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Critical mass matters: The long-term benefits of retail agglomeration for establishment survival in downtown Detroit and The Hague

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Abstract
This paper explores the long-term sensitivity of street-level retailers to agglomeration to corroborate its theorised benefits under current economic modelling. It does so by studying the annualised chance of closure of retailers as a function of the number of surrounding retailers, as well as how different types of retailers respond differently to agglomeration. A time fixed effect model is used to study the mortality rate of retailers over the period of a century. The study draws from a self-created database of retail establishment locations and types in Detroit, Michigan and The Hague, Netherlands between 1911 and 2011. The case study cities have been selected for their combination of similarities and differences. While downtown Detroit is infamous for its high vacancy and The Hague has been praised as a vibrant Dutch urban core, both cities have in fact suffered significant loss of retail activity over the past century, allowing for the study of retail closure under different socio-economic and cultural circumstances. The study demonstrates a significant sensitivity of retailers to agglomeration in both cities. The study also indicates a specifically high sensitivity to agglomeration in the case of comparison shops. Without a critical mass of peers, these retailers will face a significantly higher than average chance of closure. The sensitivity to agglomeration is remarkably similar between both case studies, urban cores which at first sight have experienced rather different fates over the past century. This cross-cultural similarity may point to a generalisability of the underlying mechanism of sensitivity to agglomeration.

Keywords
critical mass, downtown, public space, retail agglomeration, urban transformation

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Introduction

According to multiple economic theories, retailers benefit from agglomeration in their sustained success. If a retailer is surrounded by peers and compatible other land uses, it is assumed to have a higher success rate. This effect has yet to be proven over a sustained period of time with a detailed data set. This paper presents a self-assembled retail location data set at the level of the single street-level firm spanning one century in two cities, to explore the effects of micro-scale retail agglomeration on the long-term viability of retail clusters. Over the span of a century, have retailers benefited from being surrounded by other retailers in their survival rate? And do certain types of retailers benefit from being surrounded by other retailers more than others? By correlating retail closures to the number of surrounding stores within a 50 m radius, this research demonstrates a significant sensitivity of retail mortality to agglomeration. While there is a different level of sensitivity between different retail types, the data set is too small to prove statistical significance by type.

The paper studies the spatial effects of single-agent retail decision making. The outcomes of this study may hence be pertinent for retention and improvement strategies in settings where centralised acquisition, ownership and management are often impossible, such as historic cores. Theories or models of retail success at this detailed level are relatively rare. Instead, most retail theories describe the functioning of retailers at the urban or regional scale, focusing on inter-cluster hierarchy of merchandise offer in a wider context (Christaller, 1933; Lösch, 1940). At a lower scale, the hierarchical power of agglomeration is dissected in more detail (Brown, 1992, 1994; McLafferty and Ghosh, 1986). In general, retailers are assumed to benefit from agglomeration by compatible peers as they can maximise their potential market share by minimising the locational differentiation toward customers (Hotelling, 1929; Nelson, 1958). Retailers engage in a double-edged process in which they simultaneously compete with the peers while at the same time benefiting from their colocation in terms of the range and diversity of products on offer (Brandenburger and Nalebuff, 2011; Teller, 2008). In turn, consumers prefer agglomerated retailers to minimise their effort to compare and purchase goods, benefiting larger retail centres (Brown, 1987b, 1989; Christaller, 1933; Lösch, 1940; Reimers and Clulow, 2004). In his 'theory of cumulative attraction', Nelson (1958) describes how retailers benefit most from a continuous cluster of compatible peers. Non-retail land uses, vacant lots and incompatible stores can disrupt this continuity, harming the viability of surrounding retailers (Miller et al., 1999; Oppewal and Holyoake, 2004). Also, the scattering of retailers will increase walking distances and decrease the convenience of a retail centre for consumers – again harming its overall viability (Reimers and Clulow, 2004). Retailers' need for agglomeration is balanced with their ability to afford central locations, resulting in a downtown pattern of both agglomeration and dispersal into clusters, ribbons and specialty areas (Brown, 1987a; Davies, 1972; Davies and Bennison, 1978).

Yet the availability of a controlled agglomeration format has also driven many retailers to shopping malls and strips outside of the urban core (Guy, 1994; Teller, 2008). Over the previous decades, retailers have increasingly withdrawn from central streets in many Western cities to decentralised shopping facilities because of the suburbanisation of wealth, the growth of motorised transportation, and perceived and actual social issues in urban cores, especially in the USA (Davis, 1966; Fogelson, 2001; Lesger, 2013; Psarra et al., 2013). Furthermore, the retail market as a whole has consolidated from independent outlets into chains of fewer, larger establishments to benefit from economies of scale, especially in the food sector (Davis, 1966; Longstreth, 2000, 2010; Nijs and Knoester, 2007; Rutte, 1998; Smith and Hay, 2005; Wrigley and Lowe, 2014). Even the hegemony of larger stores is no longer guaranteed (Howard, 2015; Vastgoedmarkt, 2016). As retail chains control a larger portion of the consumer market, their decision to retreat from an underperforming market or retire underperforming branches can be swift, and can have strong ramifications for the retail landscape of a city or region – not to mention the impact of the increasing number of complete chain failures (Birkin et al., 2002; Hernández and Bennison, 2000; Mendes and Themido, 2004). Online shopping will likely exacerbate this pattern, although multi-channel retailing may mitigate this trend (Chan and Pollard, 2003; Schoenbachler and Gordon, 2002). As a result of these forces and trends, the street-level retailer is under threat in urban cores across the Atlantic (Birkin et al., 2002; Fogelson, 2001; Nozeman and Post, 2012; Portas, 2011) and a number of governments have taken initiatives to retain or lure back street-level retailers to their centres (Coleman, 2006; Evers et al., 2011; Frieden and Sagalyn, 1989).

Yet those who aim to turn the tide suffer from a lack of substantiation and understanding of the effects of single-agent retailer decision makings on the success of surrounding establishments. While theorists have stated that the right kind of agglomeration will improve the success of its independent parts, there is hardly any empirical evidence to corroborate these theories, and to prove to what extent and with which amplitude they are valid. Qualitative diachronic studies corroborate the benefits of agglomeration (Duren, 1995; Lesger, 2013), but quantitative diachronic studies to find the benefit of micro-scale agglomeration to retail success are rare, and absent over longer periods of time. This absence can be explained by the difficulty of assembling diachronic data sets with a sufficient level of detail to demonstrate the benefits of agglomeration, which requires the geographical location of each establishment for all time intervals. In lieu of this detail, studies have thus far mostly relied on aggregated data, making the empirical corroboration of commonly accepted theories of retail agglomeration a rather tenuous matter at the scale of a single retail cluster over a longer period of time (Brown, 1987a). The empirical corroboration of the theorised benefits of agglomeration are therefore few and far between, a knowledge gap that this paper aims to fill.

