INSTITUTE OF RETAIL ECONOMICS

RECONQUERING THE CITY: A DIFFERENCE-IN-DIFFERENCES ESTIMATION OF THE EFFECT OF PEDESTRIANIZATION ON THE ATTRACTIVENESS OF URBAN AREAS

OANA MIHAESCU

HFI WORKING PAPER No 42

Reconquering the city:

A difference-in-differences estimation of the effect of pedestrianization on the attractiveness of urban areas

Oana Mihaescu[1]

In this study I employ a difference-in-differences-type estimation to assess pedestrianisation schemes in Sweden. Pedestrianised areas attract consumers, making them appealing to firms seeking increased sales. As both businesses and residents prefer to locate in these vibrant areas, demand for commercial and residential properties rises. Assuming constant supply, prices are consequently expected to increase. The effects of pedestrianisation on property values remain, however, under-researched. Using three countrywide databases, I compare property prices in treatment areas (where pedestrian street length changed) before and after treatment with a control group. Results show a 2.77 per cent and 9.75 per cent increase in residential and commercial property prices within 0.5km of pedestrian streets for every ten-metre increase. This equals +SEK 869 (EUR 76) and +SEK 980 (EUR 86) per square metre. A ten-metre decrease results in drops of 2.88 per cent and 8.16 per cent (SEK 903 (EUR 79) and SEK 820 (EUR 72)). Effects weaken with distance from pedestrian streets.

Keywords: pedestrianisation, difference-in-differences, residential property prices, commercial property prices, distance decay

JEL codes: H44; L11; L25; R11; R12.

[1] Email: oana.mihaescu@hfi.se

Publication information

This is the Author Accepted Manuscript (AAM) published by Liverpool University Press. The final published version is available in Town Planning Review, at: https://doi.org/10.3828/tpr.2025.52

Introduction

Twenty years ago, the urban architects Gehl and Gemzoe (2000) outlined four stages in the evolving city–car relationship. Initially, the 'traditional city' balanced meeting places, markets and traffic. In the second stage, cars dominated the 'invaded city', making public spaces noisy, polluted and less walkable. In the third stage, the 'abandoned city', residents moved to the suburbs, driven by highway expansion and lower land prices. The migration of the middle and upper classes to the urban periphery was soon followed by commercial ventures and office spaces. External shopping centres emerged as strong competitors to historic city centres and traditional shopping streets, growing larger and expanding beyond retail to meet diverse customer needs. Later developments, including the rise of online shopping, sustainability demands, the COVID-19 crisis and the economic recession, have further pulled consumers away from bricks-and-mortar city shops and weakened their purchasing power. In response, city planners and officials are continuously seeking ways to revitalise these areas

Pedestrianisation has been used as a planning tool to address these challenges and draw consumers, firms and residents back to city centres (Yiu, 2011). Pedestrianisation involves partially or fully restricting car traffic in urban areas. The first traffic-free zones were recorded in Essen, Germany, in 1926. The concept spread to the US in the 1950s (Ashour and Al-Shamali, 2020) and to European countries such as Denmark and the Netherlands (Pharaoh and Russell, 1991). Sweden introduced pedestrianisation in its three largest cities – Stockholm, Gothenburg and Malmö – in 1961, with plans to pedestrianise 25 per cent of its roads by 2025 (Boverket, 2019). Gehl and Gemzoe (2000) describe this as the 'reconquered city' phase, where urban space is reclaimed for pedestrians to recreate a balance between the marketplace, traffic and public spaces. As previous studies (e.g. Parkhurst, 2003; Whitehead et al., 2006; Özdemir and Selçuk, 2017) have shown, such interventions actively reassert the value of central urban space by drawing people back into the city through improved walkability, public life and commercial vibrancy – a process underscored by Gehl's (2010) concept of 'cities for people' and reinforced by urban policy frameworks at the European level (European Commission, 2004).

Pedestrianisation has been used to increase the attractiveness of urban space because it arguably has a large palette of benefits. On a heavily trafficked road, outdoor shopping may not be enjoyable because of, for example, air pollution, noise and road hazards, which negatively impact the willingness of consumers to visit the respective area (Soni and Soni, 2016). Reducing motorised traffic is believed to improve pedestrian accessibility, lower transportation costs by decreasing car use and parking demand, and reduce congestion, road crashes and related injuries. Pedestrianisation fosters social interactions, increases safety and urban liveability and creates better conditions for heritage preservation. The environmental benefits include lower air and noise pollution and an improved urban microclimate, which can increase both physical and mental health through cleaner air, more exercise opportunities and more social contact. These advantages may drive economic revitalisation by attracting consumers and increasing local business sales and employment (Timmermans and Van den Waerden, 1992; Litman, 2003; Soni and Soni, 2016).

However, whether pedestrianisation is genuinely a local amenity is a controversial topic. While its many advantages might suggest otherwise, there is significant criticism. Some researchers note that retailers do not always see a boost in economic activity after pedestrian streets are introduced (Parajuli and Pojani, 2018). This may be because car-borne consumers, who have greater purchasing power, are often displaced by restrictions on car access. Restricting car access also limits the range of the local market (Nielsen, 1997). Cairns et al. (2002) suggest that pedestrianisation can also lead to shifts in consumer behaviour, such as changes in travel frequency, routes, destinations or even residential and job relocations. As such, it remains unclear whether pedestrianisation is an urban amenity; however, both these positive and negative effects are capitalised in property prices (Kuethe and Keeney, 2012), which can serve as appropriate proxies for measuring urban attractiveness and help address this dilemma.

Few studies have investigated the impact of pedestrian street length on property prices. Most pedestrianisation research has focused on its effects on retail and hospitality revenues, vacancy rates and social interaction (Hass-Klau, 1993). While these studies offer valuable insights, they are often difficult to generalise, as they typically focus on small, geographically limited areas (Yiu, 2011; Özdemir and Selçuk,

2017) and rely on descriptive, quantitative methods (Hass-Klau, 1993). Additionally, methodological challenges make it difficult to isolate causal effects from other simultaneous 'noise'.

In this study, I extend the current research by using a difference-in-differences type empirical approach to assess how pedestrianisation affects the attractiveness of surrounding urban areas in Sweden. I combine three national databases, including data on pedestrian street length, residential property prices and commercial property prices. I measure the impact of changes in pedestrian street length on the area's attractiveness, proxied by residential and commercial property prices, by comparing pre- and post-implementation property prices in areas with and without changes in pedestrian street length. Conducting this analysis on countrywide data increases the external validity of this study compared with previous research.

This approach is grounded in theories of agglomeration economies and the classical law of supply and demand. As pedestrianised areas attract more consumers, they become more appealing to firms because of the potential for increased sales. This growing cluster is expected to increase the utility for residents, who not only visit these spaces but also want to live there. As both firms and residents seek to locate in these attractive areas, demand for commercial and residential properties is likely to increase. According to the law of supply and demand, an increase in demand for these properties should lead to an appreciation in property prices, assuming that the supply remains constant.

