Rethinking Retail Digitisation in Urban Settings. The Case of Leipzig, Germany

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Abstract
Digitisation is considered as a key transformation in urban development and retail. However, in academia, a strong focus is put on large cities, as they are considered to be at the front line of this transformation. Second-tier cities are often neglected, although digitisation is seen as a process that offers both challenges and opportunities. This essay has two research objectives. Firstly, it investigates the German city hierarchy using social, economic and retail data. Based on a cluster analysis of the 14 largest German cities, two clusters are identified, revealing a stark contrast between more innovative and faster-growing areas (cluster 1) and cities with rather moderate dynamics (cluster 2). Secondly, Leipzig is chosen as a representative of German second-tier cities. By means of an urban living lab, the aim is to investigate the ongoing process of digitisation bringing together relevant stakeholders such as retailers, citizens, logisticians, researchers and the municipality. Different digital tools are put to the test. On that basis, living labs are discussed as a scientific approach, bridging the gap between theory and practice and adding further evidence of how digitisation takes place aside from first-tier cities.

Keywords
Sustainability, Information technology, Urban Regeneration

List of notations

V	variable
n	number
H	hypothesis
D	distance
α	type I error
r	correlation factor based on Pearson
t	t-statistic
k	number of values in a correlation analysis

1 Introduction

Digitisation causes urban transformation processes, particularly in the field of retail economics and urban development. Whereas growth in stationary retail is almost stagnating, e-commerce records an annual turnover

increase of 10 % in Germany (HDE, 2018). However, the consequences of e-commerce are diverse, ranging from social to economic impacts, and highly depend on the local urban setting. Large cities benefit from innovative multi- and cross-channel retail activities that contribute to their attractiveness and uniqueness (BBSR, 2017). The growing number of online pure players that open offline stores in such cities is just one example of that (Arlott et al., 2019). For the sociologist Saskia Sassen, digitisation is even one of the key characteristics in the global city (Sassen, 2007). Contrary to that, small and medium-sized cities show low varieties of goods and high rates of shop vacancies within city centres, due to decreasing high street footfall (Millington et al., 2015; Stepper, 2016). However, these cities still have a comparatively high share of mid-sized owner-managed stores, as homogenisation processes in retail are mainly taking place in larger cities (Korzer 2013).

Though, chain stores have replaced many owner-managed stores because chain stores are more capable to adapt to challenges of digitisation due to their central management and networks. The loss of individual owner-managed stores has caused the substituting character of high streets (figure 1), not just in Germany but also in many European cities (Monheim, 2017).

Fig. 1. Interchangeable character of high streets through chain stores in Leipzig (photo: the authors)

However, retail is still one of the main urban functions in city centres and digitisation can therefore help to develop innovative solutions (Schade et al. 2018). One can assume that the development starts in large cities because of their innovative power and digitisation standards (Van Winden and De Carvalho 2017). Nevertheless, there are also second-tier large cities that have less innovative power and still need solution approaches, which is part of the analysis in this paper.

Based on the research gap identified above, the main objective of this paper is to contribute to the ongoing discourse about digitisation, retail and urban development, focusing on German second-tier cities. We argue that digitisation is both a challenge and a strategy even in cities that are not on the frontline of the urban hierarchy.

Two methodological approaches are applied. Firstly, the researchers analyse the German city hierarchy in order to identify groups among the cities (chapter two). They use a cluster analysis including relevant social, economic and retail data. Hamburg is identified as typical representative German first-tier cities (cluster 1) while Leipzig is regarded as a frontrunner in cluster 2. Part of the research project is an urban living lab in each of the two cities. However, this paper puts the focus on Leipzig, in order to contribute to the ongoing debate about digitisation in smaller cities. For that reason, chapter three discusses urban living labs as a new methodological approach to investigate digitisation in urban contexts. Chapter four contains the results of the living lab in Leipzig. Based on the Leipzig experience, a reference procedure model is introduced which makes the lessons learnt transferable to other cases.