Case studies

This study explores the benefits of retail agglomeration at the scale of the single cluster in two case study areas: the greater urban core of Detroit, Michigan and The Hague, Netherlands. These cores are purposely broadly defined to study the effects of downtown change in the fringe, often among the city's most dynamic areas (City Plan Commission of Detroit, 1957; Conzen, 2009; Murphy, 2007; Murphy and Vance, 1954; Whitehand, 1988). The case study sites both comprise a commercial 'core' area which covers roughly 20% of the urban centre, containing most of the economic activities including ground floor retail, surrounded by 80% 'frame' accommodating more marginal business activity mixed with a large amount of non-retail land uses. Furthermore, these areas were often covered by urban renewal projects since the 1940s.[1] The maps demarcating both case study areas are provided in Figure 1. Reflecting its larger metropolitan hinterland, Detroit's greater downtown is much larger at 1510 acres than The Hague's inner city at 570 acres, but they contain a

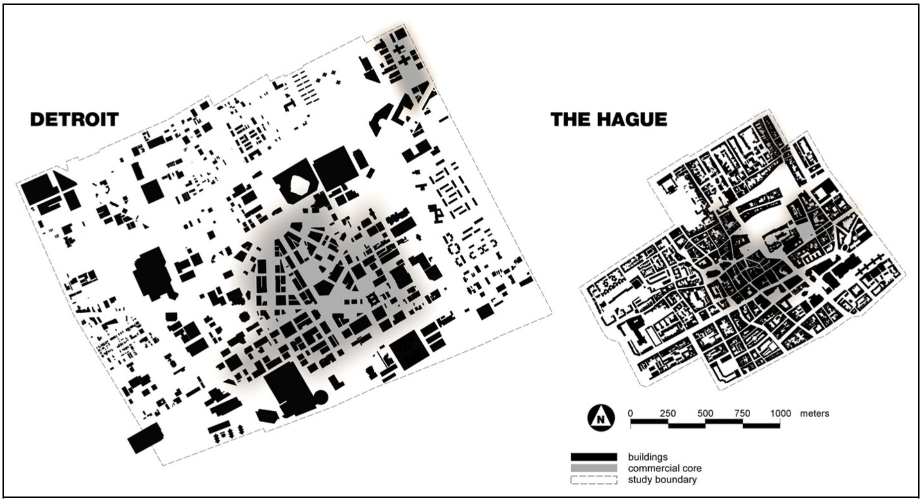

Figure 1. Core, frame and urban renewal projects in Detroit (left) and The Hague (right).

similar internal ratio between core and frame.

The two case studies have a deliberate combination of similarities and differences. While Detroit's struggling downtown and The Hague's award-winning inner city[2] have seemingly followed very different paths, the choice for these rather different urban cores may lead to generalisability of research results in case they match between their radically different socio-economic, political and cultural contexts. That said, both cores in fact share similarities as well – both have lost a large amount of street-level retail activity – between 1911 and 2011, The Hague has lost 52% of its inner city street-level retailers, compared with 90% in Detroit. The difference in amplitude of loss has specifically grown in the post-war era, as The Hague's inner city was bolstered by continued investment while downtown Detroit suffered from suburbanisation and inner city socio-economic decline. Furthermore, in both cities the downtown population declined significantly over the past century, while in Detroit the downtown working population has declined significantly during the post-war era. Retail establishments in both cities declined more if they were located far away from their centre of retail activity (known as the A1 location in the Netherlands and the 100% Corner in the USA), as many of these peripheral stores served the daily needs of a declining downtown population base. Furthermore, establishments on poorly connected streets were also more prone to closure, resulting in a contraction of stores toward central, well-connected streets in both cities. After 1961, this pattern of concentration and optimisation continued in The Hague, while Detroit's retail core almost completely failed because of the socio-economic decline the city was facing. Retailers left the downtown almost regardless of their location, leaving an almost random scattering of retailers (Kickert, 2016) (Figure 2).

Data collection

The benefits of retail agglomeration are defined by the sensitivity of retail mortality (the closure of an establishment) to the number of surrounding retailers of various types

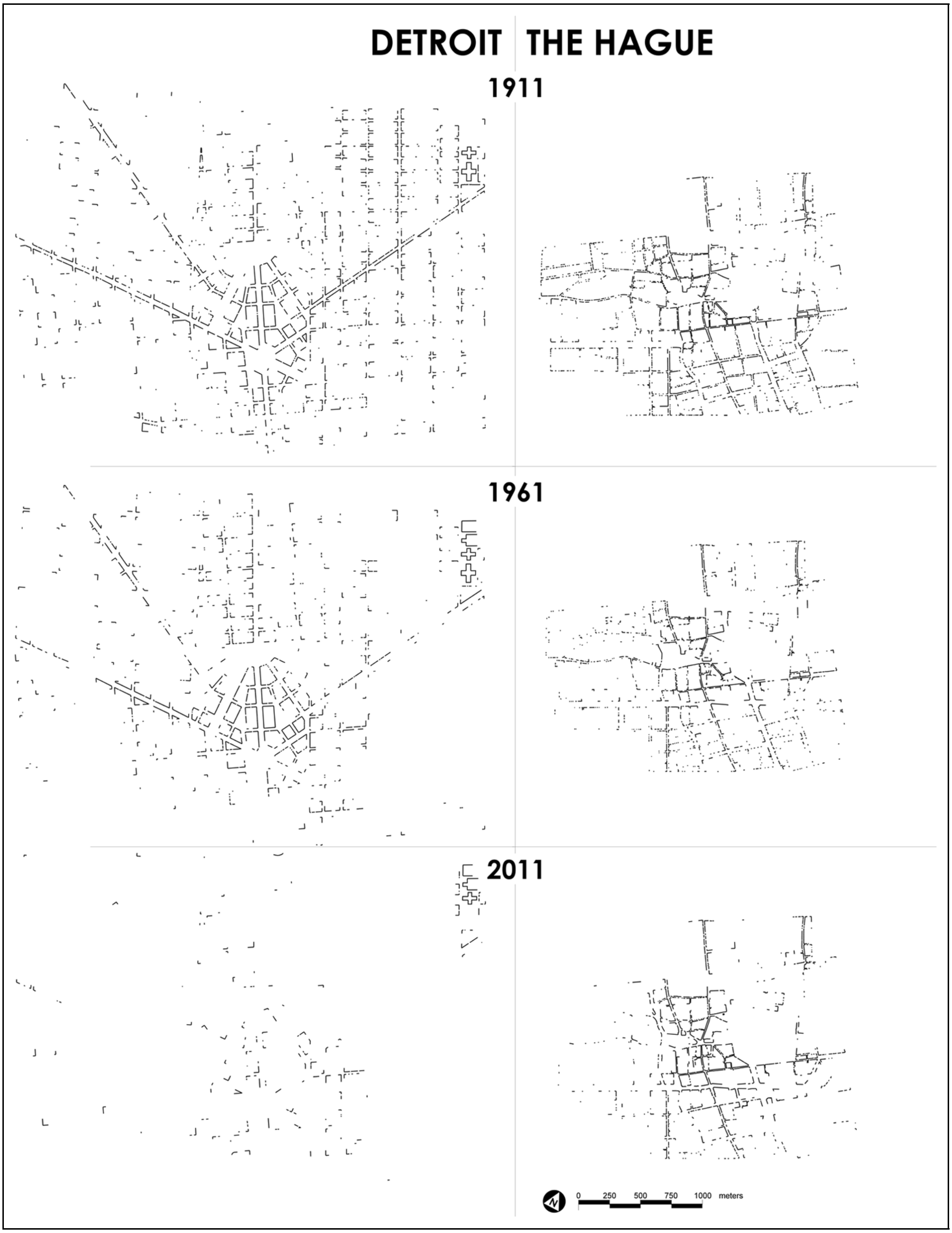

Figure 2. The locational pattern of ground floor retailers in Detroit and The Hague between 1911 and 2011, illustrating a pattern of contraction toward the city's most central and well-connected streets (Kickert, 2016).

