realtors and developers perceived this phenomenon as far more relevant to the downtown cores, especially in terms of commuter cycling. Importantly, buyers are not expressing negative opinions toward cycling infrastructure in close proximity to their potential properties.

The future of cycling impact in the Waterloo Region

For the future of cycling, realtors were once again divided. Many believed that if cycling is promoted through policy and infrastructure people would be willing to engage with cycling more. These individuals draw attention to the lack of bike parking, noting that for infrastructure to be successful, it must go hand in hand with proper bike facilities. Others argue that the community remains too car centric for this to make an impact on daily commuting, believing that unlike Europe, our winters and our historical relationship with the car are key factors that limit cycling.

Overall many realtors agreed that the changing desirability of urban areas, the growth of the tech industry and overall changing opinions could make cycling a viable mode of commuting in the future.

Similar to real estate agents, developers are hesitant to give any sort of numeric value to cycling infrastructure (with the exclusion of greenspace or dedicated trails, which they believe always increase value). But they do agree that cycling infrastructure is one of many factors that

could play into increasing housing value. Many agreed that the current direction of cycling culture and demand was positive, and that one of the remaining barriers is a lack of infrastructure. However, even those developers who did not see a current market demand for cycling were willing to integrate cycling infrastructure or facilities into their buildings.

Both realtors and developers agree that at this point, there is not a negative relationship between cycling and property values. However, there were discussions from participants own perspectives that Kitchener and Waterloo's current pilot's current impact on Downtown traffic could be seen as a negative in the future.

Summary of qualitative research:

Both realtor and developer experiences with cycling infrastructure vary, and those differences relate largely due to location and clientele. As much as urban areas are becoming more attractive, and active transportation infrastructure is becoming more available, realtors and developers assert that these areas are largely populated by young professionals and older downsizers. Therefore, those who work primarily with families looking for single family homes have seen far less concerns or desirability regarding cycling. However, almost everyone is in agreement that recreational cycling through access to a greenspace is positive and marketable.

Many believed that in some way or another cycling does, or has the potential, to positively impact property values, and no one could confidently say that it is currently having a negative impact. Many interviewees drew attention to some key considerations from their personal experiences for the city moving forward. On the pro-cycling side, positives included more cycling parking, more interconnectivity and better education for cyclists and drivers regarding sharing the road. For participants that were less supportive of the changes to cycling infrastructure, they suggested that focus should be place on building further infrastructure off-roads.

In line with the literature, this research shows that there is a clear correlation between property value and greenspace access, whether that is related to cycling or not. There is a clear perceived urban/suburban divide, across all cities in the region, that has shaped responses to cycling from buyers. It has also influenced the way in which agents and developers alike choose to include and market cycling as a valuable amenity. Because the integration of dedicated cycling infrastructure remains new, opinions have yet to be fully formed, and the role that cycling plays in actually dictating a home buying decision remains low.

As we have noted throughout our report, Waterloo Region does yet have a comprehensive network of separated or protected cycling infrastructure, and very few streets have been completely reconfigured in order to build seamless, separated cycling infrastructure. Most of the on-street infrastructure that exists today is in the form of painted bike lanes. However, there are many new projects under development that have taken place since our interviews were conducted. Therefore, it would be useful to continue to monitor the impact of cycling infrastructure, especially as the region begins to develop a network of high-quality cycling lanes seen in other cities in Canada and around the world.

Quantitative Research

Introduction to quantitative research

The qualitative analysis finds that the perceived role of cycling facilities on residential property values varies by property types (single-family homes or condos), and neighbourhood types (urban core or suburban neighbourhoods). To assess the extent to which these perceptions are reflected in home sales prices, our quantitative models seek to investigate correlations between cycling infrastructure and home sales prices, controlling to the extent possible for the myriad other factors that influence home sales. Using previously developed models, we can control for the independent influences of property type and location, and we specifically test to see whether associations between sales prices and cycling infrastructure vary by location (LRT corridor, core areas, and suburbs). We see the qualitative and quantitative research as complementary in two ways. First, a mixed methods approach allows us to look for statistical evidence consistent with the hypotheses that emerged from the qualitative research. Second, the qualitative research can provide explanations for the quantitative findings.

We employ a statistical model method entitled "hedonic modelling"[38]. This method, the current standard in land and transportation economics, views housing as composed of a set of structural attributes (such as floor area, yard size, and garage), neighborhood attributes (such as education rate, population density), and locational attributes (such as transit services, cycling facilities, and green space). Sales prices are viewed to be influenced by each of these attributes, with most models assuming that attributes have additive and independent impacts. However, hedonic models can also be used to look at interactions between variables, to answer questions such as whether cycling infrastructure values are higher or lower in urban cores. While hedonic models can examine the correlations between home sales values and home attributes, they do not speak to causality, and should not be interpreted as predictive. The results of the models are highly dependent on, and only directly relevant to, the location and time period of housing sales used to develop the models. Thus, for instance, although our models indicate that in the time period of our study, an on-road bike lane within 100 metres was associated with a 7% higher condo value, our results do not indicate that if a new on-road bike lane were installed in front of an existing or planned condo building, the units in that building would sell for 7% higher than otherwise. However, our models do allow us to assess whether, during the time of our study, cycling infrastructure was associated with higher or lower sales prices, controlling for other factors.

Data and methods

Our modelling relies on housing sales and attribute data provided by MPAC and Teranet, under a research agreement with the University of Waterloo, from Jan 2013 to Mar 2018, for the City of Kitchener. The dataset contains 13,363 observations of single-family housing transactions and 4,326 observations of condominium housing transactions. We built one hedonic model for each housing type. Single-family housing includes single-detached houses, semi-detached houses and duplex units, with a control variable for each type. Although we had sales and attribute data

[38] Rosen, 1974

from 2005-March 2018, we chose the study start date due to the relatively higher amount of cycling infrastructure present from 2013 on, as well as the availability of General Transit Feed Specification (GTFS) transit data, which were used to calculate transit access metrics. Further, we had access to only one tree canopy layer, from 2014. The end date for our analysis matches the latest date for which we have sales data.

It should be noted that the period of 2016-2018, included in our study, was a time of very steep increases in price, along with very limited supply of sales properties to the market. Our hedonic methods are most robust in highly competitive markets, where abundant supply allows buyers sufficient choice to select a home by trading off multiple attributes. Our other research found that during this time period, buyers would select properties according to minimal attributes (i.e., any home with enough space, or any home in a given neighbourhood) rather than trading off attributes[39]. Thus, values of secondary factors such as cycling infrastructure may be less well reflected in sales prices in the later time periods.

Our analysis is limited to the City of Kitchener only due to challenges in creating common cycling classification and ensuring data compatibility between Kitchener and Waterloo, the two cities for which we have sales data. Figure 1 shows the case study area and the cycling facilities in Kitchener in 2017. As a whole, Kitchener had good coverage of open space and multi-use trails across the city, but not many on-road bike lanes and only very few separated bike lanes in core area (the King and Weber rail underpasses and selected locations in the Southwest part of the city). The Kitchener urban core (defined as areas with average dwelling age 1945 or earlier) had less cycling infrastructure compared to the suburbs during the study period. In addition, the cycling infrastructure across the city was often present in isolated segments, without connections that would ensure a full trip can be completed via cycling infrastructure.

[39] Cook, 2020

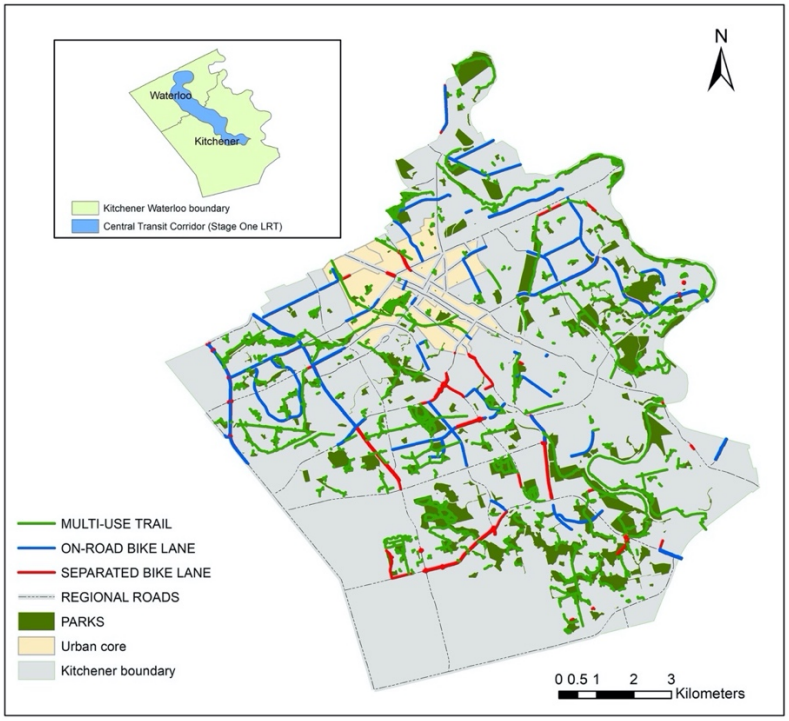

Figure 1. Cycling facilities in Kitchener in 2017 (Source: City of Kitchener)