The results reveal average increases of 2.77 per cent and 9.75 per cent in the square-metre prices of residential and commercial properties, respectively, for every ten-metre increase in pedestrian street length. This corresponds to an average increase of SEK 869 (EUR 76[2]) for residential properties and SEK 980 (EUR 86) for commercial properties in areas directly adjacent to the pedestrian street (within 0.5km). A ten-metre decrease in pedestrian street length leads to decreases of 2.88 per cent and 8.16 per cent in residential and commercial property prices, respectively, equivalent to decreases of SEK 903 (EUR 79) and SEK 820 (EUR 72) in the average pre-

[2] All conversions are at the exchange rate on 10 September 2024.

treatment square-metre prices of properties near the pedestrian street. The effects decrease with increasing distance from the street. These findings confirm that pedestrianisation is an effective revitalisation tool and provide insights for optimally managing similar future changes in the urban milieu.

The study is structured as follows: the next section discusses the theoretical background; the third reviews previous studies on pedestrianisation; the fourth outlines the data and methodology; the fifth presents the results; and the final section concludes the study.

Theoretical arguments: urban amenities and the pedestrian space

Is pedestrianization an amenity for firms and residents? The economics of location and agglomeration

The increase in demand for residential and commercial spaces in pedestrian areas can be explained by location and agglomeration economics. From the point of view of a profit-oriented firm active within the retail, hospitality or service industries, amenities are features that have the capacity to attract customers and thus lead to increased profits – by increasing sales, reducing costs or both. The increase in the customer base in an area is due to pedestrianisation enhancing consumer appeal through transportation and social, environmental and health benefits. The benefits of transportation include reduced congestion (Soni and Soni, 2016) and increased mobility for pedestrians due to improved walkability and infrastructure for non-motorised transport and public transit (Soni and Soni, 2016). Social benefits include increased social inter actions, security and improved general quality of the urban space (Dunnett et al., 2002; Litman, 2003; Cömertler, 2007). The environmental benefits include reduced air pollution and noise (Chiquetto, 1997). These changes in the urban microclimate yield health benefits because of more exercise opportunities, fewer road crashes and increased social interaction (Sarkar et al., 1997).

A growing consumer base makes the area more appealing to firms (Özdemir and Selçuk, 2017) and may lead to expanding the cluster and creating multiplier effects. As firms co-locate, demand increases because firms acknowledge the possibility for

demand (consumer-related) spillovers but also for supply spillovers (Marshall, 1890) that stem from shared inputs, access to a specialised labour pool and knowledge spill overs, described by Duranton and Puga (2004) as sharing, matching and learning. Expanding clusters become increasingly appealing and have the potential for further growth. This line of thought is promoted by location theories, which explain that consumers' market choices depend on the size and attractiveness of the market and travel distance (Huff, 1964; Christaller, 1966) and that attractive markets may further expand their market reach and customer base, drawing more visitors who stay longer and return more often (Robertson, 1994; Monheim, 2002).

Moreover, consumer theory states that rational consumers seek to maximise utility and thus choose markets that offer the highest utility (Marshall, 1890). Large clusters of retail, hospitality and service firms provide increased utility by enabling one-stop and multipurpose shopping, minimising search costs (Huff, 1964). If the implementation of pedestrian schemes leads to larger and more attractive firm clusters, the utility of the pedestrian areas is likely to increase. The utility of these spaces is further derived from the large palette of social and environmental, as well as transportation- and health-related benefits described above.

The occurrence of localised agglomeration economies following an increase in foot traffic also allows firms to benefit from being near each other and from access to a larger pool of consumers and workers. These dynamics can lead to higher business productivity, stimulate entrepreneurial activity and ultimately generate new job opportunities, particularly in labour-intensive sectors (Van den Berg et al., 2001; Rosenthal and Strange, 2004).

However, there are arguments against pedestrian streets as well. Agglomeration theories suggest that firm colocation may cause market crowding, increasing competition for consumers' disposable income. Excessive clustering can also lead to diseconomies of agglomeration, such as congestion and rising input prices (McCann and Folta, 2009). Lower-productivity firms may be forced to exit (Saito and Gopinath, 2009), reducing clustering benefits and leaving behind empty spaces that harm urban aesthetics. Moreover, car-borne consumers may have greater purchasing power (Nielsen, 1997), and restricting car access could thus reduce market reach and,

consequently, sales in the respective cluster. This is, however, a debated argument, as car-borne users are also argued to visit central areas less often (Nielsen, 1997; Kumar and Ross, 2006; Soni and Soni, 2016). Furthermore, market reach is not negatively affected by pedestrianisation as long as it is paired with improved public transport and non-motorised options such as bike lanes (Newby, 1993). At the same time, pedestrianisation projects can lead to rising commercial and residential property prices, while also contributing to shifts in both the retail composition and the social composition of the neighbourhood. This form of urban enhancement, sometimes referred to as 'aesthetic upgrading', may thus act as catalyst for urban change processes associated with both commercial and residential gentrification (Lees et al., 2008).

Pedestrianization and property prices: the law of supply and demand

If pedestrianisation is perceived as an amenity by both consumers and firms, as well as by residents, this would likely result in more firms and residents wanting to establish themselves near pedestrianised streets. This means that the attractiveness of the respective area increases and that the demand for space – both commercial and residential – at that location is expected to rise. Following the law of supply and demand, if pedestrianisation is seen as an amenity, increasing demand for both types of property, their prices are anticipated to rise, assuming that supply remains constant in areas with pedestrian spaces.

Alonso (1964) explains this relationship through his bid rent theory, which focuses on the trade-off between land costs and market accessibility. Accessibility is defined as the balance between firm density and travel distance; if travel distance remains the same, an increase in firm density enhances market accessibility. In a competitive land market, firms are willing to pay more for land with high accessibility (because of its prospective benefits), such as central business clusters, which drives up property prices in these areas. Thus, if pedestrianisation boosts market accessibility by increasing firm density, it can be seen as a factor contributing to the rise in property prices in these areas.

The demand for residential properties near pedestrian streets may also increase due to the potential for reducing consumer costs and maximising utility, as outlined in the

previous section. Mulligan (1983) links this spatial framework to neoclassical demand theory, suggesting that cost savings from being near concentrations of firms in retail, hospitality and service industries may be redirected towards housing consumption, impacting housing price elasticities in nearby areas with a variety of offerings (Daunfeldt et al., 2021). Additionally, Dunnett et al. (2002) argue that pedestrian streets, as urban functional open spaces, provide further benefits that are capitalised into housing prices, as many people are willing to pay more for properties near such spaces (Sherer, 2003). However, Yiu (2011) notes that, while amenities tend to capitalise in housing prices, there can sometimes be a time lag between the introduction of the amenity and the corresponding increase in housing prices.

Urban features can increase land and housing values if they are perceived as amenities but may decrease them if they are seen as nuisances (Rosen, 1974). Furthermore, the same urban feature, such as pedestrian streets, can be viewed as either an amenity or a nuisance depending on the target group. For example, the loss of car accessibility could incur additional costs for some customers. A reduction in the number of car-borne consumers may lower demand for local stores (e.g. Nielsen, 1997). Furthermore, competition may cause smaller, lower-productivity firms to relocate. The relationship between pedestrianisation and property prices may also evolve over time if the perceptions of the attractiveness of the respective area shift.

So, are pedestrian areas truly perceived as amenities by firms and residents? Do they make the urban space more attractive? These are important questions, especially since implementing pedestrian schemes can be costly (Judge, 2013). Previous research has sought to answer these questions but has yet to provide conclusive, robust evidence.