2 Finding structures in German cities by means of cluster analysis

As large cities take over a pioneering task in digitisation (Berger et al., 2017; Koppel, 2016), one of the objectives of this paper is to find differences and similarities among Germany's largest urban agglomerations. The aim is to investigate if groups among these cities can be identified, so that digitisation can be analysed in different types of German large cities. Against this background, a cluster analysis with 14 German cities with a population of more than half a million each is conducted. Relevant variables are identified based on the location and market analysis approach (Muncke et al., 2005; Gondringer, 2004). Table 1 presents a set of 14 variables related to demography, economy, tourism, retail and sustainability that are considered as highly relevant in order to assess the cities' current framework conditions. A mix of time series variables (V1 to V6) and snapshot variables (V7 to V14) is included, in order to analyse both existing structures and dynamics. During the selection of these variables, data accuracy, timeliness and availability played a major role. As the data were acquired from a variety of sources, different time frames had to be accepted. This might lead to a weakening of the statistical model's quality. However, the authors chose the aspect of timeliness to be more important than using uniform timeframes, in order to obtain up-to-date results. Moreover, for each variable data uniformity is ensured.

Table 1. *Set of selected variables and sources (own elaboration).*

	variable		*unit*	*source*
demography	V1	population development, 2008-2016	%	Statistische Ämter des Bundes und der Länder, 2018
	V2	development of share of inhabitants older than 65 years, 2000-2015	precentage point	Bundesinstitut für Bevölkerungsforschung und Destatis Statistisches Bundesamt, 2016
	V3	development of share of inhabitants younger than 20 years, 2000-2016	precentage point	Destatis Statistisches Bundesamt, 2018b
	V4	development of share of immigrants, 2007-2017	precentage point	Destatis Statistisches Bundesamt, 2018a
	V5	development of unemployment rate, 2008-2016	precentage point	BIAJ Bremer Institut für Arbeitsmarktforschung und Jugendberufshilfe, 2017
economy	V6	development of gross domestic product per inhabitant, 2010-2015	precentage point	Burth, 2016; Destatis Statistisches Bundesamt, 2018c
	V7	start-up rate, 2017	absolut, per 10000 inhabitants	Destatis Statistisches Bundesamt, 2018c
	V8	personal bankruptcy, 2017	absolut, per 100000 inhabitants	Statista, 2018c
	V9	overnight stays on the tourist market, 2015	absolute, per inhabitant	Statista, 2016
tourism	V10	maximal rent per retail estate (60-120 m^2) in prime location, 2018	€/m^2	Statista, 2018b
retail	V11	maximal rent per retail estate (120-260 m^2) in prime location, 2018	€/m^2	Statista, 2018a
	V12	purchasing power per inhabitant, 2018	€/inhabitant	GfK Geomarketing GmbH, 2017
	V13	number of carsharing vehicles per inhabitant, 2017	units/inhabitant	Statista, 2017
sustainablity	V14	modal split, share of motorised traffic, 2017	%	Greenpeace e.V. and Moser, 2017

2.1 The clustering process

The aim of a cluster analysis is to group data according to their similarity (Chatfield and Collins, 2000). As a result, homogenous groups are generated which do not only reduce data complexity, but also contribute to revealing structures in complex data sets (Rousseeuw and Kaufman, 2005). Nevertheless, the process depends highly on the statistician's decisions, which underlines the necessity of making the research steps transparent (figure 2).