Table 2. Variable descriptions

Variables	Description
Dependent variable	
logPrice	Logarithm of the sale price
Independent variable - structural attributes	
age	Age of each property at time of sale [year]
tot_area	Total floor area [1000 sqft]
beds	Number of bedrooms
baths	Number of bathrooms
garage	Number of garages
fireplace	Number of fireplaces
semi	Semi-detached/duplex or single-detached - dummy variable [1/0]
type	Condominium types: high-rise; walk-ups; houses
pool	Pool - dummy variable [1/0]
Independent variable - neighbourhood and locational attributes	
core	Within the Kitchener urban core (avg. age <= 1945) [1/0]
in_ctc	Within the central transit corridor (800-meter buffer) [1/0]
inter_dense	Intersection density [number of intersections within 800 meters]

rd_adj	Regional road adjacency - dummy variable [1/0]
edu_rate	Post-secondary education percentage in each census tract
os_adj	Open space adjacency - dummy variable [1/0]
os_area	Total area of open space accessible within 800 meters' access [km^2]
canopy	Percentage of tree canopy within 100 meters
trees	Number of trees within 100 meters
transit_min_hdwy	Minimum headway of the closet bus stop [minutes]
transit_express	Express bus route serves the closet bus stop - dummy variable [1/0]
transit_routes	Number of routes serving the closet bus stop
Independent variable - cycling facilities	
onrd100	Proximity to on-road bike lanes within 100 meters - dummy variable [1/0]
onrd200	Proximity to on-road bike lanes between 100-200 meters - dummy variable [1/0]
onrd400	Proximity to on-road bike lanes between 200-400 meters - dummy variable [1/0]
multi100	Proximity to multi-use trails within 100 meters - dummy variable [1/0]
multi200	Proximity to multi-use trails between 100-200 meters - dummy variable [1/0]
multi400	Proximity to multi-use trails between 200-400 meters - dummy variable [1/0]
sep100	Proximity to separated bike lanes within 100 meters - dummy variable [1/0]
sep200	Proximity to separated bike lanes between 100-200 meters - dummy variable [1/0]
sep400	Proximity to separated bike lanes between 200-400 meters - dummy variable [1/0]
Independent variable - fixed time covariates	
sale_year	Sale year - dummy variables

We employ the hedonic pricing model to examine how cycling facilities impact the property values. The basic model is specified as below:

$$p = f(S, L, \varepsilon)$$

where housing price p is determined by the structural attributes (S), the locational and neighbourhood attributes (L) and the other unobserved attributes (ε). The technical details of our model can be found in the thesis of Y. Huang[40]. We have employed the same modelling methodology, but with a shorter time period and several additional variables. This state-of-the art approach controls for differences across neighbourhoods and across time, and specifically controls for the space-time correlations between housing prices that reflect home pricing according to recent comparable sales. The thesis developed hedonic models for housing sales in Kitchener and Waterloo from 2005 to 2018, while this study is focused on Kitchener housing sales from 2013 to 2018; and this study added additional variables for cycling facilities, transit services, trees and the urban core.

Table 2 describes the variables included in the models. Specific to this study, we created three proximity buffers in ArcGIS for each type of cycling infrastructure: 0-100 meters; 100-200 meters; 200-400 meters. For each property, when it is proximate to on-road bike lanes within 100 meters, the value of *onrd100* is 1; when the proximity is between 100-200 meters, the value of *onrd200* is 1; when the proximity is between 200-400 meters, the value of *onrd400* is 1. The

[40] Huang, 2020

same holds for the other two types of facilities.[41] (Note that although the City classifies "sharrows" as on-road bike lanes, we do not include them in our analysis as there are few present, and they do not separate bike and car traffic.) This approach, taken in other similar studies[42], allows us to test whether there are differential effects of proximity. Most specifically, if bike lanes were to directly negatively impact home sales prices due to concerns regarding loss of parking, navigability, or unwanted flows of traffic, we would expect that the "within 100 metres" dummy would be negative, especially as we are not able to control for on-street parking or traffic flows, due to lack of data. However, for some residents the opposite impact might be possible—for instance, a condo resident planning to bike to work, the LRT, or the train station might have a very high value for immediate access to cycling infrastructure. Thus, our coefficients should be interpreted as net effects. Some studies find a value for being near cycling infrastructure, but not next to it, which might reflect a high use/access value, while avoiding any increased traffic dissammenities. The wider buffers will reflect these values. In short, they are more likely to measure the use and accessibility values of cycling infrastructure, independent of any perceived disammenity.

As in the qualitative findings, it can be challenging to extract the independent impacts of cycling facilities from some other factors, such as the growth of downtown core, the LRT, the tech industries, and even walkability (facilitated by a traditional block road network). As in some cities, these factors are all likely to co-occur in Kitchener, especially in transit-oriented development areas. Our model takes several strategies to control for these factors.

- First, we created a *core* dummy variable to distinguish whether the property is within the Kitchener urban core neighbourhoods (defined as having an average construction time before 1945) or in the suburban neighbourhoods. The *core* variable is expected to capture the compound effects of the LRT, the tech hub and proximity to urban amenities.
- The *in_ctc* dummy variable indicates the area proximate to the LRT line within 800 meters, the standard distance that most riders will walk to access rapid transit.
- We used the intersection density *inter_dense* as a proxy for walkability, where more intersections indicate shorter and denser streets in the area.
- Expanding on our previous modelling, which included distance to bus stop as a measure of non-LRT transit access, master's student D. Feng developed three new metrics of transit accessibility using the publicly available GTFS data, and these metrics were included for the closest bus stop to the sold property.[43] The transit service metrics reflect the number of routes, departure frequency, and express service availability at Grand River Transit bus stops during Fall service periods for the time periods, using the maximum service level available. Since the metrics use schedules of entire service periods (e.g., October – December, 2018) to seek maxima in departure frequency/route counts, they optimistically represent transit

[41] It should be noted that, ideally, network distance via walking or cycling could have been used rather than radius, as the radius may overestimate access in areas with low connectivity. However, we employed the radial approach due to data and resource limitations.
[42] See Connolly et al., 2019; Welch et al., 2016; Krizek 2006; Conrow et al., 2020; Liu & Shi 2017; Parent & vom Hofe, 2013
[43] We tested our models using only distance to bus stop and found that the new transit metrics added explanatory power to our models.

services as they tend to reflect peak-hour services, whenever they may be for a given stop. Feng analyzed transit schedule data using static GTFS files to populate each stop in the GRT network with these attributes.

  - *Minimum headway* indicates the minimum time between consecutive departures (headway, in minutes) of the single, most frequent route that services a stop. The minimum headway is the shortest length of time a rider would need to wait between trip departures of the "best" route that services a stop. Since the minimum headway attribute only represents the maximum single-route frequency at a stop, it underestimates the value of transit services at stops with multiple, overlapping routes.
  - *Number of bus routes nearby* counts the unique routes servicing a stop to indicate the stop's connectivity with the broader transit network. This metric ignores changes in the number of routes servicing the stop throughout the day and may overestimate the value of stops with low-frequency or peak-only services.
  - *Express bus nearby* is a binary indication of whether "iXpress" express bus services exist at the closest bus stop (1, if express bus service available; 0, if not). Express bus services provide shorter travel times to attractive destinations and are valued assuming that passengers derive more value from shorter travel time to popular destinations than longer travel times using regular bus services. Note that temporary service changes during LRT construction are reflected in our data. However, it is important to point out that for the 200 iExpress, the express bus service nearby may also reflect perceived value of being near a future LRT station.

- In addition, we added the regional road adjacency (*rd_adj*) variable to isolate the possible negative effect of being adjacent to higher traffic and wider regional roads. By adding these variables in hedonic models, we were able to isolate the influence of different cycling facilities on property prices.
- For green space, *os_adj* and *os_area* denote whether the property is in immediate proximity to public open space and the open space area accessible within 800-meter proximity.
- For this study only, we included the number of trees and tree canopy, with expected positive impacts on housing prices. As we only have tree data from 2014, we are making the assumption that trees present in 2014 were also there in other years. However, we know that substantial tree canopy loss occurred from 2014-2018, due to the ash borer. Thus, our tree value estimates should be considered lower bounds. Trees provide benefits in residential neighbourhoods through reductions in storm water runoff and improved aesthetics, shade/cooling and privacy, and air quality[44]. These tree canopy benefits can be translated into housing prices when buyers perceive and are willing to pay for them. The majority of studies evaluating the economic values of trees have found a positive relationship between tree canopy and housing prices[45].

Table 3 summarizes sales observations with respect to proximity to cycling facilities, demonstrating that there is enough variation in access to cycling infrastructure to conduct our

[44] Pandit et al., 2013

[45] Seo, 2020; Plant et al., 2017; Donovan et al., 2019; Donovan & Butry, 2010; Sander et al., 2010

analysis. Note, however, that access to various forms of cycling infrastructure is uneven. In particular, access to cycling infrastructure is lower in the urban core, explained in part by the prevalence of older, narrower streets, which may not have room for cycling infrastructure. Note also that while access to on-road bike lanes is quite variable, access to separated bike lanes in general is quite low (indicating that the locations that do have this infrastructure may have particular characteristics that could cloud our analysis), and access to multi-use trails is quite high. Results should be interpreted with this information in mind.

(1) 62% of single-family house sales did not have access to on-road bike lanes within 400 meters, including 64% for house sales in the core; 47% of condo sales were in locations lacking access to on-road bike lanes within 400 meters, including 58% for condo sales in the core;

(2) 82% of single-family house sales did not have access to separated bike lanes within 400 meters, 88% for house sales in the core; 76% of condo sales lacked access to separated bike lanes within 400 meters; 86% for condo sales in the core;

(3) only 9% of single-family house sales did not have access to multi-use trails within 400 meters, up to 20% for house sales in the core. 7% of condo sales lacked access to multi-use trails within 400 meters, 8% for condo sales in the core.