within 50 m from each establishment, using data in the century between 1911 and 2011 in both cities. Mortality is the strongest indicator of the loss of viability, as it demonstrates the complete failure of an establishment to survive within a cluster that is too small, scattered, or incompatible.[3] Furthermore, in this time span and for these cities, other indicators such as tenant turnover and sales or rent data have been impossible to obtain or accurately extrapolate from proxy sources, hence the reliance on complete closure, a drastic but reliably traceable event.[4]

In both cities, the location of ground floor retail businesses has been collected through the combination of various sources. Spatially, a variety of mapping sources including Sanborn fire insurance maps, real estate atlases, municipal maps and documents, and aerial photographs have been used to reconstruct address-specific maps for Detroit in 1911, 1921, 1929, 1937, 1951, 1961, 1977, 1988, 2001 and 2011. Owing to the more difficult sourcing of data in The Hague, maps have been created for 1911, 1937, 1961, 1988 and 2011 – overlapping with the eras for Detroit. It was unfortunately not possible to obtain reliable data at regular intervals for both cities. The mapping is manually combined with business directories and government records, in which the geographic location of each retail business is noted. In Detroit, Polk and Bresser's cross-listing directories have been sourced for this purpose, whereas in The Hague a variety of traditional address and phone directories had to be extensively transposed to create an address-based business database.

Furthermore, retail businesses were categorised by the type of merchandise they sell. Types vary between the standard industry category found in the United States Census of Retail Trade and various industry standard classifications such as used by Locatus in The Netherlands. Equalising these types between both countries would be very time-intensive, and would introduce data inaccuracy as detailed types vary between countries and over time. A pilot study of The Hague has concluded in a balance in retail typology between accuracy and time-efficiency: the comparison between 'Fun' (non-daily comparison or shopping goods), 'Destination' (non-daily non-comparison goods and services) and 'Run' (daily goods) retail, as well as a category for bars and restaurants. These four types, defined by Evers et al. in a countrywide study of retail in the Netherlands (2005, 2011) sufficiently demarcate the difference between a need for agglomeration within and between them. An overview of the various types of merchandise and services which fall under the four types is provided in Table 1. Retailers found in the

Table 1. Retail goods and services categorised into four retail types.

Key merchandise by store type			
Run store	Fun store	Destination store	Bar/Restaurant
Groceries	Department store	Home goods	Bar
Convenience store	Fashion	DIY/hardware	Café
Specialty foods	Leisure goods	Electronics	Restaurant
Personal care	Jewelry/luxury goods	Furnishing	Club
Drugstore	Art and antiques	Books	
	Gifts and novelty items	Services	

Note: for a more detailed categorisation, see Evers, 2005: Appendix A.

source material have been categorised by the author into one of the four types according to the merchandise they offer. In case multiple types of merchandise are on offer at an establishment (e.g. a shoe shop which also offers repairs), the highest 'tier' of merchandise is chosen, from Fun to Destination and Run, for the sake of assessing the highest need for agglomeration. Wholesalers are excluded, as are retailers explicitly aimed at cars (dealerships, garages, gas stations). The categorisation of a shop into an independent, local chain or chain has also proven impossible for the case studies, as the definitions of these designations have changed over time and most local records do not define whether a store is independent or otherwise.[5] For time efficiency, the non-overlapping eras in Detroit (1921, 1929, 1951, 1977 and 2001) have only been categorised into retail and bar/restaurant types.

The resulting database contains between 2418 and 232 establishments (Detroit) and 2925 and 1383 establishments (The Hague), for a total of 25,242 establishments in this study across all eras. The counts and their relative percentages are presented in Tables 2 and 3. Much of the loss of retailers between 1911 and 1961 can be attributed to the decline of daily goods and non-daily destination outlets, strongly changing the retail mix toward comparison shopping and leisure tenants. This led to a relatively similar pattern of retail decline in both cities until the mid-20th century. Yet in the post-war era, a sharp bifurcation between The Hague and Detroit is seen. As a result of Detroit's post-war socio-economic decline, the number of retailers in downtown Detroit was decimated, with the relatively modest decline in the number of bars and restaurants making them the dominant commercial ground floor tenant in 2011. In The Hague, downtown has remained a regional comparison shopping destination – albeit with a large number of chain stores having replaced smaller businesses – with steady growth in the leisure sector. In both cities, the daily goods sector has continued to decline as a result of declining downtown population and their expenditure on everyday food items. Hence, both cities experienced a period with relatively similar trends of retail decline, and one with potentially different trends.[6]

The next step in the data collection was to attach spatial attributes to each retail establishment, as the statistical calculations that follow are spatially dependent. The full

Table 2. Street-level retailer counts by type in The Hague 1911–2011, indicating a decline of over 50%, especially in the Run category.

Year	Run	Fun	Destination	Bar/restaurant	Total
Absolute count of stores					
1911	897	777	1077	174	2925
1937	468	537	721	191	1917
1961	301	446	617	197	1561
1988	103	431	473	333	1340
2011	108	543	386	346	1383
Percentage of stores from total					
1911	31%	27%	37%	6%	100%
1937	24%	28%	38%	10%	100%
1961	19%	29%	40%	13%	100%
1988	8%	32%	35%	25%	100%
2011	8%	39%	28%	25%	100%

Table 3. Street-level retailer counts by type in Detroit 1911–2011, indicating a decline of over 90%, especially in the Run, Fun and Destination categories.

Year	Run	Fun	Destination	Bar/restaurant	Total
Absolute count of stores					
1911	717	623	631	447	2418
1937	499	462	750	594	2305
1961	221	266	331	386	1204
1988	76	83	89	142	390
2011	45	19	38	130	232
Percentage of stores from total					
1911	30%	26%	26%	18%	100%
1937	22%	20%	33%	26%	100%
1961	18%	22%	27%	32%	100%
1988	19%	21%	23%	36%	100%
2011	19%	8%	16%	56%	100%

Table 4. Attribute table for each store and each time period of measurement.

Attribute	Definition	Unit
Centre	Centre point	(x,y) coordinate
Topleft	Top left corner	(x,y) coordinate
Bottomright	Bottom right corner	(x,y) coordinate
Type	Store type	Run, Fun, Destination, Bar/Restaurant
Mortality	Closure by next era of measurement	Yes, No
Urban renewal	Location within urban renewal area	Yes, No

frontage outline of the establishments has been mapped to enable more accurate agglomeration calculations.[7] Establishments that are within an urban renewal area (designated as an area that has a block or more of renewal) are not taken into account in the following calculations to prevent large singular events altering the observations of gradual retail evolution. The establishments have been located and attributed in a GIS database. Of each of the establishments for each of the eras of measurement, the attributes are therefore the exact location (x,y coordinates) of their centre points and their edges, and their four-tier retail category. To calculate mortality, an additional attribute is introduced. By comparing the GIS database between two eras, the closure of a retailer is noted for the subsequent era. Note that this closure is of the store as a whole, and does not take individual tenant turnover or the change of a retail category into account. The calculations presented in this paper are based on this set of attributes given to all stores in all time periods, as outlined in Table 4.