Previous research

In line with this theoretical argument, if pedestrian streets are perceived as amenities, this will be reflected in property prices (Nilsson, 2013). Most previous studies have, however, ignored this relationship and focused on the impact of pedestrianisation on consumer flows and firm performance (e.g. Yiu, 2011). Hass-Klau (1993; 2015), for example, makes a case for increased pedestrian flows in pedestrianised areas. Soni and Soni (2016) also argue that the benefits of pedestrianisation contribute to increased

foot traffic and, consequently, to a larger consumer base for firms in these areas. This may boost sales and employment and reduce vacancy rates. Several studies have reported positive effects on firm revenue (e.g. Roberts, 1990; Robertson, 1994). The OECD (1978) analysed 100 cities with pedestrian streets and reported that 49 per cent of them saw an increase in retail revenues (Lee, 2004). In line with these arguments, firm owners generally expect immediate positive impacts from pedestrian schemes (Norrman, 2002). However, reports from cities with pedestrianisation schemes show that, while some pedestrianised areas have seen an increase in retail activity, others have shown no change (Parajuli and Pojani, 2018). The argument is that new pedestrian consumers and car-borne consumers shifting to other markets counterbalance each other (Parkhurst, 2003). A decrease in car access leads to a loss of the car-borne consumer base, who often make larger purchases. On the other hand, some studies suggest that, while car-borne consumers may spend more, they visit central urban areas less frequently than non-car consumers do (e.g. Nielsen, 1997). Furthermore, impacts may differ by industry sector, with firms in hospitality typically seeing delayed effects compared with retail firms (Hass-Klau, 1993; Crawford, 2000).

Few studies have explored the direction and magnitude of the effects of pedestrianization on property prices in depth. Soni and Soni (2016) conducted a meta-analysis of previous studies and discuss the positive relationships between pedestrian and customer flows, retail revenues, municipal income and occupancy rates. They also identify a link between pedestrianisation and rising land values, property tax assessments and rents. Arslani et al. (2017) study the impact of pedestrianisation on the revitalisation of a declining neighbourhood in Istanbul's old city centre. Their analysis revealed that, after a pedestrian street was implemented, pedestrian flows and trade volumes increased, historic buildings were restored more quickly and crime rates decreased. They reported that real estate values tripled from 1986 to 2005, becoming the highest in Istanbul, which they attributed to intensified domestic and foreign investment. This led to the conversion of old manufacturing and storage spaces into banks, hotels, restaurants and cultural venues. Ashour and Al-Shamali (2020) also argue that a pedestrian-friendly environment may trigger a positive feedback loop, starting with increased foot traffic that leads to higher sales for firms, more private sector investment (evidenced by the entry of new firms), occupancy rates and demand for space, resulting in higher property prices (Judge, 2013). Cömertler (2007)

goes a step further by using hedonic regression on 140 observations from the Forbes Pedestrian Way in Izmir, Turkey. He concludes that proximity to pedestrian streets is an important contributor to increased property prices. This hypothesis is also supported by Hass-Klau (1993), Chau et al. (2000), Kumar and Ross (2006), Jeong and Kim (2007), Pivo and Fisher (2011) and Hon-Yip (2014).

Collectively, these studies suggest that pedestrianisation can be a powerful tool for urban revitalisation, with significant implications for real estate markets. However, they lack robust statistical evidence in linking pedestrianisation to property prices. One study argues that the impact can be 'intuitively felt and observed unsystematically' (Cömertler, 2007). Other studies rely on surveys, interviews, isolated cases or cross-sectional analysis (e.g. Parajuli and Pojani, 2018; Ashour and Al-Shamali, 2020), which raises concerns about their internal and external validity. Surveys and cross-sectional studies offer an illustrative snapshot of the analysed areas but are mostly descriptive, lacking causal inference. Before/after and longitudinal studies fail to control for spatial or temporal heterogeneity, making it unclear whether trends result from pedestrian schemes or other phenomena and economic trends (Yiu, 2011). Some studies are based on weak designs. Yiu (2011) compares pre- (1999–2000) and post- (2008–2009) pedestrianisation periods in a panel regression with space and time fixed effects, finding a 17 per cent rise in retail rental values. However, using a very small treatment area and a control area that is very close to the treatment, while assuming no spillover effects, potentially biased estimates and limits their generalisability. Furthermore, Swedish research is scarce and relies on non-academic reports with low external validity. For example, a report based on before/after surveys revealed that pedestrianisation in the Lycksele municipality did not increase city centre attractive ness, accessibility, social interactions or local shopping. Store owners noted possible accessibility and customer flow improvements but no significant changes in retail sales (Lycksele Kommun, 2018).

Data and model identification

Data

In this study, I aim to investigate the effects of pedestrian streets on the attractiveness of urban spaces. To assess the impact of pedestrian streets on urban attractiveness, I

use national data from the Swedish Transport Administration to measure the length of pedestrianised street segments[3] across the country. The total pedestrian street length is aggregated yearly for 250 × 250-metre grids, as defined by Statistics Sweden. Adding new pedestrian street segments increases the total length in a grid, whereas reopening streets to motorised traffic reduces it. The analysis includes the 50 largest urban settlements in Sweden, defined as areas with over 25,000 inhabitants and a population density exceeding 300 inhabitants per square kilometre (ESPON, 2014). This nationwide approach offers a methodological advantage over previous case-based studies that lack generalisability and exhibit low external validity (e.g. Cömertler, 2007; Arslani et al., 2017). The study covers the period from 2011 to 2019, based on data availability from the Swedish Transport Administration. Figure 1 provides an example of changes in pedestrian street length in the city of Helsingborg between 2011 and 2019.

Figure 1: Pedestrian streets in Helsingborg, 2011 (solid line) and 2012–2019 additions (dotted line)

[3] I focus on traditional pedestrian streets, that is, road segments fully closed to motorised traffic.

I link this information with a national database of all single-family houses sold between 2011 and 2019 from the Swedish Mapping, Cadastral, and Land Registration Authority and with a national database of all commercial properties sold in Sweden during the same period from Datscha, a consultancy firm specialising in real estate market analysis. I use property prices as a proxy for place attractiveness, as both firms and individuals are willing to pay a premium to operate or live in desirable locations (Glaeser et al., 2001), and amenities (or disamenities) are considered to explain most of the variation in real estate prices across cities and over time (Rosen, 1974). Previous research further indicates that the effects of amenities are capitalised in property prices far more significantly than in, for example, wage levels (Nilsson, 2013). The attractiveness differs between residential and commercial contexts because in a residential context it is the residents that drive up real estate prices by increasing their demand in areas that have become more attractive. In a residential context it is the firms that drive up real estate prices or rents by increasing their demand for space in the respective areas. This difference arises because the factors that attract residents – such as quality of life, amenities and safety – are not always the same as those that attract firms, which may prioritise foot traffic or proximity to complementary businesses.

Identification strategy

To examine the relationship between access to pedestrian streets and place attractive ness, measured by real estate property prices, I use changes in pedestrian street length as a quasi-natural experiment, combined with a difference-in-differences within estimation (Card and Krueger, 1994). This approach involves comparing the property prices in areas that experienced changes in the length of the pedestrian street with the property prices in the same areas before the treatment (i.e. the change in the length of the pedestrian street) and with the property prices in a set of control areas.