Table 3. Summary of sales observations with respect to proximity to cycling facilities

	Single-family house sales				**Condominium dwelling sales**			
	All (n = 13,363)		Core area (n = 1,500)		All (n = 4,326)		Core area (n = 731)	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
onrd100	1057	8%	110	7%	672	16%	17	2%
onrd200	1442	11%	133	9%	529	12%	77	11%
onrd400	2607	20%	298	20%	1114	26%	216	30%
No onrd	8257	**62%**	959	**64%**	2011	**47%**	421	**58%**
multi100	3555	27%	261	17%	998	23%	184	25%
multi200	4350	33%	409	27%	1393	32%	183	25%
multi400	4284	32%	535	36%	1652	38%	304	42%
No multi	1174	**9%**	295	**20%**	283	**7%**	60	**8%**
sep100	311	2%	15	1%	143	3%	2	0%
sep200	618	5%	50	3%	288	7%	3	0%
sep400	1440	11%	110	7%	612	14%	96	13%
No sep	10994	**82%**	1325	**88%**	3283	**76%**	630	**86%**
Not at all	697	5%	212	14%	198	5%	60	8%

Findings

Table 4 shows the hedonic model results for condo sales in terms of the estimated coefficients for the variables of interest. The significance level in the table mainly refers to the probability of each coefficient outcome likely to occur almost always in repeated sampling, where the 0.001

level (denoted as ***) indicates a 99.9% chance of the coefficient occurring; the 0.01 level (denoted as **) indicates a 99% chance; and the 0.05 level (denoted as *) indicates a 95% chance. The estimate indicates the magnitude of the correlation. Thus, an impact may be statistically significant but have a relatively low association with property values. The validity of these confidence levels relies on the validity of our model assumptions: Did we include the right data? Did we estimate the correct models? To ensure model validity, we have run many alternative models, also exploring which data should be included. We find that the model can explain 81% of the price variations, indicating that around 20% of price variations are likely due to factors we were not able to include in our models. The significant results (including all three significance levels) for condos are summarized below, with further discussion.

- On average, condo values are higher with 100 metres (7%), between 100-200 metres (5.8%) and between 200-400 metres (7.7%) of on-road bike lanes. These results indicate a fairly uniform potential access value for on-road bike transportation for condos, without a strong disammenity value for a location on a road with an on-road bike lane.
- Multi-use trails are also associated with higher values: 5.5% within 100 metres, 4.1% between 100-200 metres, and 3.6% for 200-400 metres. Not surprisingly, values of multi-use trails are highest closest to trails for condos. Many multi-use trails in Kitchener are also green corridors, where windows or balconies overlooking trails may provide green amenities. These numbers may also represent high recreation value, as well as commuting value, as discussed in the literature and seen in interviews.
- However, separated bike lanes are associated with lower condo prices: 9.7% less within 100 metres, 7.3% less between 100-200 metres, and 7.6% less between 200-400 metres. Given the very sparse prevalence of separated bike lanes in the city, we caution that this result likely does not represent a causal relationship, but rather what is called “spurious correlation.” During the study period, separated bike lanes were present on very high-traffic roads in the suburban areas, which are likely to have lower property values due to traffic disammenities and lack of on-street parking. Further, almost no separated bike lanes are present in the Kitchener downtown core. While the Weber and King street underpasses near Victoria are labeled as separated bike lanes, there is no signage or markings to indicate this use, and these lanes are not connected to other cycling infrastructure. Thus, we think this result, rather than reflecting the presence of the separated bike lanes, reflects the relatively sterile and traffic impacted reduction in property values due to the road form.
- While we tested models with interaction terms between the urban core and the three types of cycling infrastructure, these results were not significant. This result differs from the perceptions expressed by realtors and developers. Together, the results may indicate that while many in the core may have a strong preference for cycling, there is not yet sufficient infrastructure present to meet the demands of this demographic. Alternatively, with relatively few condo development sites available in the core, developers may not be able to prioritize access to cycling infrastructure when selecting condo sites, as discussed in the qualitative section. More significantly, these results suggest that suburbanite condo dwellers also value cycling infrastructure, not only for recreation value (as indicated by values for multi-use trails), but for commuting value (on-street bike lanes).

- iXpress bus route service at the nearest bus stop is associated with 7.1% higher condo prices and an additional bus route with 1.5% higher prices. Consistent with results from previous realtor interviews by our research group, these results indicate that iXpress bus routes are playing a role in local real estate markets—developers may perceive proximity as a feature demanded by their buyers, and on re-sale, these locations may sell for a premium. Future research might investigate who values iExpress access, especially balance of work vs. educational institution commuting, and the extent to which the iExpress is used to access end destinations vs. to connect with the ION LRT.
- Adjacency to open space is associated with 1.7% higher values; however, the area of open space in the neighbourhood is not a significant factor. Note that our previous research[46] has demonstrated that open space access is fairly uniform in the Cities of Kitchener and Waterloo, and we also found similar open space premia.
- New to this study, every 10% increase of the tree canopy within 100 meters is associated with 1.2% higher condo prices, and 10 more trees within 100 meters increase condo prices with another 0.8%. We suggest that developers consider these results in their site plans. Preservation of existing trees may contribute more than enough to sales values to compensate for site plan modification to allow their preservation. Addition of treed areas, especially considering the premium for open-space adjacency, may provide additional sales premia.
- Prices of condos in the Kitchener urban core are on average 13.3% higher than condos in the suburban areas. This new result demonstrates higher values associated with our urban cores, beyond walking access to LRT stops. In fact, this study found that for the base year of 2013, condo values were lower in the central transit corridor. Here, it is important to note that the central transit corridor includes a variety of neighbourhoods, inside and outside the urban core, and that the ION LRT was not yet running during our study period. Condo values throughout the city increased in each study year, and most steeply in 2017 and 2018. In this study, we did not test whether condo values increased more steeply in the CTC corridor. (Huang provides additional evidence and discussion of associations between CTC and property value changes from 2005-2018[47].)

Table 4. Hedonic model results for condominium dwellings

	Estimates	sig	*p*-value
Cycling Accessibility			
On-Road Bike Lane: 0-100m (1/0)	7.0%	***	0.000
On-Road Bike Lane: 100-200m (1/0)	5.8%	***	0.000
On-Road Bike Lane: 200-400m (1/0)	7.7%	***	0.000
Multi-Use Trails: 0-100m (1/0)	5.5%	***	0.000
Multi-Use Trails: 100-200m (1/0)	4.1%	***	0.000
Multi-Use Trails: 200-400m (1/0)	3.6%	**	0.002

[46] See Babin, 2016
[47] See Huang, 2020

Separated Bike Lane: 0-100m (1/0)	-9.7%	***	0.000
Separated Bike Lane: 100-200m (1/0)	-7.3%	***	0.000
Separated Bike Lane: 200-400m (1/0)	-7.6%	***	0.000
Bus Transit Accessibility (at nearest stop)			
Minimum Headway (min)	0.1%		0.117
Express bus (1/0)	7.1%	***	0.000
Number of bus routes	1.5%	***	0.000
Open Space Accessibility			
Open Space Adjacency (1/0)	1.7%	**	0.019
Open Space Area (per km^2)	-0.6%		0.185
Tree			
Tree canopy (per 10%)	1.2%	***	0.000
Number of trees within 100 meters (per 10 trees)	0.8%	***	0.000
Downtown			
Urban Core (1/0)	13.3%	**	0.027
In CTC (1/0)	-10.2%	***	0.000

***Note**: $p < 0.001$ ***; $p < 0.01$ **; $p < 0.05$* ($n = 13,363$)*

Table 5 shows the hedonic model results for single-family house sales. We find:

- The model can explain 83% of the price variations.
- Most cycling facilities do not have a significant impact on housing prices.
- However, on-road bike lanes within 200-400 meters are associated with 1.3% higher house prices.
- Together, these results indicate that we find no evidence that cycling infrastructure adjacent to homes is associated with reduced property values.
- An additional bus route at the nearest stop is associated with 1% higher house prices.
- Access to open space positively impacts house prices, where every 1 km^2 of open space accessible within an 800-meter radius is associated with 2% higher prices, and being adjacent to open space is associated with a further 1% increase.
- Every 10% increase of the tree canopy within 100 meters is associated with a 1.4% sales price, and 10 more trees within 100 meters with an additional 0.2%. Again, we strongly encourage developers and builders to take these open space and tree values into account in their site plans. A site plan that preserves existing mature trees can result in a significant sales premium, especially at the subdivision level, when open space adjacency, tree canopy, and individual tree values are all accounted for.
- We found no price difference between the core area and the suburban area after controlling for all other factors; thus, we excluded this variable from our model. Further, we found no significant interactions between core areas and cycling infrastructure.

Table 5. Hedonic model results for single-family houses

	Estimates	**sig**	***p*-value**
Cycling Accessibility			

On-Road Bike Lane: 0-100m (1/0)	0.3%		0.486
On-Road Bike Lane: 100-200m (1/0)	0.4%		0.328
On-Road Bike Lane: 200-400m (1/0)	1.3%	***	0.000
Multi-Use Trails: 0-100m (1/0)	0.3%		0.532
Multi-Use Trails: 100-200m (1/0)	0.0%		0.984
Multi-Use Trails: 200-400m (1/0)	0.7%		0.100
Separated Bike Lane: 0-100m (1/0)	-0.9%		0.317
Separated Bike Lane: 100-200m (1/0)	-0.3%		0.601
Separated Bike Lane: 200-400m (1/0)	-0.3%		0.527
Bus Transit Accessibility (at nearest stop)			
Minimum Headway (min)	0.0%		0.228
Express bus (1/0)	-1.0%		0.235
Number of bus routes	1.0%	***	0.000
Open Space Accessibility			
Open Space Adjacency (1/0)	1.2%	**	0.002
Open Space Area (per km^2)	2.0%	***	0.000
Tree			
Tree canopy (per 10%)	1.4%	***	0.000
Number of trees within 100 meters (per 10 trees)	0.2%	***	0.000

***Note**: $p < 0.001$ ***; $p < 0.01$ **; $p < 0.05$* ($n = 4,326$)*

Discussion:

This study applied quantitative methods to examine the relationship between cycling infrastructure and residential property values. Most of these findings are in line with the qualitative analysis results. First, the impacts of cycling facilities on residential prices are different for condos and single-family houses. While this research does not directly measure the values of individual buyers, these results are consistent with lifestyle and preference differences revealed in other research, including the interviews conducted for this study. Condo buyers tend to have high values for an urban lifestyle, including access to transit and alternative transportation. Home buyers tend to hold much higher values for open space, including private yard space, and they may be more reliant on automobile transportation. Second, the downtown core provides a significant price premium for condos, possibly due to the attractiveness of the tech hub and the transportation hub, and the concentration of urban amenities (such as libraries, restaurants, and cultural destinations).