Base calculation

As described in the data collection section, the effect of critical mass on retail performance is defined in terms of retail mortality: the complete closure of one establishment between two subsequent sample intervals t and $t+1$. The increased or decreased chance of closure as a function of the number of surrounding stores defines the sensitivity of the performance of retail properties to critical mass. Mathematically, the base definition of the chance of closure of a business with characteristics x is demonstrated in equation (1):

$$Pt(B_x) = \frac{B_x(\text{closed})}{B_x(\text{total})} \quad (1)$$

In equation 1, $Pt(B_x)$ is the chance a business with characteristics X closes between time interval t and $t + 1$, B_x(closed) is the number of businesses with characteristics X closing between time interval t and $t + 1$, and B_x(total) is the total number of businesses with characteristics X in time interval t. Because the time intervals unfortunately vary in duration, the chance of business closures is annualised by equation (2):

$$\mathrm{P(B_x)} = 1 - (1 - \mathrm{Pt(B_x)})^{(1/\Delta t)} \quad (2)$$

In equation (2), $P(B_x)$ is the annual chance a business with characteristics X closes, and $Pt(B_x)$ is the chance as business with characteristics X closes between time interval t and $t + 1$, and Δt is the time difference in years between time interval t and $t + 1$.

The average chance of central business closure varies greatly between Detroit and The Hague, and between years as their macro economies grow and contract. Detroit has suffered from decades of socio-economic and population decline, the growth of competing retail areas and chain stores in the suburbs, a negative perception of inner city crime and racial discrimination. Conversely, The Hague's inner city has suffered a roughly 50% decline in retail numbers over the past century, a much lesser extent than Detroit as the city benefits from centralising public transit, a growing population and a positive perception of downtown, culminating in a national award in 2013. The average annual chance of business closure greatly varies between intervals as well (Table 5). Both cities started with a comparable rate of decline (both in amplitude and locational pattern) until 1937, before the speeds of decline began to differentiate markedly in the following decades. In The Hague, the decline in retail businesses actually decreased by 35.8% for the period from 1961 to 2011. Detroit, on the other hand, saw a slow pre-war increase in the average annualised chance of closure, while for the post-war period the average annualised chance of closure shot up 136.6% to levels above 5.0%.

Table 5. Average annualised chance of business closure in Detroit and The Hague for overlapping periods between 1911 and 2011, demonstrating an increasing trend in Detroit and relative stability in The Hague.

Time period	Detroit	The Hague
1911–1937	0.0273	0.0215
1937–1961	0.0306	0.0162
1961–1988	0.0501	0.0137
1988–2011	0.053	0.0104

Note: The chance of closure is annualised and averaged across the number and type of surrounding businesses.

To ensure that these varying rates of average decline due to externalities such as overall socio-economic decline, population decline and marketing transformation do not influence micro-scale calculations in this paper, the chance of closure is therefore controlled against the average chance of business closure in an interval.

This is done as follows in equation (3):

$$cP(B_x) = \frac{P(B_x)}{P(B_{\text{all}})} - 1 \quad (3)$$

In equation (3), $cP(B_x)$ is the above/below average annual chance a business with characteristics X closes, $P(B_x)$ is the annual chance a business with characteristics X closes, and $P(B_{\text{all}})$ is the annual chance any business (i.e. all businesses) closes. This formula for controlling versus the average chance of closure by division is rather sensitive to smaller sample sizes, as for example a 100% chance of closure (1 out of 1 business) results in a similar 100% annual chance of closure, and will hence yield a very high above average count.

Closure as a function of surrounding retailers

In this section, the agglomeration benefits on business viability is defined by the sensitivity of business closure as a factor of the number of businesses surrounding a retail property. More specifically, the question answered in this section is: Does the chance of closure of a retail business decrease when it is surrounded by more other businesses, hence proving the beneficial effect of retail agglomeration? In order to measure this sensitivity, a mortality rate is defined as the above/below average chance of a business of closing down for a given period, i.e. between two years for which data are available. The inclusion of the average chance of business closure controls for the aforementioned macro-economic effects. In order to measure agglomeration effects, for each retail property in the database the number of retail properties within a 50 m radius in each cardinal direction from the property is counted. This distance was chosen to balance the perceived micro-scale beneficial effects of retail agglomeration and the need for a sufficient count of surrounding businesses.[8] The count for each property is detailed by Fun, Destination, Run and Bar/Restaurant type.[9] The result is a matrix of counts for each type of retail property within a given distance from each base type of retail property, augmented with the information as to whether the business in the property closed during the observed time interval.

A Bayesian least square dummy variable (LSDV) regression was conducted in order to determine whether the relationship between the chance of a business to close (versus the average chance of closure) decreases as the number of surrounding businesses within 50 m increases. For this type of panel regression, the type of business is disregarded, including the type of surrounding businesses, in order to have a sufficient sample size of businesses for each time period. Because of the sparse number of businesses surrounded by 31 or more other businesses within 50 m, only businesses with up to 30 stores within 50 m were included in the panel analysis. In a last step, three extreme outlying observations for Detroit ($2 \times 2157\%$ and $1 \times 1414\%$) and four extreme observations for The Hague ($2 \times 7198\%$, $1 \times 4724\%$, and $1 \times 9538\%$) are excluded, as these are the result of the sensitivity annualisation calculation to 100% chances of closure in low sample sizes. For comparison, the descriptive statistics for the panel data are provided in Tables 6–8.

It is interesting that the summary statistics for Detroit (Table 6) indicate a fairly constant mean above/below average annual chance that a business closes for the first five time periods with values ranging between 7.60% and 12.70%, while dropping significantly for the last three periods with values of −21.46%, −13.10%, and −30.09%, respectively. The Hague on the other hand exhibits a quite different trend over time with constant high values of 39.02–60.48% across all four reported periods (Table 6). Next, Table 8 shows the aggregated summary statistics across the available time periods for each city, calculated with a total of 267 observations for Detroit and 116 for The Hague. In these statistics, the results for all time periods are aggregated into one data set, after which an average across time periods is weighted by the number of stores of each class in each time period. The calculated mean above/below average annual chance

Table 6. Descriptive statistics for Detroit's Mortality Rate (MR) as a function of the number of surrounding stores for each of the nine time periods. The statistics demonstrate that the mean mortality rate as a function of surrounding stores has gone down.