Real estate prices are affected by significant heterogeneity owing to varying city level economic conditions (Pope and Pope, 2015), making it difficult to find a suitable control group. To address this challenge, I first limit the sample to properties within cities that experienced changes in pedestrian street length between 2011 and 2019. I then follow Pope and Pope (2015) and divide the sample into a treatment group (properties within 2km of streets with length changes) and a control group (proper ties

2–10km away). To account for local property market dynamics, I then perform a within-estimation approach.

Another empirical challenge of this method is that changes in pedestrian street length are not random. Decision makers often choose to increase pedestrian street length as a regeneration method in inner-city areas experiencing economic downfall (e.g. Wooller et al., 2012; Soni and Soni, 2016). Consequently, a direct comparison of property prices in the treatment areas (0–2km) to property prices in control areas (2–10km) is likely to yield biased estimates. Unbiased identification of the effects of such changes thus requires finding a control group of properties that are located in the control areas (2–10km) and are as similar as possible to properties in the treatment group (0–2km).

To identify appropriate control properties, I use coarsened exact matching (CEM), as outlined by Iacus et al. (2012) and Lindgren et al. (2022). Since I am not working with panel data, matching cannot be performed based on the dependent variable (price per square metre) before treatment but must rely on other property characteristics available in the database. For residential properties, I match units on the basis of factors such as building area, building age, annex area, property acreage, sales year and city. The CEM method generates a 1:1 match, ensuring equal numbers of treated and matched properties. Continuous variables are coarsened into ten equally sized bins, with a maximum allowed difference of 10 per cent within each bin. The matching process is further constrained to properties sold in the same year and city as the treated properties. For commercial properties, matching is based on the building area, property type and sales year.[4] The advantage of CEM lies in its ability to set a maximum imbalance threshold (Iacus et al., 2012). Moreover, CEM improves balance in one covariate without disrupting the balance of other covariates, a key advantage over methods such as propensity score matching, which might improve balance in one covariate but worsen it in another. Additionally, CEM reduces model dependence, making the findings more robust to different estimation methods and model specifications (Ho et al., 2007). Descriptive statistics for the price, price per square

[4] The difference in matching variables reflects differences in data availability and what is observable and meaningful for each property type. Matching variables were selected to achieve optimal balance while minimising observation loss, in line with best practices in the field (e.g. Iacus et al., 2012).

metre and its logarithm, and distance to the closest pedestrian street for both residential and commercial properties in the treatment and control groups before and after treatment are presented in Table 1.

Table 1: Variable definitions and descriptive statistics pre- and post-treatment after the CEM matching.

		Mean		**Median**		**Mean**		**Median**	
		Treatment group		**Treatment group**		**Control group**		**Control group**	
Variable	**Variable definition**	**pre-tr**	**post-tr**	**pre-tr**	**post-tr**	**pre-tr**	**post-tr**	**pre-tr**	**post-tr**
Residential properties									
price	market price (tSEK)	3 493.21	3 826.68	3 000.00	3 450.00	3 023.63	3 191.40	2 600.00	2 860.00
	change pre/post	*+9.55%*		*+15.00%*		*+5.55%*		*+10.00%*	
price_sqm	market price per sqm (SEK)	25 666.84	27 827.92	22 243.59	25 204.93	22 980.06	25 396.07	20 000.00	22 184.26
	change pre/post		*+8.42%*		*+13.31%*		*+10.51%*		*+10.92%*
ln *price_sqm*	market price per sqm (logarithm)	9.94	10.08	10.01	10.13	9.79	9.95	9.90	10.01
distance_km	distance to the closest pedestrian street (km)	1.22	1.18	1.29	1.24	4.50	4.76	3.89	4.11
Commercial properties									
price	market price (tSEK)	22 900.00	23 300.00	6 126.50	7 058.00	23 600.00	10 600.00	5 900.00	4 500.00
	change pre/post	*+1.75%*		*+15.20%*		*-55.08%*		*-23.73%*	
price_sqm	market price per sqm (SEK)	13 848.30	12 239.69	3 712.44	3 889.91	6 390.34	3 822.44	2 066.24	1 623.75
	change pre/post	*-11.62%*		*+4.78%*		*-40.18%*		*-21.45%*	
ln *price_sqm*	market price per sqm (logarithm)	8.18	8.17	8.22	8.27	7.61	7.34	7.63	7.39
distance_km	distance to the closest pedestrian street (km)	0.96	0.87	0.94	0.81	4.72	4.84	4.13	4.29

The descriptive statistics show that residential properties in the treatment group, sold before the treatment, had an average market price per square metre of SEK 25,667 (EUR 2,243), compared with SEK 27,828 (EUR 2,432) for those sold after the treatment, reflecting an increase of 8.42 per cent. In contrast, the control group showed a 10.51 per cent increase in the average price per square metre from before to after the treatment. The average distance from the treated properties to the nearest pedestrian street decreased slightly, from 1.22km before to 1.18km after treatment. For

commercial properties, the average price per square metre decreased post-treatment, with a much greater decrease in the control group (−40.18 per cent) than in the treatment group (−11.62 per cent). The key question is how much of these pre- and post-treatment changes can be attributed to the treatment rather than to other factors, such as economic trends. This will be addressed using a difference-in-differences regression model, as described in the next section.

A difference-in-differences empirical model

I estimate a difference-in-differences model that uses both cross-sectional and temporal variation in the data to identify the impact of changes in pedestrian street length on real estate prices in the treatment area (0–2km). To correct for possible differences in property characteristics between the treatment and control groups, I first estimate the price per square metre ($price\_sqm$) for all properties as a function of their structural characteristics available in the database, using a vector of variables X_i. For residential properties, X_i includes the building area, annex area, and property acreage (in square metres), as well as the building's age (in years). I also include squared terms for these variables to account for non-linearities in the relationship with price. For commercial properties, X_i includes the building area, property acreage, and their squared terms.

$$\ln price\_sqm_i = \beta_0 + \beta_1 \times X_i + \beta_1 \times X_i^2 + \varepsilon_i. \quad (1)$$

I save the residuals from this estimation, $\ln price\_sqm\_adj_{i,c,t}$ (the logarithm of property price per square metre, adjusted for structural characteristics), to use as the outcome variable. The key assumption in a difference-in-differences model is that the treatment and control properties would have had parallel post-treatment trends in the outcome variable (adjusted price per square metre) in the absence of treatment. As explained by Pope and Pope (2015), this implies that the trends in property prices near (0–2km) and further (2–10km) from the treatment area would have been parallel in the absence of treatment. Since this condition cannot be observed, the standard approach is to check that the pre-treatment trends in $\ln price\_sqm\_adj_{i,c,t}$ are parallel for properties in the treatment and control groups and assume that they would continue to be parallel if no treatment had occurred. Figure 2a shows the trends for

residential properties, indicating nonparallel trends pre-treatment (year 0) without CEM but parallel trends when we use CEM to find control properties. T-tests confirm that the null hypothesis of equal means between the treatment and control groups for residential properties cannot be rejected pre-treatment (p value = 0.623) but is rejected post-treatment (p value = 0.000). In terms of commercial properties (Figure 2b), the pre-treatment trend of the CEM showed less improvement. T-tests show that the null hypothesis of equal means can be rejected both pre- and post-treatment, suggesting that caution should be taken when commercial property results are interpreted.