Specific findings from our other research are also relevant to interpret these results. Huang[48] conducted a residential location choice survey in KW in 2017 and identified two different lifestyle groups through analyzing their home buying preferences: one prefers a more urban lifestyle, favouring better access to transit, ease of walking and cycling and better access to retailing stores and services; the other group prefers a more suburban lifestyle where housing size and green space are of higher importance. Huang found, however, that many buyers who

[48] Huang, 2020

preferred more urban lifestyles did not purchase homes in the central transit corridor, seemingly due to the difficulty in finding affordable units that provided enough space in the CTC. Thus, Huang found evidence of latent demand for transit-oriented development in the area. Cook[49], in interviews with local realtors, found a growing preference in the region for an urban lifestyle, especially the young professionals who work in the core and prefer to walk, cycle or take transit for commuting and non-commuting activities. Tran[50], in developer interviews, found that core area infill developers recognized these young professionals and empty nesters as target markets in the core areas, but they did not plan developments targeting young families. Our qualitative research found that investors expect strong price appreciations for condos in the core area. The potentially integrated transportation network (GO train + LRT + cycling + walking) might contribute to further increases to condo prices in the core area, but that dynamic may also be influenced by pandemic-triggered shifts to working from home.

Huang's residential location choice study also revealed a common preference for active-transportation-friendly environments. 39% of homebuyers perceived *ease of cycling* as an important factor in their home purchase decision making, and 35% marked it as a very important factor. Furthermore, 85% of homebuyers preferred to live in a neighbourhood with a medium-to-high level of ease of cycling. Pi's survey of renters[51] in KW had similar findings: almost 70% of renters considered ease of cycling as an important or very important factor in their renting decision. Thus, the majority of homebuyers and renters held positive weights for cycling in their neighbourhood choice. Despite that, both surveys also found that *ease of walking* is a more important built-environment factor than cycling in home decision making.

D. Feng analysed modal shares using Huang's homebuyer survey data comparing commuter mode choices before and after residential relocation. He found that among the individuals who reported mode choices both before and after moving, 80.1% did not switch modes. Feng classified the mode switchers based on their current (post-move) mode: switchers to active modes, including cycling and walking (n=32), or switchers to automobile modes, including driving and passenger modes (n=33). Switchers to transit comprised the rest (n=13). The group of homebuyers who switched to active modes included a higher proportion of high-income households, had larger household sizes, and were more often couples with children. This group switched to active modes despite having about the same automobile ownership rates as the average homebuyer in the entire survey (~1.7 cars per household). These household characteristics suggest that given the financial resources, households may self-select into neighbourhoods that fulfill their desire to use active modes. However, neither group was more likely to move into the CTC corridor. Approximately 23.1% of switchers to active modes and 19.2% of switchers to automobile modes relocated to within the 800m CTC corridor boundary. This suggests that mode switchers among homebuyers pursue opportunities for active mobility when they are financially unencumbered (e.g., earning higher incomes, not paying price premiums in the core) and may prioritize moving to places where their children can walk and cycle to school.

Even though this study is carefully designed, it is not without limitations. First, a lack of data for the whole Region limits the generality of the results for Waterloo and Cambridge. As

[49] Cook, 2019
[50] Tran, 2017
[51] Pi, 2017

our previous studies did not find housing market differences between cities, we expect results to mirror those found for Kitchener. However, if moving forward the three cities are able to collect and archive cycling infrastructure data using common definitions, it would be informative to estimate models for all three cities, especially considering the potential influence of the universities and Conestoga College.

During the time of this study, the Kitchener cycling infrastructure was recognized to be sparse and not well connected. This limits the information gained by our analysis, as some well-connected cycling segments may have very high accessibility values, and disconnected segments low accessibility value. However, this lack of connectivity can give us confidence that disamenity values of cycling infrastructure are low. If they were high, and accessibility benefits low, estimated impacts on net would likely be negative. However, we see this result only for condo sales near separated bike lanes, which likely have high disamenity values for the reasons discussed in detail above. It is highly recommended that a follow-up study be conducted later when more cycling facilities are installed, and the active transportation network is more integrated into the overall transit system.

We used a geometric radius, rather than network distance, to measure distance to cycling infrastructure for our transit accessibility metrics. This approach may overestimate access to cycling infrastructure. More significantly, we do not evaluate the extent to which cycling infrastructure provides connectivity to other active transport modes, such as access to transit, which allows riders to bring bicycles on board. Further, we do not account for how the cycling and other active transit networks provide access to key destinations, such as employment and recreation. Additional modelling of these aspects, as data become available, would measure broader values of cycling infrastructure.

Please see Appendix B for 1) cycling facility proximity buffers, 2) descriptive statistics, and 3) full model results.

Conclusions

Cycling has numerous health, mobility and quality of life enhancements that are increasingly being recognized by local governments. There is also a growing body of evidence to suggest that cycling infrastructure has a neutral, or even positive impact on local economies. However, there is also persistent and vocal opposition to the implementation of new bike lanes. Research suggests that this opposition to bike lanes represents a minority of views. This discord was particularly evident in the early phases of the COVID-19 pandemic, when many cities, including the Region of Waterloo, implemented new bike lanes as part of a suite of policy measures to deal with the consequences[52].

Nevertheless, there remains a need for detailed research into the impacts of bike lanes in order to deconstruct some of the myths and negative perceptions about them. Therefore, the aim of this report was to examine to what extent bike lanes impact residential property values. Our research utilized a mixed-methods approach, with both in-depth interviews with realtors and developers, and hedonic modelling of real estate transaction data and the presence of cycling infrastructure.

In both methods, we found no evidence to indicate that cycling infrastructure significantly decreases property values. In many urban areas, they are an amenity that is both highly valued by a growing segment of the population and correlated with an increase in property values, compared with similar properties that are not in proximity to bike lanes. This research therefore debunks the myth that bike lanes will lead to a lowering of property values. Contrary to this myth, our research is part of a growing body of literature that indicates the economic value of cycling infrastructure[53].

Our research has found that open spaces are highly valued, especially housing that is in direct proximity to open spaces. This value was evident in both the qualitative and quantitative parts of our research and was especially evident for family households.

For single family housing in particular, but for all housing in general, the value of parking is high. However, there is a growing divergence between core urban areas, and automobile-oriented suburban neighbourhoods, as well as among young professional and empty nesters, who are less focused on an automobile-dominant lifestyle. Some developers are now constructing projects with fewer parking spaces than housing units, though this is not yet the case for family-sized properties. Access to connected cycling infrastructure may be particularly important for such properties, where car ownership is likely to be lower.

It is interesting to note that while there is qualitative evidence to suggest that core-area buyers value cycling (particularly as a mode of transport) more than suburban households, and quantitative evidence to support the value for condo residents, cycling infrastructure is less developed in core urban areas. However, these older urban neighbourhoods have an urban form, street design, and land use patterns that are more favourable to on-street cycling than the large arterial roads of neighbourhoods constructed after 1945. When looking at the urban morphology of different parts of the city, cycling is much more difficult and challenging in automobile-oriented communities without the development of separate cycling infrastructure.

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[52] Carter, 2020

[53] See Reid, 2017; Smith Lea, 2018

While our research has examined residential property values, we are keen to stress that property values are not the only factor that should determine good urban planning, particularly when it comes to cycling and active transportation. In particular, public cycling values such as pollution reductions and public health benefits are not reflected in property sales. It is also important to stress that not all residents are homeowners and that the impact on property prices should not be the sole, or even primary determinant of transportation policy. In this study, we did not examine rental markets and how cycling infrastructure impacts rental prices. Xinyue Pi's thesis[54] explored this topic, and her analysis could be enhanced to include cycling infrastructure. Therefore, another avenue for future research should also be in-depth interviews with residents (both renters and owners) to better understand what cycling infrastructure means to them and their housing choices.

The starting point of this research was to examine the impact of cycling infrastructure on residential property values in order to provide some data and evidence to deconstruct the myth that bike lanes reduce property prices. We have demonstrated that this is not the case locally, and our research is part of a growing body of literature indicating the economic uplift that can result due to new bike lanes. There is a body of scholarly literature that suggests that – rather than reducing property prices – bike lanes actively contribute to increasing property values through gentrification[55]. Related to property uplift, there is a danger that bike lanes can contribute to gentrification, a process that makes a neighbourhood far more expensive to live in and displaces many low-income residents. The Region of Waterloo has concluded that gentrification may be happening along the ION LRT corridor, as evidenced by increasing average incomes in core urban areas, especially when compared to changes in regional averages[56]. To date, there is little evidence that the current cycling infrastructure is contributing to gentrification along the LRT corridor; however, as we have noted, bike lanes enhance quality of life and make neighbourhoods more attractive to many professional and affluent households. Further research, especially taking into account the new challenges of the COVID-19 era, into the relationship between buyers' values and their transportation behaviour, could also shed light on this in the Region of Waterloo.