Statistic	1911–1920	1921–1928	1929–1937	1938–1950	1951–1960	1961–1976	1977–1987	1988–2000	2001–2011
Mean	7.62%	12.70%	10.12%	7.73%	7.60%	−1.41%	−21.46%	−13.10%	−30.09%
Standard deviation	79.83%	37.61%	45.85%	47.36%	40.24%	43.59%	59.09%	93.15%	57.44%
Min	−83.80%	−59.77%	−60.67%	−84.10%	−50.40%	−64.88%	−100.00%	−100.00%	−100.00%
Max	198.87%	92.26%	120.52%	125.42%	95.66%	108.68%	102.97%	266.29%	95.97%
Number of observations	30	30	30	30	30	30	30	28	29

that a business closes in Detroit is −2.07% versus 50.55% in The Hague. This positive number reflects the tail of the data set, which reports a consistently lower than average chance of closure. The Hague shows more variability in the above/below average annual chance a business closes than Detroit with standard deviations of 84.66% and 59.41%, respectively. This agglomeration sensitivity is graphically displayed in Figure 3. These graphically displayed differences in higher/lower chance of closure versus average mortality rate for all businesses between Detroit and The Hague mostly reflects upon the summary statistics in Table 4. In addition, The Hague's extreme outliers at a low number of surrounding businesses demonstrates a higher sensitivity to critical mass within 50 m in The Hague, potentially pointing to a greater reliance of the Dutch businesses on pedestrian passers-by versus Detroit's automobile oriented clientele. In The Hague, being surrounded by less than 23 retailers results in a higher than average chance of closure, while in Detroit this number is less than 16. The greater variance in the tail of each graph points to lower sample sizes for a larger amount of surrounding businesses.

For the Bayesian least square dummy variable (LSDV) regression, the dependent variable is the annualised disaggregated above/below average chance of closure versus average (mortality rate, MR) for each time period that data were available. The number of surrounding businesses within 50 m, the explanatory variable (number businesses, NB), remains the same across time periods.[10] A time fixed effects model was chosen to eliminate potential omitted variable bias. Specifically, the time fixed effects regression model uses $t - 1$ binary regressors, which encapsulates all of the variables that affect MR_{it} cross-sectionally, but are constant over time. This allows the regression line to shift for each time period. Our regression model is thus defined in equation (4):

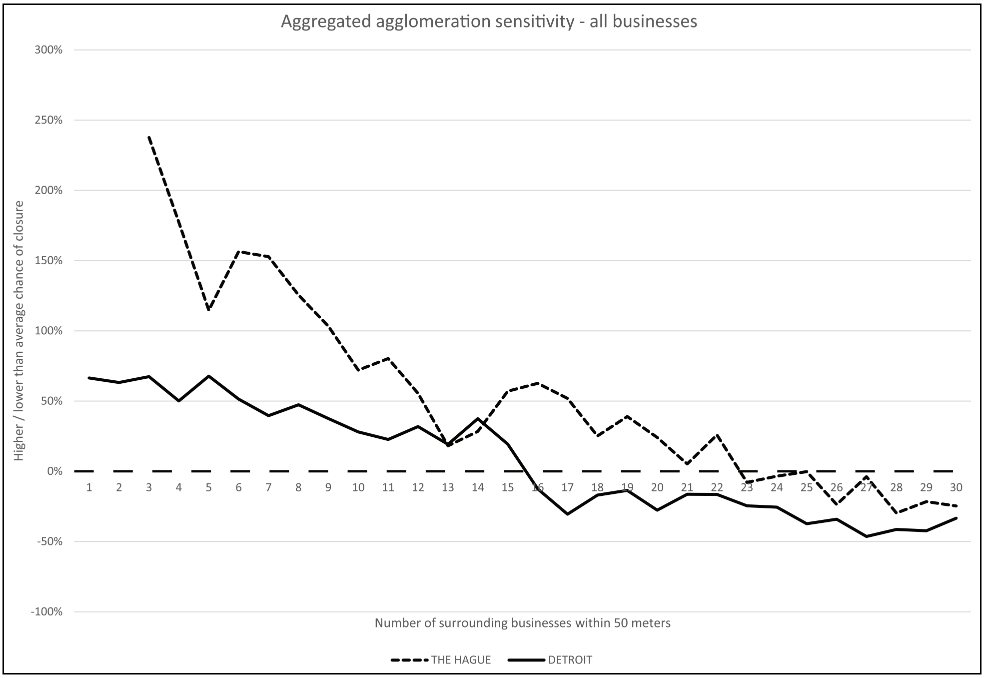

Figure 3. Sensitivity of mortality of all types of retailers to the number of all types of surrounding retailers within 50 m.

Table 7. Descriptive statistics for The Hague's Mortality Rate (MR) as a function of the number of surrounding stores for all of the four time periods. These statistics demonstrate a relative stability in MR as a function of the number of surrounding stores.

Statistic	1911–1937	1938–1960	1961–1987	1988–2011
Mean	53.49%	48.87%	39.02%	60.48%
Standard deviation	48.06%	86.53%	97.34%	99.93%
Min	−28.10%	−71.19%	−81.38%	−80.53%
Max	189.99%	255.26%	304.71%	287.74%
Number of observations	30	30	28	29

$$MR_{it} = \beta_0 + \beta_1 NB_{it} + \gamma_2 P_2 + \dots + \gamma_t P_t + \varepsilon_{it} \quad (4)$$
$$\varepsilon_{it} = NID(0, \sigma^2)$$

In equation 4, β_0 is the constant term, β_1 the coefficient for the number of surrounding businesses, γ_2 to γ_t the time period coefficients, MR is the mortality rate (i.e. above/below chance of closure versus average), NB the number of surrounding businesses (1 … 30), and *P* are the binary (dummy) variables for each time period. A linear form is selected as neither transforming the dependent variable (MR) nor transforming the explanatory variable (NB) improved significantly the models results.[11] Subscript *i*

Table 8. Descriptive statistics for Detroit and The Hague's Mortality Rate (MR) as a function of surrounding stores, aggregated across time periods. The difference in mean mortality rate as a function of surrounding stores can be attributed to various externalities such as auto-dependence and statistical distribution.

Statistic	Detroit	The Hague
Mean	−2.07%	50.55%
Standard deviation	59.41%	84.66%
Min	−100.00%	−81.38%
Max	266.29%	304.71%
Total sample size	267	116
Time periods	9	4

Table 9. LSDV regression results for Detroit (n = 267, 9 time periods).

Variables	Coefficient	Standard deviation	t-statistic
Constant	0.282	0.090	3.120
Number of businesses	−0.041	0.003	−15.456
1911–1920	0.345	0.113	3.050
1921–1928	0.478	0.106	4.519
1929–1937	0.460	0.104	4.430
1938–1950	0.403	0.105	3.852
1951–1960	0.459	0.106	4.347
1961–1976	0.334	0.104	3.214
1977–1987	0.092	0.108	0.855
1988–2000	−0.018	0.115	−0.152
R-square	0.413		
Adjusted R-square	0.399		
F-statistics	20.091		

denotes the total number of observations per city. Given that some observations were deleted as explained earlier this gives us two unbalanced panels with a total of 267 observations for Detroit and 116 observations for The Hague. There are nine time periods for Detroit and four time periods for The Hague, denoted by t. To avoid perfect collinearity in the binary regressors, the 2001–2011 period is excluded to become the baseline, represented by the intercept term β_0 (i.e. the constant). Finally, ε_{it} are the error terms, which are as usual normally and independently distributed with a mean of zero and a common variance σ^2. The slope coefficient β_1 remains constant across time periods. The LSDV regression results are listed in Table 8 for Detroit and in Table 9 for The Hague.