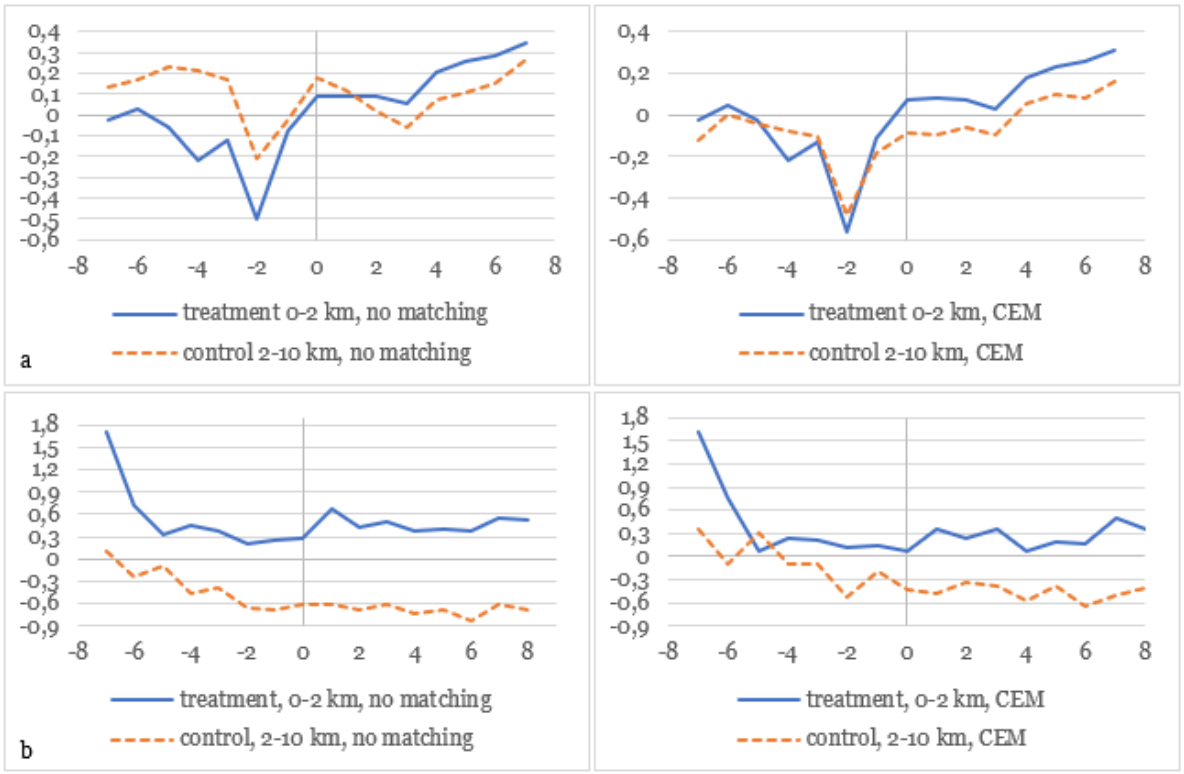

Figure 2: Trends in residential (a) and commercial (b) property prices in the treatment and control group in the absence of CEM (left) and after using CEM (right).

The classical approach in a difference-in-differences model defines treatment using an indicator variable equal to 1 after the treatment in the treatment area and 0 before the treatment in the treatment area, as well as throughout the analysis period in the control area. To account for the fact that the impact of pedestrianisation depends on the size of the change in the length of the pedestrian street, the direction of the change

(positive or negative) and distance to the nearest pedestrian street, I adjust the classical model as follows:

$$\ln price\_sqm\_adj_{i,c,t} = \beta_0 + (\beta_{0\_0.5} \times tr_{0\_0.5} + \beta_{0.5\_1} \times tr_{0.5\_1} + \beta_{1\_1.5} \times tr_{1\_1.5} + \beta_{1.5\_2} \times tr_{1.5\_2}) + \delta_t + \gamma_c + (\delta_t \times \gamma_c) + \varepsilon_{i,c,t}, \quad (2)$$

where $price\_sqm\_adj_{i,c,t}$ is the adjusted market price per square metre for residential or commercial property i located in city c and sold during year t. To further adjust for time-variant heterogeneity given by, for example, nationwide trends in property prices, I include a year-specific fixed effect, δ_t; to control for any city-specific time invariant heterogeneity, I include a city-specific fixed effect, γ_c.[5] I further include the interaction $(\delta_t \times \gamma_c)$, which is a city-year specific fixed effect, to adjust for potential city-year specific shocks to the local real estate market, including city-specific inflation and other secular trends.[6]

The estimated coefficients $\beta_{0\_0.5}$, $\beta_{0.5\_1}$, $\beta_{1\_1.5}$, and $\beta_{1.5\_2}$ indicate the direction and magnitude of the change in the outcome variable $\ln price\_sqm\_adj_{i,c,t}$ due to a change in pedestrian street length for properties within 0–0.5km, 0.5–1km, 1–1.5km and 1.5–2km from the nearest pedestrian street and holding all other variables, including fixed effects, constant. The log transformation of property prices makes the parameter estimates interpretable in percentage terms. The distance from each property to the nearest pedestrian street is calculated using a Euclidean distance measure in ArcGIS. This allows testing for geographical heterogeneity. Arslani et al. (2017) suggest that such heterogeneity may stem from 'Brownian motion', where effects spill over to

[5] This approach follows standard practice in applied econometrics, where fixed effects are included at the most granular level possible given the data and computational feasibility (Angrist and Pischke, 2009). When fine grained unit-level fixed effects are unavailable, researchers often adopt fixed effects at a higher aggregation level, such as neighbourhoods or cities, to absorb unobserved locational heterogeneity.

[6] In the absence of detailed data on other potential time-varying confounders, such as transport enhancements and other similar interventions, the study addresses confounding through city-level fixed effects and pre-intervention matching. These strategies control for time-invariant heterogeneity and enhance internal validity, although they do not fully account for unobserved time-varying shocks.

adjacent areas and further neighbours. The equation includes a constant term β_0 and a random error term assumed to have zero mean and constant variance ($\varepsilon_{i,c,t}$).[7]

This model specification does not, however, allow me to identify the magnitude of impact for different directions (positive or negative) and intensities of the changes in the length of the pedestrian street. To consider these situations, I redefine the model as follows:

$$\ln price\_sqm\_adj_{i,c,t} = \beta_0 + (\beta_{0\_0.5} \times tr'_{0\_0.5} + \beta_{0.5\_1} \times tr'_{0.5\_1} + \beta_{1\_1.5} \times tr'_{1\_1.5} + \beta_{1.5\_2} \times tr'_{1.5\_2}) + \delta_t + \gamma_c + (\delta_t \times \gamma_c) + \varepsilon_{i,c,t}, \quad (3)$$

where $tr' = length_{g,t} - length_{g,t-1}$ represents the absolute change in the length of pedestrian streets in every grid, yearly, measured in metres. A criticism of this approach is that some changes may be small but significant relative to the previous length of pedestrian streets in the grid, whereas others may be large but insignificant in that context. To capture the relationship between the actual change and the previous length of pedestrian streets in each grid, I adjust the model to define the treatment as the relative change (i.e. the percentage change between year *t* and year *t–1*) rather than an absolute change:

$$\ln price\_sqm\_adj_{i,c,t} = \beta_0 + (\beta_{0\_0.5} \times tr''_{0\_0.5} + \beta_{0.5\_1} \times tr''_{0.5\_1} + \beta_{1\_1.5} \times tr''_{1\_1.5} + \beta_{1.5\_2} \times tr''_{1.5\_2}) + \delta_t + \gamma_c + (\delta_t \times \gamma_c) + \varepsilon_{i,c,t},$$

and

$$tr'' = \left(\frac{length_{g,t}}{length_{g,t-1}}\right) * 100 - 100. \quad (4)$$

To capture the effects of positive and negative changes in the length of the pedestrian street, I run the model in Equation (4) separately for positive and negative changes.