[54] Pi, 2017
[55] Immergluk & Balan, 2017; Zavestoski & Agyeman, 2014; Stehlin, 2019
[56] Region of Waterloo, 2019, p. 40

Recommendations and further monitoring

We suggest that local governments take the following information into account when developing active transportation policy in order to ensure the continued development of cycling infrastructure is done in a well-informed, equitable way:

- Off-road shared pathways can have a double dividend when combined with green corridors, contributing to open-space, recreation, and commuting values.
- As core-area buyers seem to place a high priority on cycling, efforts to connect safe cycling infrastructure in the core should be continued.
- We find strong evidence of the value of urban trees. Thus, any development of on-road or separated cycling infrastructure that sacrifices mature trees should be carefully considered.
- The cities and Region should continue to develop and publicize cycling infrastructure data and ensure that all current infrastructure is signed, so that residents can make the best use of existing infrastructure (including use in way-finding and transportation apps), and up-to-date walkability and cycling access is shown on Reator.ca.
- They should continue to develop cycling infrastructure in core urban areas because there is clear evidence of demand for cycling, both in terms of the number of users and in terms of what potential buyers are looking for in a residential neighbourhood.
- They should continue to develop cycling infrastructure in suburban areas where the road conditions are not conducive to safe and enjoyable cycling. Better cycling infrastructure in suburban areas is also necessary if core urban areas gentrify; as lower-income residents are pushed out of the urban core. If local governments are committed to equitable access to active transportation, they will need to ensure that proper infrastructure is in place in all areas in order to ensure that everyone has the ability to cycle safely, regardless of where they live.
- Future research projects could focus on the accessibility aspects of cycling and preferences for type of cycling infrastructure. For instance, cyclists could be geotracked to monitor their preferred routes and destinations. Further studies could examine the physiological impacts (stress responses) while riding on on-road, separated, and shared path off-road bike lanes. Such research could also interview riders regarding their preferences and route choices.

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References

Agyeman, J. (2020). Poor and black 'invisible cyclists' need to be part of post-pandemic transport planning too, *The Conversation.* 27 May.

Asabere, P. K., & Huffman, F. E. (2009). The relative impacts of trails and greenbelts on home price. *The Journal of Real Estate Finance and Economics*, *38*(4), 408-419.

Babin, R. (2016). Estimating Homebuyer Preferences Under Intensification: Hedonic Modelling of Open Space and Multimodal Transit Amenities Preceding Light Rail in Kitchener-Waterloo. UWSpace. http://hdl.handle.net/10012/10936

Bassett D.R., Pucher, J., & Buehler, R. (2008). Walking, cycling and obesity rates in Europe, North America and Australia. *J Phys Act Health, 5*: 795–814.

Buck, D., & Buehler, R. (2012, January). Bike lanes and other determinants of capital bikeshare trips. In 91st Transportation research board annual meeting.

Buehler, R., Pucher, J., Merom, D., & Bauman, A. (2011). Active travel in Germany and the US: contributions of daily walking and cycling to physical activity. *American Journal of Preventive Medicine*, *41*(3), 241-250.

Carter, A. (2020). Torontonians support bike lanes, want to see more protections, new poll suggests. *CBC News.* 18 September.

Cavill, N., Kahlmeier, S., Rutter, H., Racioppi, F., & Oja, P. (2008). Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review. *Transport policy, 15*(5), 291-304.

Chapple, K., & Loukaitou-Sideris, A. (2019). *Transit-oriented displacement or community dividents?* Cambridge: MIT Press.

Connolly, C., Livy, M. R., Qiu, Y., & Klaiber, H. A. (2019). Capitalization of interconnected active transportation infrastructure. *Landscape and Urban Planning, 182*, 67-78.

Conrow, L., Mooney, S., & Wentz, E. A. (2020). The association between residential housing prices, bicycle infrastructure and ridership volumes. *Urban Studies*. https://doi.org/10.1177/0042098020926034

Cook, J. (2019). Light Rail Transit in the Region of Waterloo: A qualitative examination of urban rail's effects on real estate, development and urban identities. UWSpace. http://hdl.handle.net/10012/14345

Donovan, G. H., & Butry, D. T. (2010). Trees in the city: Valuing street trees in Portland, Oregon. *Landscape and Urban Planning*, *94*(2), 77–83. https://doi.org/10.1016/j.landurbplan.2009.07.019

Donovan, G. H., Landry, S., & Winter, C. (2019). Urban trees, house price, and redevelopment pressure in Tampa, Florida. *Urban Forestry and Urban Greening*, *38*(January), 330–336. https://doi.org/10.1016/j.ufug.2019.01.014

Dunne, J. (2019). Love them or hate them, research offers financial case for big city bike lanes, *CBC News.* 8 June. https://www.cbc.ca/news/business/biking-lanes-business-health-1.5165954

Filion, P. (2018). Enduring features of the North American suburb: Built form, automobile orientation, suburban culture and political mobilization. *Urban Planning, 3*(4), 4-14.

Harris, B., Schmalz, D., Larson, L., Fernandez, M., & Griffin, S. (2019). Contested Spaces: Intimate Segregation and Environmental Gentrification on Chicago's 606 Trail. *City & Community*.

Hess, D. B., & Almeida, T. M. (2007). Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York. *Urban Studies, 44*(5–6), 1041–1068. https://doi.org/10.1080/00420980701256005

Huang, Y. (2020). Analyzing housing market dynamics and residential location choices concurrent with light-rail transit investment in Kitchener-Waterloo, Canada. UWSpace. http://hdl.handle.net/10012/15801

Immergluck, D. (2009). Large redevelopment initiatives, housing values and gentrification: the case of the Atlanta Beltline. *Urban Studies*, *46*(8), 1723-1745.

Immergluck, D., & Balan, T. (2018). Sustainable for whom? Green urban development, environmental gentrification, and the Atlanta Beltline. *Urban Geography 39*(4), 546-562.

Karssenberg, H., Laven, J., Glaser, M., & van 't Hoff, M. (2016). *The City at Eye Level: lessons for street plinths.* Delft: Eburon.

Kinsella, A. (2020). Bike to the future How Miovision and CycleWR are looking to data to make streets more equitable. *Communitech News.* 27 August.

Krizek, K. J. (2018). Measuring the wind through your hair? Unravelling the positive utility of bicycle travel. *Research in Transportation Business & Management*, *29*, 71-76.

Krizek, K. (2006). Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits. *American Planning Association. Journal of the American Planning Association*, *72*(3), 309–320.

Lindsey, G., Man, J., Payton, S., & Dickson, K. (2004). Property Values, Recreation Values, and Urban Greenways. *Journal of Park & Recreation Administration*, *22*(3).

Li, W., & Joh, K. (2017). Exploring the synergistic economic benefit of enhancing neighbourhood bikeability and public transit accessibility based on real estate sale transactions. *Urban Studies, 54*(15), 3480-3499.

Liu, J. H., & Shi, W. (2017). Impact of bike facilities on residential property prices. *Transportation research record*, *2662*(1), 50-58.

Loukaitou-Sideris, A., Gonzalez, S., & Ong, P. (2019). Triangulating neighborhood knowledge to understand neighborhood change: Methods to study gentrification. *Journal of Planning Education and Research*, *39*(2), 227.

Mayers, R. F., & Glover, T. D. (2019). Whose Lane Is It Anyway? The Experience of Cycling in a Mid-Sized City. Leisure Sciences, 1-18.

Mogush, P., Krizek, K., & Levinson, D. (2005). Value of Trail access on home purchases. IDEAS Working paper series from REPEc.

Ohler, A., & Blanco, G. (2017). Valuing public goods, the time to capitalization, and network externalities: a spatial hedonic regression analysis. *Land Economics, 93*(1), 127-144.

Pandit, R., Polyakov, M., Tapsuwan, S., & Moran, T. (2013). The effect of street trees on property value in Perth, Western Australia. *Landscape and Urban Planning*, *110*(1), 134–142. https://doi.org/10.1016/j.landurbplan.2012.11.001

Parent, O., & Vom Hofe, R. (2013). Understanding the impact of trails on residential property values in the presence of spatial dependence. *The Annals of Regional Science*, *51*(2), 355-375.

Pelechrinis, K., Zacharias, C., Kokkodis, M., & Lappas, T. (2017). Economic impact and policy implications from urban shared transportation: The case of Pittsburgh's shared bike system. *PloS one*, 12(8), e0184092.

Pelzer, P. (2010). Bicycling as a way of life: A comparative case study of bicycle culture in Portland, OR and Amsterdam. In *7th cycling and society symposium* (pp. 1-13).

Pi, X. (2017). Exploring Rental Housing Market in Kitchener-Waterloo, Ontario. UWSpace. http://hdl.handle.net/10012/12431

Plant, L., Rambaldi, A., & Sipe, N. (2017). Evaluating Revealed Preferences for Street Tree Cover Targets: A Business Case for Collaborative Investment in Leafier Streetscapes in Brisbane, Australia. *Ecological Economics*, *134*, 238–249. https://doi.org/10.1016/j.ecolecon.2016.12.026

Remax. (2020). Best Places to Live 2020: Canada Liveability Report, 30 April. https://blog.remax.ca/canada-liveability-report/

Ried, C. (2018). Cyclists Spend 40% More In London's Shops Than Motorists, *Forbes.* 16 November. https://www.forbes.com/sites/carltonreid/2018/11/16/cyclists-spend-40-more-in-londons-shops-than-motorists/#a6de46f641ef

Rigolon, A., & Németh, J. (2020). Green gentrification or 'just green enough': Do park location, size and function affect whether a place gentrifies or not?. *Urban Studies*, *57*(2), 402-420.

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy, 82*(1), 34–55. https://doi.org/10.1086/260169

Sander, H. A., & Haight, R. G. (2012). Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. J*ournal of environmental management*, *113*, 194-205.