Both regression models for Detroit and The Hague are statistically significant at the 1% level with F-statistics of 20.09 and 32.06, respectively. The R^2 values of 0.413 and 0.536 show some moderate fit of the regression lines to the data. The models' underlying assumptions on the regressors and the error terms have been checked. Following LeSage,[12] the Bayesian estimation method with Gibbs sampler has been used to produce model results with robust standard errors. Evaluation of the variance inflation factors and the condition indices shows no sign of multicollinarity in either model. Two extreme studentised residuals have been detected for Detroit (i.e. 6.06 and 4.98), but none for The Hague. However, the Cook's and the leverage values indicated that these two observations do not qualify as influential observations so they are retained in the panel. Further, the residual plots indicate no issues with non-stationarity of the dependent variable in either of the two models.

When interpreting the estimated coefficients, the outcomes are quite different when comparing the results for Detroit with those of The Hague. Both estimated coefficients for the number of surrounding businesses within 50 m variables are negative and highly statistically significant with t-statistics of −15.46 for Detroit and −10.53 for The Hague. This shows that the chance of a business closing decreases as the number of surrounding businesses within 50 m increases. Specifically, in Detroit the chance of a business closing decreases by 4.1% for each additional business within the 50 m buffer. In The Hague, the chance of closure decreases by even 7.0% for an additional business with close proximity. This can be explained by the higher number of comparison stores in The Hague which are known to have a higher sensitivity to agglomeration (see Table 1).

The regression results for Detroit demonstrate that the estimators for the binary variables 1911–1920 to 1961–1976 are significant. This implies different, but parallel regression lines for these periods. For instance, the estimated regression model for 1911–1920 becomes $MR_{it} = 0.627 - 0.041NB_{it}$ indicating chance of closure of 62.7% above average if no business is within the 50 m perimeter. The highest chance of closure for a solitary business is 76.0% for 1921–1928 and the lowest chance of closure is 61.5% for 1961–1976. This can be explained by the rise of car ownership, decreasing the amount of foot traffic on the city's sidewalks and increasing the percentage of businesses that catered to a driving audience with less need for micro-scale agglomeration. The estimators for the binary variables 1977–1987 and 1988–2000 are insignificant, indicating that for these two later periods, the chance of closure above average if no business is within the 50 m perimeter is not different from the 2001–2011 period of 28.2%. This finding is also partly a result of the low sample size for these years (see Table 1). For instance, for 1988–2000, 12 data entries indicate a 0.00% higher/lower chance of a business closing versus average.

In comparison with the results for Detroit, the estimated coefficients for the binary variables for The Hague on the other hand are all statistically insignificant. The chance of closure for a solitary business is 167.3% above average for all periods. This high mortality rate is a sign of the high dependence of The Hague's businesses on foot traffic. Business agglomeration seems to matter more in The Hague, as a result of lower car use in the downtown area and the greater percentage of comparison stores. Further, the insignificant binary variable estimators can be explained by the long time periods for The Hague. One must keep in mind that the higher/lower chance of business closure versus average calculated statistics are annualised numbers and as such, they are identical for each year within one period. The long time periods used for this annualisation process in The Hague (i.e. 27, 23, 27, and 23 years) smooth out most of the economic conjunctures occurring over time. As a result, no significant variation between the time periods exist. In other words, there does not exist significant variation between the time periods with respect to the intercepts, the chance of closure for a solitary business.

Closure as a function of the type of retailer

As indicated previously, some types of retailers are believed to be more sensitive to agglomeration than others. Comparison retailers (fun stores) are more dependent on impulse purchases achieved through the foot traffic that establishment agglomeration can provide, while others (destination and run stores) can more easily survive on their own (Brown, 1992; Evers et al., 2005, 2011; Nelson, 1958). This section will delve into the sensitivity of each of the four types of retailers to the number of surrounding businesses: are certain types of retail business more sensitive to a lack of agglomeration by other retailers than others?

Unfortunately, the disaggregation of the study data set into four types yields an insufficient sample size to conduct a panel regression at the level of detail explained in the previous section. Instead, one aggregated regression analysis is performed over all time

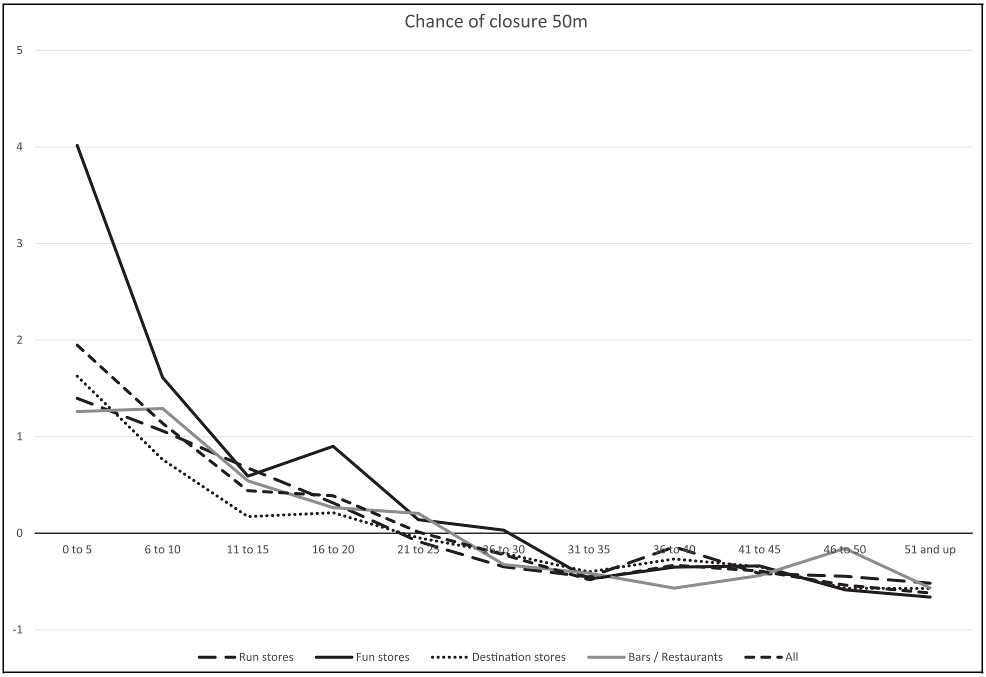

Figure 4. Sensitivity of mortality of categorised types of retailers to the number of retailers within 50 m in The Hague.

periods, using the same base calculation as in the previous section as demonstrated in Figure 3, but split by retail type. As in the previous section, individual time periods weighted by the number of stores in each class, and the sensitivity of retail types is still calculated as a function of surrounding businesses of all types in order to keep up the sample size. Furthermore, the low sample size of the disaggregated data set, especially for later years in Detroit, requires the calculation bracketing by multiples of five surrounding businesses. This does allow the calculations to take up to 50 surrounding businesses into account. Figures 4 and 5 and Tables 11 and 12 illustrate the results for The Hague and Detroit.