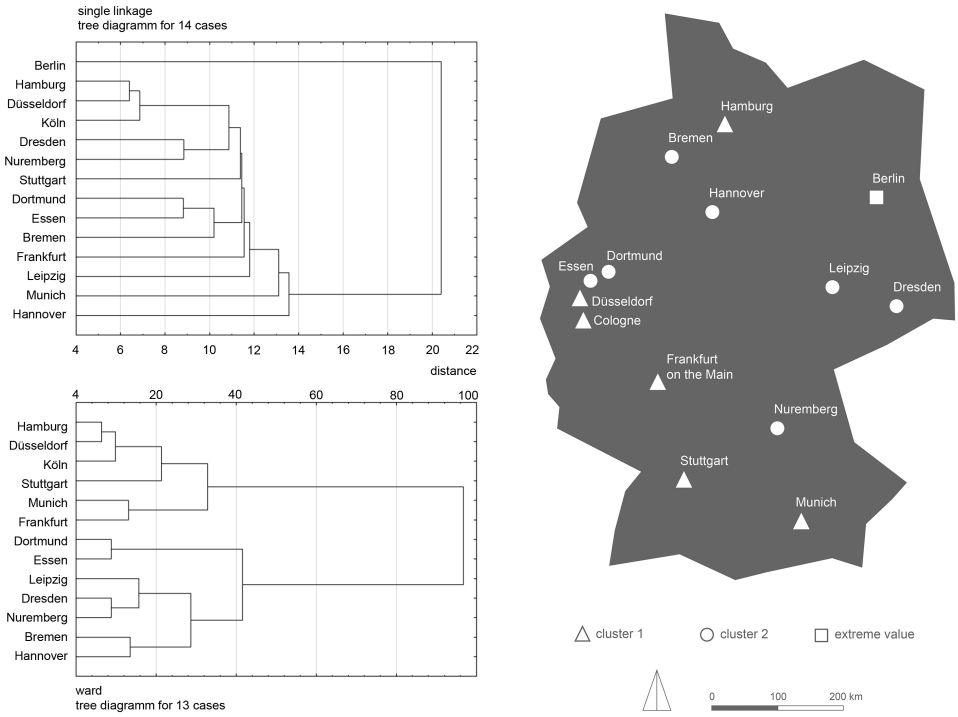

Fig. 2. Research Design. Selecting variables according to different criteria (own elaboration).

As shown in the figure, several statistical requirements have to be met. Missing values have to be eliminated, data have to be checked for correlations (Bacher, 1989) and data distribution has to be analysed (Schendera, 2010). Due to high data quality (figure S1), no missing values are detected. The statistical distribution of the set is tested with a Kolmogorov-Smirnov test for normality (Lilliefors, 1967). The data should ideally be distributed in a similar way in order to avoid distortion of the results. All of the tested variables meet this demand except for the variable "unemployment rate" (V5), which is not distributed normally and is thus eliminated from the study (figure S2). Furthermore, correlations are tested based on Pearson's correlation coefficient r (Bakdash and Marusich, 2017), revealing relations between variables (figure S3). In the data set, a strong correlation between variables V10 and V11 representing the rents in retail estate (r = 0,99) is identified, which is why variable V11 is eliminated in order not to distort the whole analysis. The remaining 12 variables show acceptable correlation factors.

The final clustering process takes place in three steps. First of all, the squared Euclidean distance is defined as measure of proximity, considering the distance between each value (Schendera, 2010). Secondly, the hierarchic approach is chosen as a grouping mechanism, (Hesse, 2014). Within this approach, a variety of algorithms exists. This paper employs two

methods in order to combine different advantages. Initially, a single linkage algorithm is applied, which shows to be vulnerable to extreme values. In the prevailing study, Berlin stands out for several reasons, which is reflected in a higher distance within the grouping process (figure 3) and which is also the reason why Germany's capital is excluded from the further analysis. With the remaining 13 cities, a second clustering process is done. The ward method is able to identify realistic structures in data. On that basis, the number of clusters is determined graphically in the scree plot by means of the elbow method (Backhaus et al., 2016).

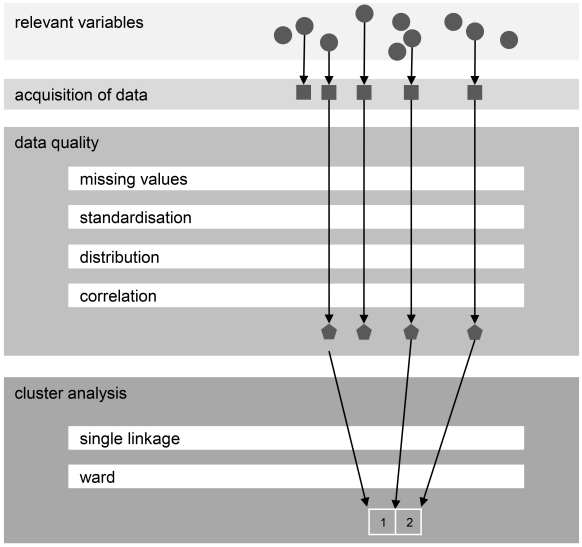

Fig. 3. Clustering algorithms single linkage (above) and ward (below) and the spatial distribution of the final two clusters (own elaboration).