Sander, H., Polasky, S., & Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. *Ecological Economics*, *69*(8), 1646–1656. https://doi.org/10.1016/j.ecolecon.2010.03.011

Seo, Y. (2020). Varying effects of urban tree canopies on residential property values across neighborhoods. *Sustainability (Switzerland)*, *12*(10). https://doi.org/10.3390/su12104331

Smith Lea, N., Verlinden, Y., Savan, B., Arancibia, D., Farber, S., Vernich, L. & Allen, J. *Economic Impact Study of Bike Lanes in Toronto's Bloor Annex and Korea Town Neighbourhoods*. Toronto: Clean Air Partnership, 2017.

Stein, S. (2011). Bike lanes and gentrification. *New York City's Shades of Green, Progressive Planning*, *188*, 34-37.

Stehlin, J. (2019). *Cyclescapes of the Unequal City: Bicycle Infrastructure and Uneven Development*. Minneapolis: University of Minnesota Press.

Tran, J. (2017). Understanding Developer's Decision Making in the Region of Waterloo. UWSpace. http://hdl.handle.net/10012/11163

Te Brömmelstroet, M., Nikolaeva, A., Glaser, M., Nicolaisen, M. S., & Chan, C. (2017). Travelling together alone and alone together: mobility and potential exposure to diversity. *Applied Mobilities*, *2*(1), 1-15.

Welch, T. F., Gehrke, S. R., & Wang, F. (2016). Long-term impact of network access to bike facilities and public transit stations on housing sales prices in Portland, Oregon. *Journal of Transport Geography, 54*, 264-272.

Zavestoski, S., & Agyeman, J. (Eds.). (2014). *Incomplete Streets: Processes, practices, and possibilities*. Routledge.

Appendix A Semi-Structured Interview Guide

UNIVERSITY OF WATERLOO | FACULTY OF ENVIRONMENT SCHOOL OF PLANNING

Semi-Structured Interview Guide Realtors: These questions are designed to lead discussions with Real Estate Agents to better understand the economic and social implications that cycling infrastructure can have on housing value.

The current state of cycling plans in the Waterloo Region:
In the wake of growing environmental issues and public health concerns, political bodies have begun to support more health conscious and eco-friendly forms of transit. Active forms of transportation, like cycling and walking, are being prioritized within cities, changing the way in which neighbourhoods perceive cycling and walking infrastructure. We are slowly seeing this transformation in the Tri-City Area, with Cambridge, Kitchener and Waterloo currently developing Transportation Master Plans that take cycling into account. As public perception of cycling lanes, faculties and cyclers themselves is rapidly changing, it is important to understand the specific impacts that the integration of cycling infrastructure is having on property values.

Key terms list:

Mobility: The forms of movement (walking, biking, driving etc.) performed

Transit: The facilities (bike lanes, train tracks) and instruments (vehicles, bicycles) through which movement is possible.

Cycling infrastructure, defined as the facilities allocated for cyclists, can be broken down to three different types.

- Off-road cycling lanes: lanes adjacent to roads, but separated by a physical divider
- On-road cycling lanes: painted lanes on pre-existing roads
- Separated bike lanes: on street bike lanes physically separated from traffic
- Protected bike lanes: on street bike lanes physically separated from traffic by protective bollards or barriers
- Multi-use trails and paths: Pathways away from roads that are cyclist friendly but also open to other forms of movement

(See appendix for a photo example of each)

Background information

1) What city or neighbourhood do you primarily list in?
2) How long have you worked as a Real Estate Agent?
3) Have you bought or sold homes along a street with cycling infrastructure? Ask about the details of this and to what extent this infrastructure featured in buyers/sellers' decision/experience?

a) Same question but with the neighbourhood?

b) Same question but with reference to specific pieces of cycling infrastructure (e.g. Spur Line, Iron Horse, Community Trails, Craig's Grossing, Grand River Bridge (Cambridge)

4) To what extent do your clients express a desire in changing the number of vehicles in their household when they buy or sell a property?

    a) Discuss deeper based around who (age, household composition, demographics)

    b) Discuss deeper based around location (where are people moving from/to who want changes in the number of vehicles they want to have)

5) To what extent have preferences for home buyers shifted over the past ten or twenty years?

    a) How have mobility/transportation preferences changed over these time periods?

    b) To what extent are there differences in preferences (general and transportation) based around age?

Conversations with clients

6) How do mobility considerations enter into a client's home purchase decision?
    a. Can you describe the mobility checklists of your clients (i.e what are they looking for in terms of transportation options)?
    b. To what extent is cycling a mobility priority for your clients? If so, what type of clients? Where are these clients looking for properties?
    c. To what extent do your clients request neighborhoods that have cycling infrastructure?
    d. For clients who express a value in having close proximity to cycling infrastructure, what value do they place on public transportation and walkability?
    e. Do clients distinguish between their desire for cycling infrastructure for commute versus recreational purposes?
7) In your professional view, does the presence of cycling infrastructure have any noticeable impact on property value?
    a) If so, does the impact vary with the type of cycling lanes?
        a. multi-use trails (shared trails used by cyclists and other users)
        b. roadside bike lanes (bike lanes on the road)
        c. off road bike lanes (bike lanes near the road but separated)
    b) If so, where is this cycling infrastructure located in relation to the property? (same street, adjacent road, nearby park?)
8) Are you aware of the "cycling friendly" ratings available on commercial listing sites? What do these ratings mean, in your opinion?
    a) To what extent are your clients using or referring to "cycling friendly" ratings available on commercial listing sites?
        a. If so, how do they use them?

9) To what extent do you see differences in desirability of cycling accessibility for buyers looking for houses versus condos? If differences are seen, what buyer characteristics are associated with these differences?

List of topic suggestions to discuss deeper

a. Buyer age
b. Family versus single
c. Pre-existing cycling culture in areas that cater to one (housing) or the other (condo)?
d. Affordability
e. Kids of school age

Cycling at the neighborhood level

10) To what extent do you see differences in desirability of cycling accessibility across different neighbourhoods? If differences are seen, what neighbourhood characteristics are associated with these differences?

List of topic suggestions to discuss deeper

a. Family versus single
b. Pre-existing cycling culture in areas that cater to one (housing) or the other (condo)?
c. Affordability
d. School locations and transit options to get there (walk/bike vs. bus)
e. Other recreational / open space facilities (forests, park amenities, etc.)
f. Age of the neighborhood
g. Average age of the neighborhood residents
h. Access to greenspace
i. Proximity to downtown cores

Follow up: Do specific characteristics of a neighbourhood (as discussed above) have any relation to the form of cycling infrastructure that buyers are looking for?

Summing up:

11) What is your perception of the current market demand for cycling infrastructure in your city (Cambridge, Kitchener, Waterloo)?
12) What transportation factors are influencing changes in price in these areas?
    a) How does this differ based around demographic factors based around age?
13) What major changes in the housing market have you observed since the beginning of your career (or over the past decade)?

The future of cycling impact in the Waterloo Region

14) As cycling infrastructure expands and the political shift towards cycling continues, how do you see cycling impacting house value in the future?
15) How do you think a larger cycling network will impact the attractiveness of homes in that network for buyers?
16) Is there anything else you would like to add?

Semi-Structured Interview Guide Developers: These questions are designed to guide the conversation with developers to better understand the impact that cycling infrastructure can have for developers looking for new areas to build in, or older neighbourhoods to expand on.

The current state of cycling plans in the Waterloo Region:
In the wake of growing environmental issues and public health concerns, political bodies have begun to support more health conscious and eco-friendly forms of transit. Active forms of transportation, like cycling and walking are being prioritized within cities, changing the way in which neighbourhoods perceive cycling and walking infrastructure. We are slowly seeing this transformation in the Tri-City Area, with Cambridge, Kitchener and Waterloo currently developing Transportation Master Plans that take cycling into account. As public perception of cycling lanes, faculties and cyclers themselves is rapidly changing, it is important to understand the specific impacts that the integration of cycling infrastructure is having on property values.

Key terms list:

Mobility: The forms of movement (walking, biking, driving etc.) performed

Transit: The faculties (bike lanes, train tracks) and instruments (vehicles, bicycles) through which movement is possible.

Cycling infrastructure: defined as the facilities allocated for cyclists, can be broken down to three different types.

- Off-road cycling lanes: lanes adjacent to roads, but separated by a physical divider
- On-road cycling lanes: painted lanes on pre-existing roads
- Multi-use trails and paths: Pathways away from roads that are cyclist friendly but also open to other forms of movement

(See appendix for a photo example of each)

Cycling culture: The active support and participation in cycling, its facilities and the expansion of cycling infrastructure in a given neighbourhood.

Background information

1) Where are your current development locations and projects?
2) What types of developments are you involved in building there?
    a. From your perspective, which factors made these areas desirable locations to develop in?

3) Have you developed property along a street with cycling infrastructure? Ask about the details of this and to what extent this infrastructure featured in buyers/sellers' decision/experience?

   A: Same question but with the neighbourhood?

   B: Same question but with reference to specific pieces of cycling infrastructure (e.g. Spur Line, Iron Horse, Community Trails, Craig's Grossing, Grand River Bridge (Cambridge)

4) For the types of properties that you develop, to what extent do the people living in them want to change the number of vehicles in their household when they buy or sell a property?
   a. Discuss deeper based around who (age, household composition, demographics)
   b. Discuss deeper based around location (where are people moving from/to who want changes in the number of vehicles they want to have)

5) To what extent have preferences for home buyers shifted over the past ten or twenty years?
   a. How have mobility/transportation preferences changed over these time periods?
   b. To what extent are there differences in preferences (general and transportation) based around age?