[7] To mitigate possible heteroskedasticity problems I estimate all the models using White (1980) heteroskedasticity robust standard errors. I also check the correlations between the independent variables by investigating their variance inflation factors, which are well below the commonly used rule of thumb of 10 (Kutner et al., 2004). As such, I do not consider multicollinearity to be an issue in these estimations.

Effects of pedestrianization on urban attractiveness

The estimated impacts of pedestrianisation on the market prices of the residential properties in the treatment area (i.e. 0–2km from the closest pedestrian street) are presented in Table 2.

Table 2: Estimated impact of pedestrianization on residential property prices

	positive & absolute change		**negative & absolute change**		**positive & relative change**		**negative & relative change**	
	coefficient (p-value)	***effect%***	**coefficient (p-value)**	***effect%***	**coefficient (p-value)**	***effect%***	**coefficient (p-value)**	***effect%***
0 – 0.5 km	0.003*** (0.000)	*0.277****	-0.003*** (0.000)	*-0.288****	0.002*** (0.000)	*0.174****	-0.002*** (0.004)	*-0.207****
0.5 – 1 km	0.001*** (0.000)	*0.149****	-0.004*** (0.000)	*-0.382****	0.001*** (0.000)	*0.106****	-0.005*** (0.000)	*-0.510****
1 – 1.5 km	0.001*** (0.000)	*0.073****	-0.001*** (0.000)	*-0.127****	0.000*** (0.002)	*0.032****	-0.002*** (0.005)	*-0.192****
1.5 – 2 km	0.000 (0.735)	*0.007*	-0.002*** (0.001)	*-0.159****	0.000 (0.901)	*-0.002*	-0.002*** (0.005)	*-0.158****
No.obs.	57 767		51 953		57 767		51 953	
R-squared	0.412		0.414		0.412		0.414	

* Significant at the 10% level

** Significant at the 5% level

*** Significant at the 1% level

The results show an average increase of 2.77 per cent in the adjusted price per square metre for residential properties located 0–0.5km from the closest pedestrian street for every ten-metre increase in pedestrian street length. The effect diminishes with distance – +1.49 per cent for properties 0.5–1km away, +0.73 per cent for properties 1–1.5km away – and becomes insignificant for properties in the 1.5–2km range. When the treatment variable is measured in relative terms, the effects are slightly smaller but show a similar trend, with the largest impacts close to the pedestrian street and a distance decay: +1.74 per cent for every 10 per cent increase in pedestrian street length for properties in the 0–0.5km buffer, +1.06 per cent for the 0.5–1km buffer, +0.32 per cent for the 1–1.5km buffer and no significant effect at further distances.

The effects of negative changes in pedestrian street length are negative and stronger near the streets where changes occur. When measured in absolute terms, the effects decrease from −2.88 per cent in the adjusted price per square metre for residential properties located 0–0.5km from the pedestrian street and −3.82 per cent for proper ties 0.5–1km away to −1.27 per cent and −1.59 per cent in the 1–1.5km and 1.5–2km buffers, respectively. When measured in relative terms, the effects are −2.07 per cent and −5.10 per cent in the closest buffers and −1.92 per cent and −1.58 per cent in the 1–1.5km and 1.5–2km buffers, respectively. Figure 3 illustrates these estimated coeffi cients and 95 per cent confidence intervals.

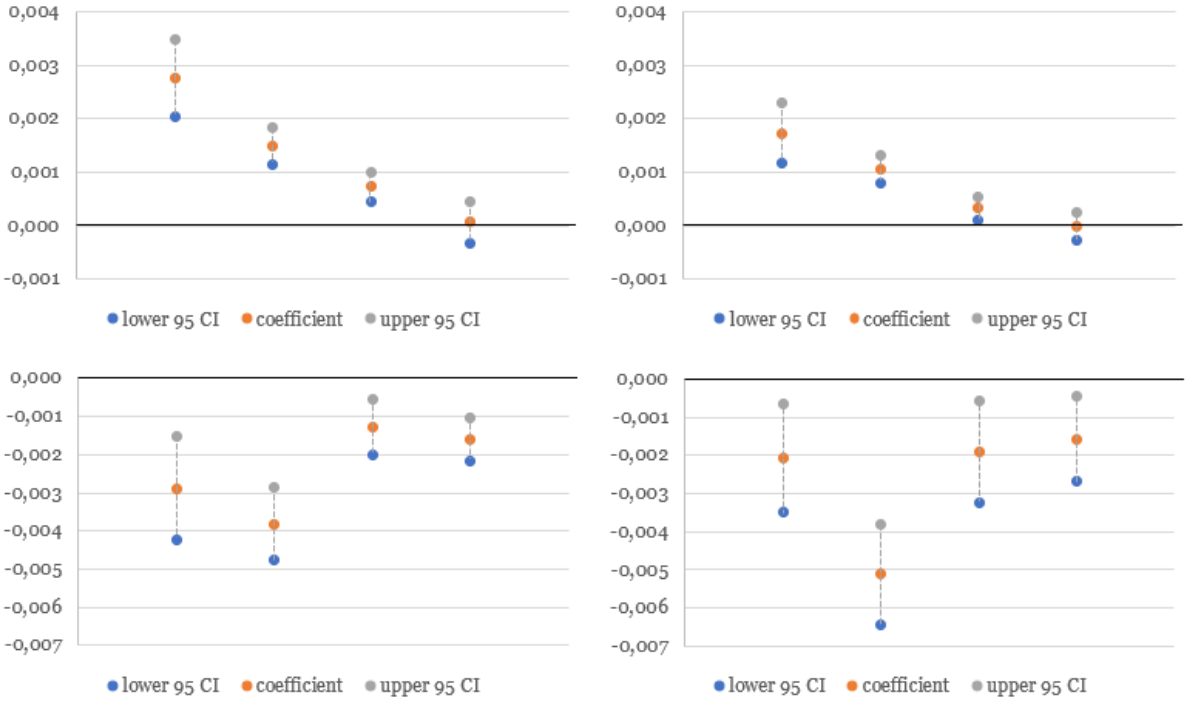

Figure 3: Effects of positive (upper row) and negative (lower row) changes in pedestrian street length on the market prices of residential properties, by distance from the closest pedestrian street – point estimates and 95% confidence interval (CI) for absolute (left) and relative (right) changes in the length of the pedestrian street.

Table 3 summarises the effects of pedestrianisation on the market prices of commercial properties in the treatment area (0–2km from the nearest pedestrian street).