As demonstrated in the graphs and Tables 11 and 12, different retail types indeed demonstrate different sensitivities to a lack of surrounding businesses. Especially Fun stores are highly sensitive to a lack of surrounding businesses, which corroborates retail literature in their need for foot traffic and nearby peers to generate impulse purchases and allow for the comparison of merchandise. Run and destination stores, and bars and restaurants demonstrate this effect to a smaller extent, yet still show a significant correlation between a lack of agglomeration and establishment failure. Interestingly, the correlation and its extents are quite similar between Detroit and The Hague – two cities which at first sight have taken vastly different paths in their history. It must again be noted that sample sizes are relatively small for this section (n varies between 2154 and 2), with lower sample sizes mostly in the lowest and highest number of surrounding businesses. The lower sample size, combined with the annualisation calculus, amplifies the negative effects of low agglomeration in both cases, which is most visible for Fun stores.

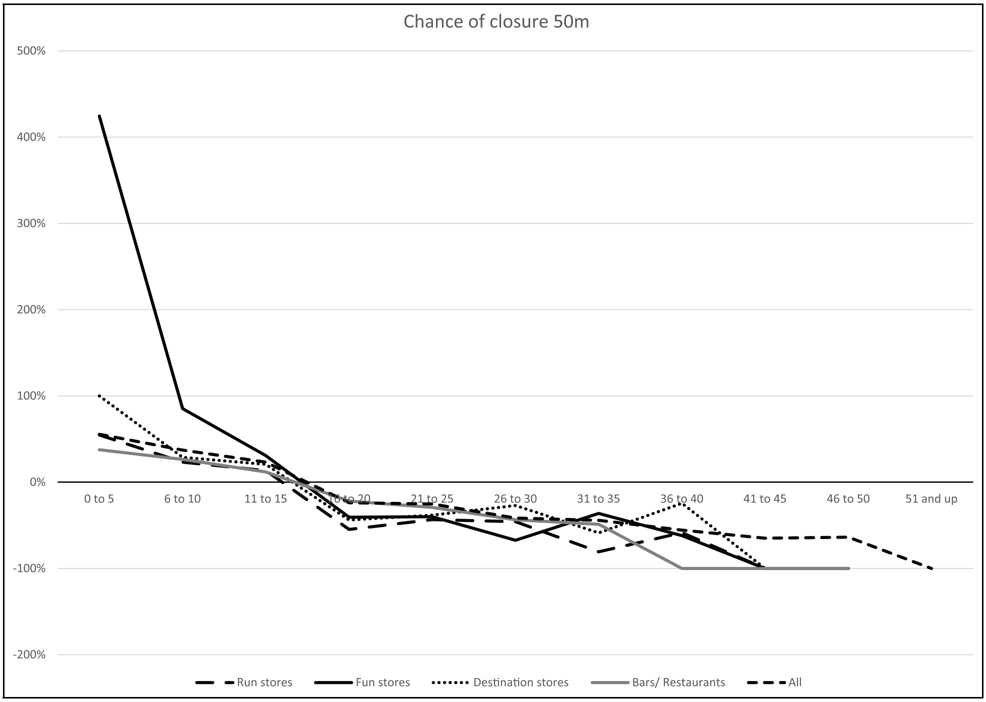

Figure 5. Sensitivity of mortality of categorised types of retailers to the number of retailers within 50 m in Detroit.

Table 10. LSDV regression results for The Hague (n = 117, 4 time periods).

Variables	Coefficient	Standard deviation	t-statistic
Constant	1.673	0.167	10.043
Number of businesses	−0.070	0.007	−10.534
1911–1937	0.028	0.156	0.178
1938–1960	−0.122	0.151	−0.804
1961–1987	−0.224	0.156	−1.436
R-square	0.536		
Adjusted R-square	0.519		
F-statistics	32.060		
F-statistics	32.05603448		

Conclusions

As demonstrated by the preceding regression analysis outlined in equation (4) and Tables 9 and 10, street-level retail is indeed significantly sensitive to agglomeration in Detroit and The Hague. In Detroit, the chance of a business closing decreases on average 4.1% with each additional surrounding business, in The Hague this chance decreases by 7%. This can be explained by the higher percentage of Fun stores in The Hague, which are

Table 11. Sensitivity of various retail types to surrounding businesses of all types in The Hague.

Average annualised chance of closure					
	Run	Fun	Destination	Bar/Restaurant	Total
Number of surrounding businesses					
0–5	140%	402%	163%	126%	195%
6–10	106%	161%	76%	129%	114%
11–15	68%	59%	17%	54%	44%
16–20	31%	90%	21%	27%	39%
21–25	−9%	14%	−5%	21%	1%
26–30	−35%	3%	−21%	−32%	−22%
31–35	−45%	−47%	−40%	−41%	−48%
36–40	−14%	−35%	−27%	−57%	−33%
41–45	−42%	−34%	−35%	−44%	−39%
46–50	−44%	−59%	−57%	−16%	−54%
51 +	−52%	−66%	−57%	−57%	−62%
Descriptive statistics					
Linear correlation (R^2)	0.8302	0.7038	0.7749	0.7850	0.8150
Pearson *r*	−0.9112	−0.8389	−0.8803	−0.8860	−0.9028
p-value	0.0002	0.0020	0.0008	0.0006	0.0003
Negative vector	−0.1831	−0.3462	−0.1745	−0.1832	−0.2178

Table 12. Sensitivity of various retail types to surrounding businesses of all types in Detroit.

Average annualised chance of closure					
	Run	Fun	Destination	Bar/Restaurant	Total
Number of surrounding businesses					
0–5	55%	424%	100%	38%	55%
6–10	23%	85%	29%	26%	37%
11–15	13%	31%	21%	12%	23%
16–20	−55%	−41%	−44%	−22%	−24%
21–25	−43%	−40%	−38%	−29%	−25%
26–30	−46%	−67%	−27%	−44%	−42%
31–35	−81%	−36%	−59%	−49%	−44%
36–40	−59%	−62%	−24%	−100%	−56%
41–45	−100%	−100%	−100%	−100%	−65%
46–50		−100%		−100%	−64%
51 +					−100%
Descriptive statistics					
Linear correlation (R^2)	0.8570	0.5799	0.7448	0.9602	0.9030
Pearson *r*	−0.9258	−0.7660	−0.8630	−0.9815	−0.9608
p-value	0.0003	0.0100	0.0030	<0.0001	<0.0001
Negative vector	−0.1739	−0.3936	−0.1837	−0.1683	−0.1389

Note: the statistical calculations have been conducted with the maximum of each bracket as the defining x-value, based on the least-square linear regression. The values for all retailers in Detroit are lower than the average of the four types because the uncategorised calculations for 1921, 1929, 1951, 1977 and 2001 are now also integrated.

more sensitive to agglomeration. While the disaggregated data set has an insufficient sample size to conduct a panel regression for the various store types, an initial bracketed regression indicates a higher than average sensitivity of Fun stores to agglomeration, which can be ascribed to their desire to be surrounded by peers for merchandise comparison by consumers. The sensitivity of retailers to agglomeration and the variation between types of retailers show similarities between Detroit and The Hague, cities with vastly different socio-economic, cultural and physical settings and histories.