Current impact of cycling on location planning

i. What is your impression of the role that mobility and transit factors play when thinking about where to invest and what type of product (houses/condos) to build?

ii. To what extent does the availability of cycling infrastructure attract developers to a given area? Does this change with type of cycling infrastructure?

a. multi-use trails (shared trails used by cyclists and other users)

b. roadside bike lanes (bike lanes on the road)

c. off road bike lanes (bike lanes near the road but separated)

iii. Have you observed any impact from current cycling infrastructure on the way in which developments are planned?

a. Are new developments marketed to the existing cycling culture? (if applicable)

b. Are attempts made to integrate cycling into developments in areas where cycling is not current prevalent?

iv. Do you perceive any patterns in the types of neighbourhoods that have cycling infrastructure? Provide examples if possible. (potential neighbourhood qualities that could relate to cycling)

a. Old neighbourhoods/ new neighbourhoods

b. Condo communities
c. Communities with only residential housing
d. Neighbourhoods with a primarily young population/older population
e. Wealthier neighbourhoods
f. Affordable neighbourhoods

v. From your perspective, does proximity to the universities/ colleges have any impact on the way in which developments incorporate (or do not incorporate) cycling culture into plans?

vi. Are there currently any incentives to support or help create cycling culture for developers?

vii. Have you seen any change in the relationship between cycling and real estate in different parts of the city and region? (i.e. urban/suburban, or different municipalities)

The future of developing in the Waterloo Region

viii. As cycling infrastructure expands and the political shift towards cycling continues, how do you see the relationship between cycling infrastructure and property development evolving in the future?

a. How will this impact the neighbourhoods they will be built in?

ix. What is your impression of the role of cycling infrastructure in changing the way in which new developments will be approached moving forward?

a. Will this be location specific? (provide current examples of changing neighbourhoods if possible)

x. Is there anything else that you would like to add?