Table 3: Estimated impact of pedestrianization on commercial property prices.

	positive & absolute change		negative & absolute change		positive & relative change		negative & relative change	
	coefficient (p-value)	***effect%***	**coefficient (p-value)**	***effect%***	**coefficient (p-value)**	***effect%***	**coefficient (p-value)**	***effect%***
0 – 0.5 km	0.010*** (0.000)	*0.975****	-0.008*** (0.000)	*-0.816****	0.006*** (0.000)	*0.627****	-0.024*** (0.000)	*-2.349****
0.5 – 1 km	0.007*** (0.000)	*0.661****	-0.007 (0.266)	*-0.650*	0.005*** (0.000)	*0.537****	-0.012 (0.138)	*-1.173*
1 – 1.5 km	-0.003** (0.046)	*-0.320***	-0.002 (0.551)	*-0.241*	-0.001 (0.598)	*-0.073*	0.002 (0.795)	*0.172*
1.5 – 2 km	-0.003* (0.076)	*-0.291**	0.011*** (0.002)	*1.142****	-0.002 (0.285)	*-0.150*	0.020** (0.017)	*2.046***
No.obs.	8 804		8 699		8 804		8 699	
R-squared	0.271		0.271		0.269		0.271	

* Significant at the 10% level

** Significant at the 5% level

*** Significant at the 1% level

The results show an average increase of 9.75 per cent in adjusted price per square metre for commercial properties 0–0.5km from the nearest pedestrian street for every ten-metre increase in pedestrian street length. The effect diminishes with distance – +6.61 per cent for properties 0.5–1km away – and becomes negative for properties further away: –3.20 per cent for properties in the 1–1.5km buffer and –2.91 per cent for those in the 1.5–2km buffer. The effects are slightly smaller when the treatment variable is measured in relative terms, showing the largest impacts close to the pedestrian street and a distance decay: +6.27 per cent for every 10 per cent increase in pedestrian street length for properties in the 0–0.5km buffer and +5.37 per cent for properties 0.5–1km away, with the effect becoming insignificant at longer distances.

The effects of negative changes in pedestrian street length are strongest near the streets where the changes take place: –8.16 per cent in adjusted price per square metre for commercial properties located 0–0.5km from the pedestrian street. The effect becomes insignificant further away and even positive for properties in the 1.5–2km buffer. A similar trend is observed when the treatment is measured in relative terms: –23.49 per cent in the closest buffer, insignificant further away and positive in the 1.5–

2km buffer.[8] Figure 4 illustrates the estimated coefficients for the effects on commercial property prices and the associated 95 per cent confidence intervals.

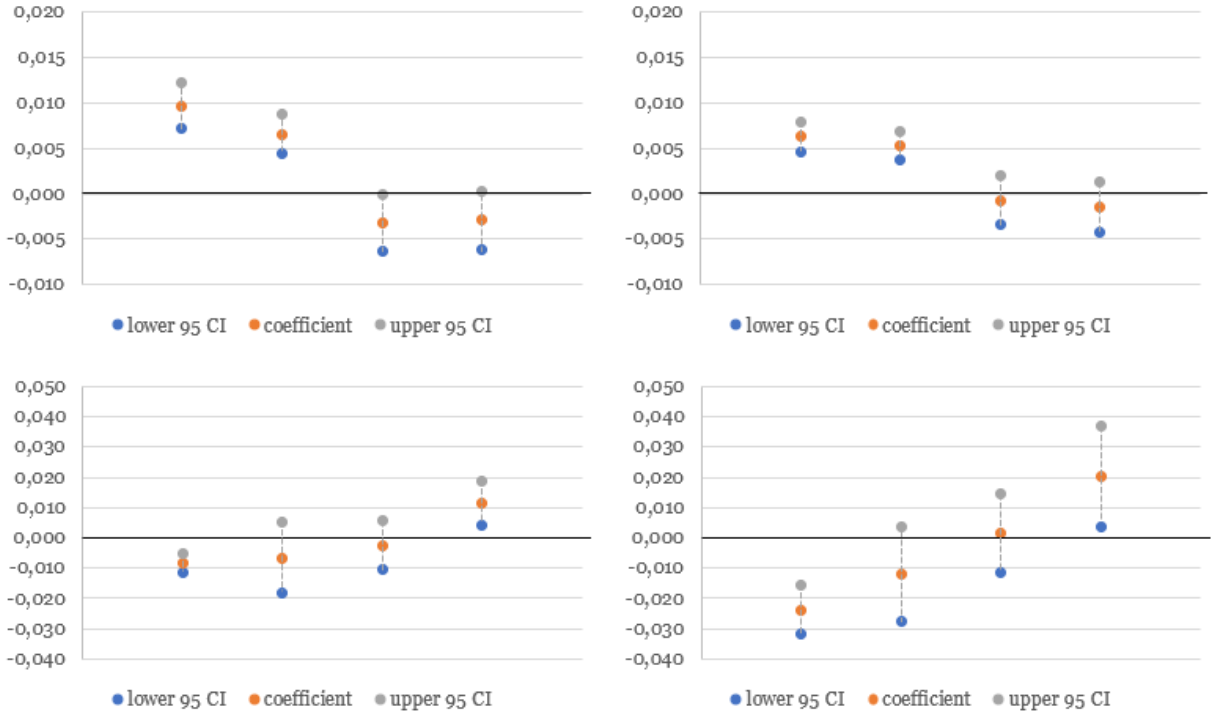

Figure 4: Effects of positive (upper row) and negative (lower row) changes in pedestrian street length on the market prices of commercial properties by distance from the closest pedestrian street, point estimates and 95% confidence interval (CI) for absolute (left) and relative (right) changes in the length of the pedestrian street.

Conclusions and discussion

Pedestrianisation has been widely used in Sweden for urban regeneration with the aim of 'reconquering' the city (Gehl and Gemzoe, 2000) by reclaiming urban space for pedestrians and balancing the marketplace, traffic and meeting areas. Pedestrianisation is believed to increase consumer flows, positively affecting store performance and the local economy (Dunnett et al., 2002; Litman, 2003). Business owners have high expectations, viewing pedestrian streets as 'no doubt the best thing that could happen to the city' (Norrman, 2002). Increased footfall (Özdemir and Selçuk, 2017) is expected because pedestrianisation is associated with reduced traffic congestion, road hazards, air pollution and noise (Timmermans and Van den

[8] For this buffer, the model is run on quite a small number of observations, so caution is recommended in reading the results.

Waerden, 1992; Soni and Soni, 2016), encourages alternative transport, such as cycling and walking, and enhances accessibility and mobility. However, pedestrianisation faces a great deal of criticism, particularly from retailers, who argue that car access is needed for consumer access to shops. Some also contend that car users have more purchasing power and travel from a broader area, thus expanding the local market. Additionally, pedestrianisation projects are considered expensive (Cömertler, 2007). In particular, during financially constrained times (Nicholls, 2002), it is crucial to express pedestrianisation benefits in monetary terms.