Recommendations

These conclusions have strong implications for practice. As retailers are sensitive to agglomeration, the success of retail districts depends on providing a sufficient critical mass of businesses within a retail cluster, especially if Fun stores are contained within it. Figure 3 demonstrates a lower than average chance of business failure in clusters of 26 establishments in The Hague, compared with 16 in Detroit. Conversely, declining business districts should strategise to maintain contiguous clusters of retailers. If a trend of business closure has commenced, deterioration of agglomeration benefits may accelerate this trend. Efforts to counteract the scattering of retail clusters are underway in the Dutch proposal for the 're-parcelling' of struggling areas – effectively re-clustering remaining retailers into a continuous area (Nieland, 2012). Temporary retail tenants, rent abatements, food trucks, temporary festivals and other programmed activities are other examples of 'tactical' measures to maintain a critical mass of business activity in commercial areas (Lydon and Garcia, 2015; Mukhija and Loukaitou-Sideris, 2014; Niehm et al., 2006). Retail district or street management can markedly aid these processes, as it can align the interests of retailers, landlords and local governments (Glaser et al., 2012; Portas, 2011).

Discussion

While the study has been able to demonstrate retailers' sensitivity to agglomeration, its design has a few caveats that future research projects may be able to address. First, the data collection has only allowed for the study of full closure of retail establishments, leaving out important indicators of retail performance such as tenant turnover, change between retail type and retail rent. Studies that are based on a more detailed data set could hence provide further insight into the effects of agglomeration. While no reliable base data were found to create this set over a century in the Netherlands and the USA, other countries may have kept more detailed records.

Another possibility for more detailed insight could be to look into the effects of retailers' establishment size in agglomeration, for which reliable diachronic base data could also not be found in both case studies. Models of retail gravity and theories of retail anchoring (Brown, 1992, 1993) could therefore not currently be fully corroborated. Similarly, the number of entrances for retail establishments could not be counted, leading to the potential underestimation of the agglomerating power of larger establishments such as department stores. Furthermore, the collected data only cover street-level retailers, potentially negating agglomeration benefits from retailers within enclosed shopping centres and on higher floors. As these retail formats are mostly segregated from public space, their impact at street level is assumed to be minimal.

Future studies may also focus on larger urban cores to reach a sample size that is sufficient to study agglomeration benefits of various retail types. The sample sizes in this study have been insufficient for the disaggregation into separate time periods and retail types. Especially the annualisation of the chance of closure skews small sample sizes upward when all stores in a sample have closed, which can easily occur at a low sample size (an effect that can be observed in Figures 2 and 3). There are two remedies for this effect, either of which were not possible with the data for this study. First, when the time periods of measurement are at regular intervals, annualisation may not be necessary to equalise the data. Second, urban cores can be selected with a larger sample size of stores, e.g. in major shopping cities such as London or Paris. An increased sample size can enable a panel regression on the effects of agglomeration on the closure of stores by type, and they can even delve into the effects of agglomeration of certain types of retailers on other types of retailers (e.g. whether Fun stores benefit more from agglomeration with other Fun stores).

In future studies, it is also advisable to create a buffer zone around the defined urban core to minimise edge effects. Especially at higher radii of measurement, the current statistical method may suffer from this effect. Retailers toward the edge of the case study area are counted as having few surrounding stores, when stores may be located right outside. Peripheral retail streets in both cities may therefore exhibit a higher than expected rate of closure compared with central streets, even though they contain a similar cluster of retailers. This effect is likely limited at smaller measurement radii, and the number of retailers in peripheral areas is far lower than in core areas. Our agglomeration radius of 50 m is therefore assumed to minimise this effect.

Similarly, the chance of establishment closure in a cluster may also be influenced by its overall location within the urban core. As noted in the case study rationale, the most central and well-connected streets in both cities had the highest establishment survival rate because of a stronger customer accessibility than peripheral streets. These locational differences have been shown to influence retail performance (Brown, 1984; Van Nes, 2002). More detailed studies can control for these differences with various measures on centrality (e.g. Hillier et al., 2012) to ensure locational advantages do not influence diachronic outcomes.

A methodical expansion of the number of case studies that focus on various downtown-wide agglomeration profiles can help to corroborate the findings presented in this paper, especially when taking different socio-economic and cultural contexts into account. That said, the process of assembling the data sets for this type of study is highly labour intensive, making the scalability of future research on this topic rather expensive. Nevertheless, technological advances in the automation of data acquisition (such as Optical Character Recognition of old business records) and geographic processing (using GIS address databases) may ease the expansion of this research perspective.

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Notes

1. The definition of core and frame varies between academic and professional disciplines, such as economic geography (e.g. Horwood and Boyce, 1959) and urban morphology (e.g. Whitehand, 1988). In

government documents, the definition is mostly made between areas with high (retail) business activity, such as The Hague's 'shopping core' and Detroit 'business core'. The definitions of core and frame in both urban centres have been flexible over time and between defining agencies.

2. Inner city is the typical Dutch reference to the American downtown – the city originally within the medieval fortifications.
3. Other indicators of poor viability are lower sales, usually reflected in lower retail rents, as well as higher retail turnover (Dawson, 2012).
4. While retail turnover and rent indicators are a signifier of retail success (Brown, 1992; Coleman, 2006; Gibbs, 2012). These data are impossible to reliably obtain over the full length of this study. This article therefore focuses on the unique length of the data set (one century) rather than its depth to reach its conclusion.
5. For example, the Hudson's department store in downtown Detroit has family-owned roots (counting as an independent store), but branched out in the 1950s (changing its status to a local chain) before merging with a national chain and ultimately closing their downtown plant in 1983.
6. As discussed by Yin (1994) and Creswell (2009), the bandwidth between sufficient similarities and case-specific differences will enhance the generalisability of patterns found between these case studies. If a similar micro-scale pattern of agglomeration economies is found despite the seemingly disparate macro-scale pattern of decline in these two seemingly disparate cities, a site-agnostic and generalisable system may be assumed.
7. At the level of detail presented in this paper, the centre point of storefronts wider than 100 m (e.g. department stores) would otherwise be out of range to neighbours, even though their retail frontage abuts them.
8. A study of the effects of increasing or decreasing the catchment area radius from 25 m to 50 m, 100 m and 200 m does demonstrate that the radius influences the amplitude of the sensitivity to agglomeration, but not the overall effect in The Hague. In Detroit, the catchment area radius did not strongly influence sensitivity.
9. Except for the non-overlapping Detroit measurements of 1921, 1929, 1951, 1977 and 2001, in which only 'retail' and 'bar-restaurant' were specified.
10. We would like to thank an anonymous reviewer of an earlier version of the manuscript who suggested using a panel regression model instead of a simple ordinary least square regression model.
11. The widely used log-transformation of the dependent variable (our first choice when looking at the scatterplots of MR against NB) is not possible due to negative values of MR. Adding a squared term (NB^2) as explanatory variable has very little impact on improving the R^2s in either regression. Detroit's R^2 improved by a mere 0.0006 after adding NB^2 to the regression, while The Hague's R^2 improved by 0.013. Given these marginal improvements in the R^2s and the fact that after reaching a minimum the combined effect of NB and NB^2 will become positive, which is neither supported by the theory nor by the data in this study, a linear form is therefore used.
12. *Source*: LeSage (1999).

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