Appendix B Quantitative study appendices

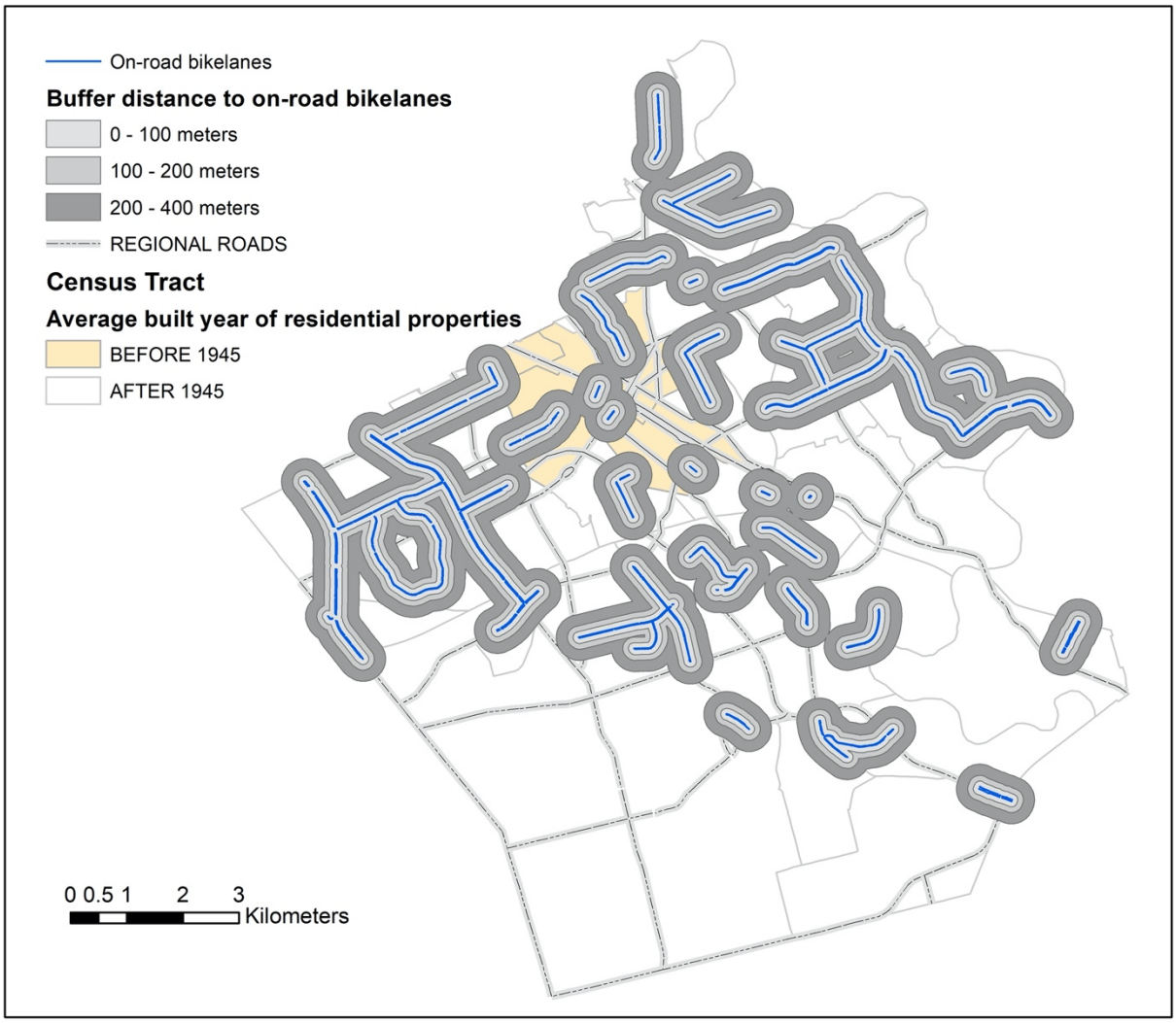

Figure 2. Buffer distance to on-road bike lanes

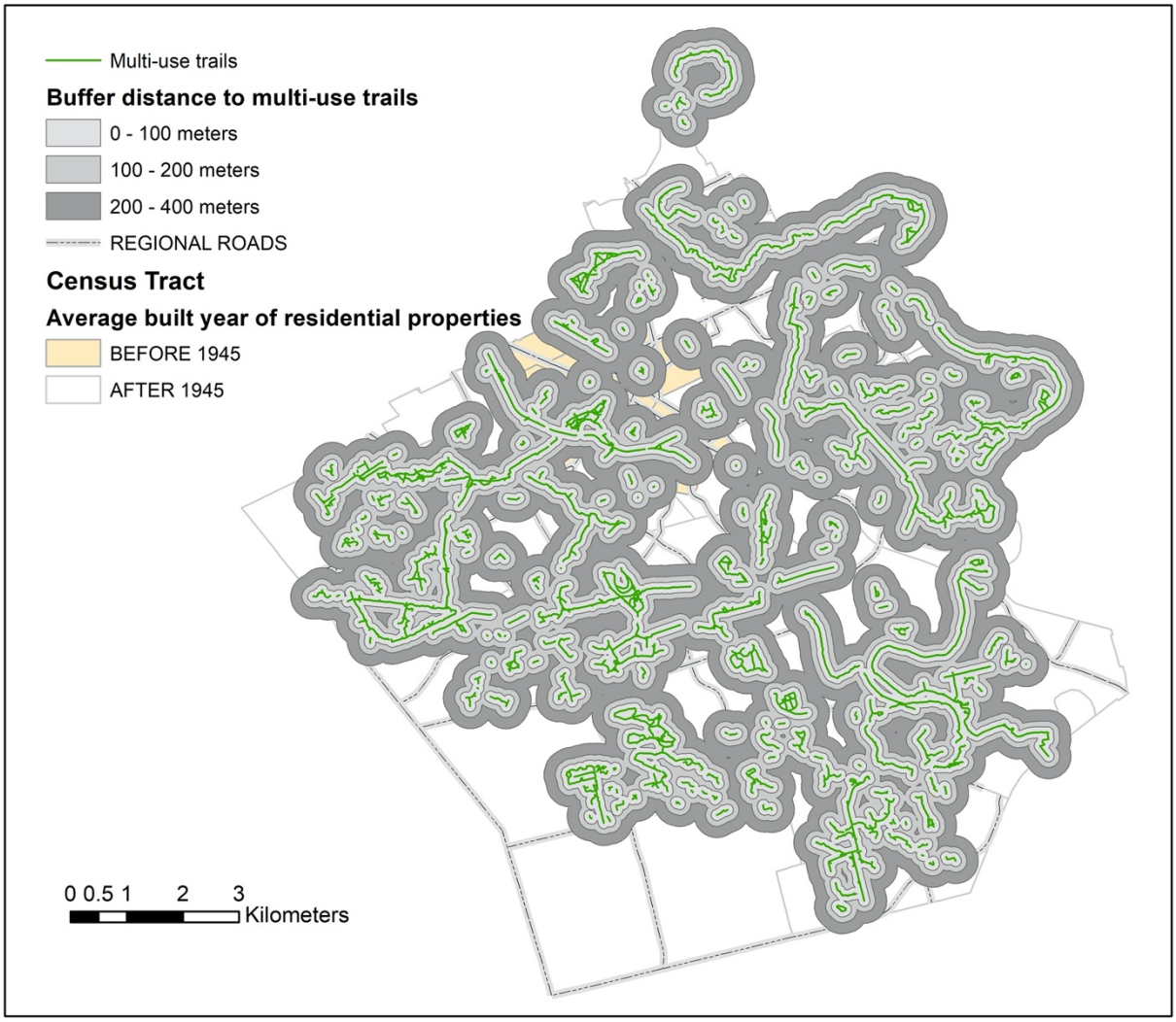

Figure 3. Buffer distance to multi-use trails

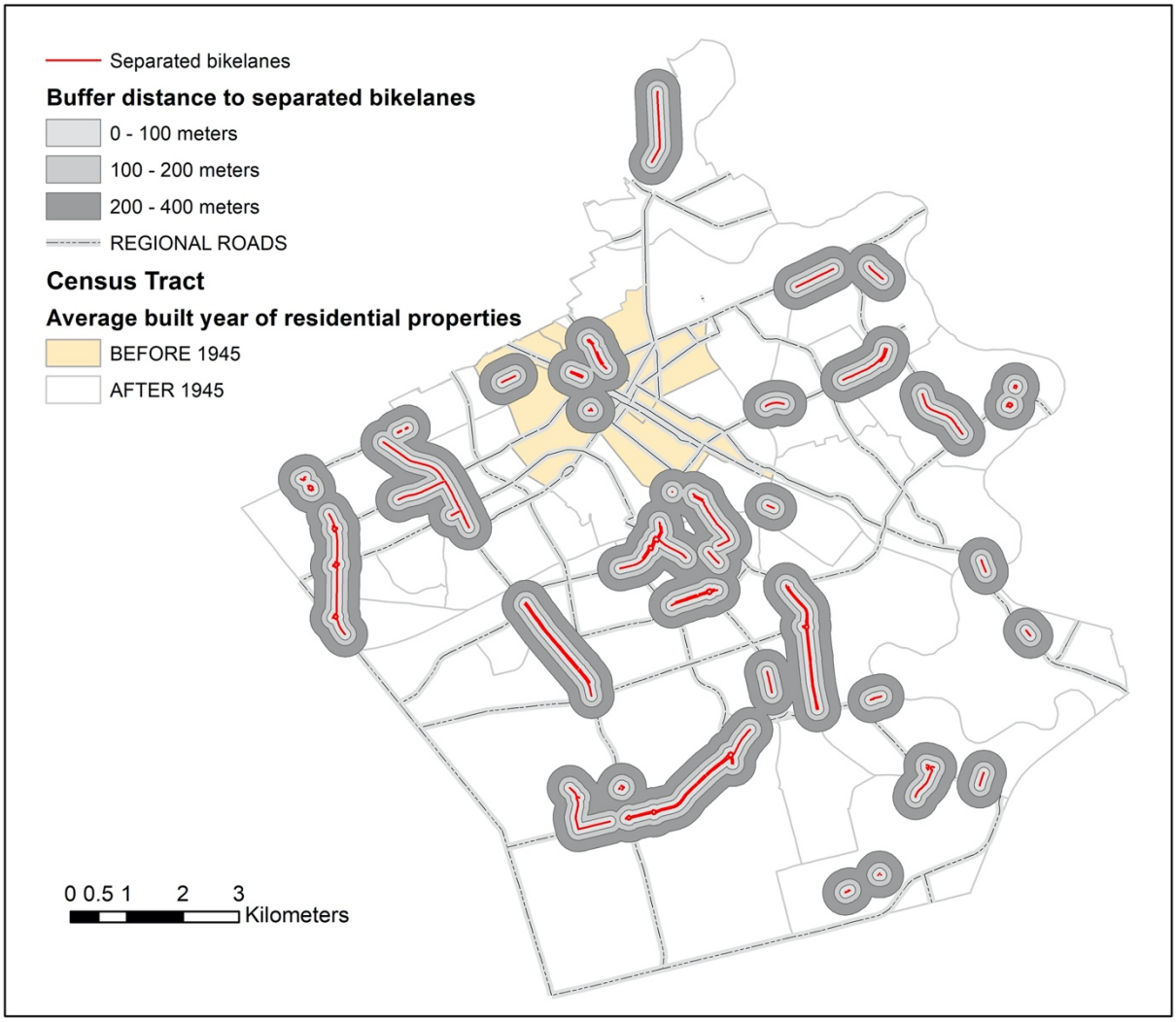

Figure 4. Buffer distance to separated bike lanes

Table 6. Descriptive statistics for condos (n = 4,326)

Statistic	Mean	St. Dev.	Min	Max
sales price	223,294	85,364	13,500	942,000
logPrice	12.3	0.3	9.5	13.8
sale_year	2,015	2	2,013	2,018
age	23	14	0	61
tot_area	1.1	0.3	0.4	3.3
beds	2.3	0.8	0	4
baths	1.5	0.5	0	4
garage	0.4	0.5	0	2
inter_dense	33	16	7	77
dis_bus	1.7	1.4	0.1	14.5
rd_adj	0.4	0.5	0	1
os_adj	0.3	0.4	0	1
os_area	1.1	1.1	0.02	6.7
core	0.2	0.4	0	1
in_ctc	0.2	0.4	0	1
edu_rate	51.1	6.6	38.9	67
onrd100	0.2	0.4	0	1
onrd200	0.1	0.3	0	1
onrd400	0.3	0.4	0	1
multi100	0.2	0.4	0	1
multi200	0.3	0.5	0	1
multi400	0.4	0.5	0	1
sep100	0.03	0.2	0	1
sep200	0.1	0.2	0	1
sep400	0.1	0.3	0	1
canopy	0.3	0.2	0	1
trees	16	24.7	1	357
Transit_min_hdwy	18.8	8.9	0	59
transit_express	0.02	0.2	0	1
transit_routes	1.5	1.2	0	9

Table 7. Descriptive statistics for single-family houses (n = 13,363)

Statistic	Mean	St. Dev.	Min	Max
sale price	390,817	155,338	120,000	2560,000
logPrice	12.8	0.3	11.7	14.8
sale_year	2015	1.5	2013	2018
semi	0.1	0.3	0	1
age	36	25	0	177
tot_area	1.5	0.6	0.5	7.4
lot_size	0.1	0.1	0.003	4.9
beds	3.1	0.6	0	11
baths	1.9	0.7	0.5	7.5
garage	1.1	0.8	0	5
fireplace	0.4	0.6	0	4
pool	0.1	0.2	0	1
inter_dense	33	12	1	82
rd_adj	0.1	0.3	0	1
os_adj	0.1	0.4	0	1
os_area	0.8	0.6	0	7.1
core	0.1	0.3	0	1
in_ctc	0.1	0.3	0	1
edu_rate	53	6.5	38.9	70
onrd100	0.1	0.3	0	1
onrd200	0.1	0.3	0	1
onrd400	0.2	0.4	0	1
multi100	0.3	0.4	0	1
multi200	0.3	0.5	0	1
multi400	0.3	0.5	0	1
sep100	0.02	0.2	0	1
sep200	0.05	0.2	0	1
sep400	0.1	0.3	0	1
canopy	0.2	0.2	0	1
trees	41	28	1	246
transit_min_hdwy	21.8	8.9	0	60
transit_express	0.02	0.1	0	1
transit_routes	1.2	0.5	0	9

Table 8. Full model results for condos

Variables	coefficient	*p* value	sig
(Intercept)	11.6793	0.000	***
age	-0.0276	0.000	***
age2	0.0003	0.000	***
tot_area	0.3885	0.000	***
baths	0.0806	0.000	***
garage	0.0951	0.000	***
os_adj	0.0169	0.019	**
rd_adj	-0.0241	0.000	***
os_area	-0.0058	0.185	
in_ctc	-0.0970	0.000	***
factor(sale_year)2014	0.0372	0.000	***
factor(sale_year)2015	0.0629	0.000	***
factor(sale_year)2016	0.1405	0.000	***
factor(sale_year)2017	0.3389	0.000	***
factor(sale_year)2018	0.4127	0.000	***
factor(type)condo apt_walkup	0.0757	0.000	***
factor(type)condo houses	0.0867	0.000	***
core	0.1250	0.027	**
onrd100	0.0679	0.000	***
onrd200	0.0561	0.000	***
onrd400	0.0740	0.000	***
multi100	0.0537	0.000	***
multi200	0.0400	0.000	***
multi400	0.0356	0.002	**
sep100	-0.1018	0.000	***
sep200	-0.0760	0.000	***
sep400	-0.0793	0.000	***
trees	0.0008	0.000	***
canopy	0.1119	0.000	***
transit_min_hdwy	0.0006	0.117	
transit_express	0.0688	0.000	***
transit_routes	0.0145	0.000	***
core:transit_routes	0.0146	0.005	**

Note: $p < 0.001$ ***; $p < 0.01$ **; $p < 0.05$* ($n = 4{,}326$); $R^2 = 0.810$

Table 9. Full model results for single-family houses

Variables	coefficients	*p* value	sig
(Intercept)	11.9405	0.000	***
age	-0.0054	0.000	***
age2	0.0000	0.000	***
tot_area	0.2101	0.000	***
lot_size	0.3339	0.000	***
baths	0.0395	0.000	***
garage	0.0510	0.000	***
fireplace	0.0341	0.000	***
pool	0.0520	0.000	***
os_adj	0.0119	0.002	**
rd_adj	-0.0287	0.000	***
os_area	0.0202	0.000	***
in_ctc	0.0275	0.000	***
factor(sale_year)2014	0.0377	0.000	***
factor(sale_year)2015	0.0763	0.000	***
factor(sale_year)2016	0.1814	0.000	***
factor(sale_year)2017	0.3886	0.000	***
factor(sale_year)2018	0.3983	0.000	***
Semi	-0.0960	0.000	***
edu_rate	0.0015	0.027	**
inter_dense	0.0012	0.000	***
onrd100	0.0034	0.486	
onrd200	0.0042	0.328	
onrd400	0.0128	0.000	***
multi100	0.0032	0.532	
multi200	0.0001	0.984	
multi400	0.0074	0.100	
sep100	-0.0086	0.317	
sep200	-0.0033	0.601	
sep400	-0.0028	0.527	
trees	0.0002	0.000	***
canopy	0.1287	0.000	***
transit_min_hdwy	-0.0002	0.228	
transit_express	-0.0103	0.235	
transit_routes	0.0097	0.000	***

***Note**: $p < 0.001$ ***; $p < 0.01$ **; $p < 0.05$* ($n = 13{,}363$); $R^2 = 0.833$*