2.2 Clustering large German cities

As figure 3 shows a clear dualistic structure, two final clusters are chosen. Although the cities' population size was intentionally not included in the analysis, the 13 agglomerations are allocated to their clusters according to their size. Consequently, the population size is directly linked to the other parameters. As a result, the six largest cities are labelled as cluster 1, the remaining seven agglomerations as cluster 2. Figure 3 reveals a clear spatial divide between the eastern and western part of Germany. Apart from Berlin, only two large cities exist in East Germany (cluster 2). Contrary to that, all of the first-tier cities from cluster 1 are located in West Germany. Cluster 1 is clearly more dynamic, particularly when it comes to population and economic growth (figure 4). Not only is there a much higher share of start-ups, but also a significantly higher purchasing power. While societies in cluster 2 became older, cities in cluster 1 were getting younger during the last six years. On the retail estate market, a considerable gap is identified between German first-tier cities in cluster 1 and second-tier cities in cluster 2. However, there are some variables such as "development of

the share of immigrants" and "modal split" that do not contribute to a clear differentiation between both clusters.

variable	V1 population development	V2 development of share of inhabitants older than 65 years	V3 development of share of inhabitants younger than 20 years	V4 development of share of immigrants	V6 development of gross domestic product per inhabitant	V7 start-up rate	V8 personal bankruptcy	V9 overnight stays on the tourist market	V10 maximal rent per retail estate (60-120 m^2) in prime location	V12 purchasing power per inhabitant	V13 number of carsharing vehicles per inhabitant	V14 modal split, share of motorized traffic
time unit	2008-2016 %	2000-2015 percentage point	2000-2016 percentage point	2007-2017 percentage point	2010-2015 percentage point	2017 absolute, per 10000 inhabitans	2017 absolute, per 100000 inhabitants	2015 absolute, per inhabitant	2018 €/m^2	2018 €/inhabitant	2017 units/ inhabitant	2017 %
Cluster 1	6,8	1,3	0,5	6,4	17,0	105,5	121	8,5	304	26657	0,00116	0,40
Cluster 2	3,7	2,7	-0,2	6,2	15,0	84,5	150	5,2	151	22168	0,00037	0,41
Leipzig	10,8	2,7	0,4	4,9	24,5	104,0	166	5,8	130	20125	0,00052	0,32
Hamburg	2,2	1,8	0,4	3,8	14,7	104,6	155	8,1	310	25242	0,00093	0,42

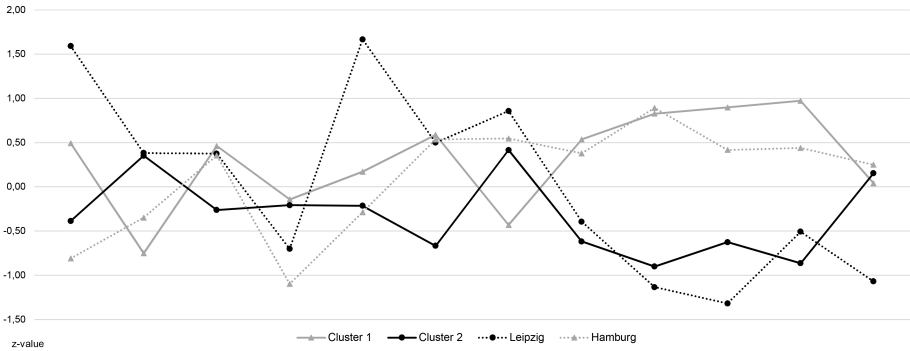

Fig. 4. Characteristics of the two clusters and of Leipzig and Hamburg as case studies (own elaboration).