However, measuring these effects robustly has proven challenging. Previous research often relies on case studies of small areas (Yiu, 2011; Özdemir and Selçuk, 2017), and the few quantitative studies are descriptive or focus on the effects on retail and hospitality firms, social interactions or vacancy rates (Hass-Klau, 1993). While these studies offer valuable insights, their findings are difficult to generalise, and methodological limitations complicate the confirmation that the observed effects are due to pedestrianisation rather than other concurrent factors. This study contributes to the literature on urban planning and economic geography by using a robust quantitative approach to investigate how changes in pedestrian street length affect residential and commercial property prices in targeted areas. This approach addresses concerns related to both external and internal validity and provides results that are unbiased and consistent. I hypothesise that, if pedestrianisation is perceived as an amenity and thus the demand for space with pedestrian streets increases, the prices of real estate properties also increase.

The results show an average increase of 2.77 per cent in adjusted price per square metre for residential properties located 0–0.5km from the nearest pedestrian street for every ten-metre increase in street length. The effect exhibits distance decay, decreasing to +1.49 per cent for properties 0.5–1km away and +0.73 per cent for properties 1–1.5km away and becoming statistically insignificant for properties 1.5–2km away. For residential properties in the closest area (0–0.5km), this translates into an average increase of SEK 869 (EUR 76) in the pre-treatment square-metre price (SEK 31,360 or EUR 2,737) or SEK 106,830 (EUR 9,325) in the pre-treatment sales price (SEK 3,856,694 or EUR 336,653) for every ten-metre increase in pedestrian

street length. Similar but slightly smaller effects are observed when the treatment is measured in relative terms.

Negative changes in pedestrian street length lead to negative effects, which are stronger in close proximity to the streets where the changes take place: −2.88 per cent in adjusted price per square metre for residential properties 0–0.5km from the street, −3.82 per cent for properties 0.5–1km away and −1.27 per cent and −1.59 per cent for properties in the 1–1.5km and 1.5–2km buffers, respectively, for every ten-metre decrease. For properties 0–0.5km from the pedestrian street, this translates into an average decrease of SEK 903 (EUR 79) in the pre-treatment square-metre price or SEK 111,073 (EUR 9,696) in the pre-treatment sales price for every ten-metre decrease in street length.

The results show an average increase of 9.75 per cent in the adjusted price per square metre for commercial properties located 0–0.5km from the nearest pedestrian street for every ten-metre increase in pedestrian street length. The effect decreases with distance – +6.61 per cent for properties 0.5–1km away – and becomes negative for properties further away (−3.20 per cent for properties in the 1–1.5km buffer and −2.91 per cent for those in the 1.5–2km buffer). This translates into an average increase of SEK 980 (EUR 86) in the pre-treatment square-metre price (SEK 10,051 or EUR 877) or SEK 2,301,000 (EUR 200,831) in the pre-treatment sales price (SEK 23,600,000 or EUR 2,059,804) for properties within 0.5km of pedestrian streets for every ten-metre addition in street length.

This pattern suggests a spatial redistribution of commercial attractiveness following the introduction of pedestrian streets. While areas immediately adjacent to these zones benefit from increased appeal – likely due to improved accessibility, foot traffic and urban ambiance – areas located slightly further away, particularly beyond a 1km radius, may experience a relative decline. This indicates that the positive effects of pedestrianisation on commercial property values are highly localised, reinforcing the notion that such interventions can concentrate economic activity in close proximity to the pedestrian core, potentially at the expense of surrounding areas.

Negative changes in pedestrian street length lead to negative effects, which are strongest (−8.16 per cent) in close proximity to streets with changes in pedestrian street length (0–0.5km) but insignificant for properties further away. The effect is greater in percentage terms for commercial properties than for residential properties, suggesting that colocation may be particularly important for firms benefiting from agglomeration economies. The negative effect on commercial properties translates to a decrease of SEK 820 (EUR 72) in the pre-treatment square-metre price or SEK 1,925,760 (EUR 168,080) in the pre-treatment sales price for properties within 0.5km of pedestrian streets for every ten-metre decrease in street length. However, the results for commercial properties should be interpreted with caution, as pre-treatment trends are not fully parallel between the treatment and control groups, even after CEM is used to select the controls. Additionally, for grids with negative changes and commercial properties located 1.5–2km away, the model is based on few observations, warranting further caution.

The dynamics of property prices in an urban context is relevant as property prices are a reflection of urban amenities and disamenities. Both amenities and disamenities are capitalised in property prices (Kuethe and Keeney, 2012). This makes property prices a useful proxy for determining whether pedestrianisation is an amenity or disamenity. The positive effect of increased pedestrian street length on property prices suggests that pedestrianisation is perceived as an amenity by both residents and consumers (and thus firms), as higher property prices indicate increased demand for space in these areas, assuming that supply remains constant. Attractive places attract further investment and fast economic growth, potentially transforming them into central markets and shifting the power away from external urban cores and digital spaces. Planning tools that increase the attractiveness of city centres can thus help cities compete with external shopping centres and online retail services, offering a potential solution to urban sprawl. According to Gehl and Gemzoe (2000), this reflects the latest stage of city transformation: the ‘reconquered city’.

This study provides valuable insights for city officials and developers working to create vibrant city centres. However, the increase in commercial property prices due to pedestrianisation should be interpreted with caution, since ownership of the premises may not always be held by the shopkeeper. The rising popularity of and sales in

pedestrianised areas allow shop owners to charge higher rents but this can displace low-productive firms unable to afford the rent, a phenomenon known as commercial gentrification (Rankin, 2008; Hon-Yip, 2014). Mihaescu et al. (2023) note that commercial gentrification is evident in the shrinking number of small independent stores, replaced by larger chain stores, particularly in Sweden's largest cities over the last decade. This process can lead to residential gentrification and threaten social sustainability in inner cities (Parajuli and Pojani, 2018). Thus, the displacement of firms due to rising rents in pedestrianised areas should be closely monitored to prevent undesirable consequences (Özdemir and Selçuk, 2017).

Further research could focus on better understanding how pedestrianisation and similar urban regeneration efforts drive commercial and residential gentrification, as well as their potential consequences and management strategies. This approach fits into the broader discussion on implementing successful pedestrianisation schemes, which also require measures such as managing public parking, ensuring public trans port access, an adequate demarcation of spaces for loading and unloading, improved cleaning, security and maintenance of the public spaces, and finding a solution to the various parking and traffic problems that surround and occasionally intrude upon the pedestrianised areas (Sastre et al., 2013; Özdemir and Selçuk, 2017; Parajuli and Pojani, 2018). Future studies should also consider alternatives to traditional pedestrian streets, such as mixed-use pedestrian streets (allowing limited motorised traffic) and transit pedestrian streets (allowing public transit). These alternatives may be more effective in boosting pedestrian traffic and economic viability, offering better access and consumer choice without fostering negative side effects such as gentrification (Ashour and Al-Shamali, 2020).

Acknowledgements

Research funding from Hakon Swenson Research Foundation (Hakon Swenson Stiftelsen, grant number 2020005) is gratefully acknowledged. I would also like to thank participants at the Nordic Retail and Wholesale Conference (9–11 November 2021), the European Regional Science Association 60th Congress (24–27 August 2021), and Södertörn University Higher Seminars in Economics (21 April 2021) for their helpful comments. I am also grateful to the Swedish

Association of Town Centres (Svenska Stadskärnor) for their support with the project. Many thanks also to Helena Nilsson for aggregating annual pedestrian street lengths from the Swedish Transport Administration for the 250 × 250-metre grid cells.

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