As this paper focusses on Leipzig as a case study and gives a short preview on a planned living lab in Hamburg, both cities are now characterised. Leipzig is labelled as a second-tier city in cluster 2, although it shows to be the frontrunner in various variables, such as growth both in population and in gross domestic product (figure 4). When it comes to the modal split and the number of start-ups, Leipzig appears to have more similarities with first-tier agglomerations such as Munich and Hamburg. Considering these time-related structural variables, Leipzig can be considered as a very dynamic city with a strong potential of development, which makes it an interesting case study from a scientific point of view.

According to the variables V1 to V6, Hamburg is regarded as a rather untypical representative of cluster 1. This applies particularly to the lower population growth and the higher rise of the share of inhabitants older than 65 years. Nevertheless, regarding the snapshot variables V7 to V14, Hamburg perfectly represents the average of cluster 1.

The prevailing cluster analysis revealed that the 14 largest German cities can be divided clearly into two groups, showing not only different urban settings, but also a diverging

development pace. Analysing and implementing digitisation strategies should thus be adapted to both city types. Against this background, this study shifts the focus on conceptualising an urban living lab in Leipzig as representative of German second-tier cities. In the last chapter, a short outlook is done in order to introduce the second living lab which will take place in Hamburg (cluster 1).

3 Living labs as a research methodology

Living labs (also known as real-world laboratories, places of learning and urban offices) have caught on in international research over the past ten years (Defila and Di Giulio, 2018; Schneidewind and Scheck, 2014; Millington et al., 2015; Marvin et al., 2018). They were first developed and refined in sustainability research (Marvin et al., 2018; WBGU, 2011; Schneidewind and Singer-Brodowski, 2014) as well as in sociology and economics (Defila and Di Giulio, 2018).

In Germany, living labs have only received broad support since 2015 thanks to financial backing in the state of Baden-Württemberg. 'Urban offices' are being set up in the context of knowledge-based urban development during the IBA International Building Exhibition being held in Heidelberg, Baden-Württemberg from 2012 to 2022 under the motto 'Wissen schafft Stadt' ('Knowledge Based Urbanism') (Marquardt and West, 2016). Moreover, living labs are increasingly being used in various fields in response to the growing involvement of stakeholders in urban transformation processes, the establishment of new technologies in the course of digitisation, and tendencies in society towards individualisation (Masseck, 2017; Cosgrave et al., 2013; Cardullo et al., 2018).

What makes living labs so innovative is not the use of new research and participation methods but instead the novel combination of research methods (some of which are already tried and tested), the embedding of these methods in various practical contexts, and the real-time testing of social and technical innovations (Defila and Di Giulio, 2018). Although there is not yet any clear definition of living labs, some essential basic criteria have been identified in recent research (Defila and Di Giulio, 2018; Schneidewind and Scheck, 2014; Marquardt and West, 2016; Liedtke et al., 2012; Schäpke et al., 2017; MWK, 2013; Rogga et al., 2018):

- the transdisciplinary combination of research and practice, i.e. real-world experimentation an interdisciplinary research design
- the development of solutions to achieve socially legitimate goals (e.g. in sustainability), for instance by means of the participatory design and application of technology (normative)
- the networking, co-design and co-production of the research process among research organisations, public institutions, civil society, the private sector and community stakeholders (transformative)
- ensuring the continuous methodological reflection of the process

Collaboration between stakeholders is central to the success or failure of a living lab process. Cooperation allows the initiation of new research processes and offers the various stakeholders with their different views an opportunity to reformulate current research questions and research goals. However, who are the stakeholders – and what roles do they assume in living labs? Here, too, there has been a variety of attempts at definition. Cosgrave et al. (2013) name three key stakeholders – universities, the private sector and the public sector – along with their respective roles. Seebacher et al. (2018, figure 5) develop an open circular model, which allows for stronger differentiation between the stakeholders and their roles.

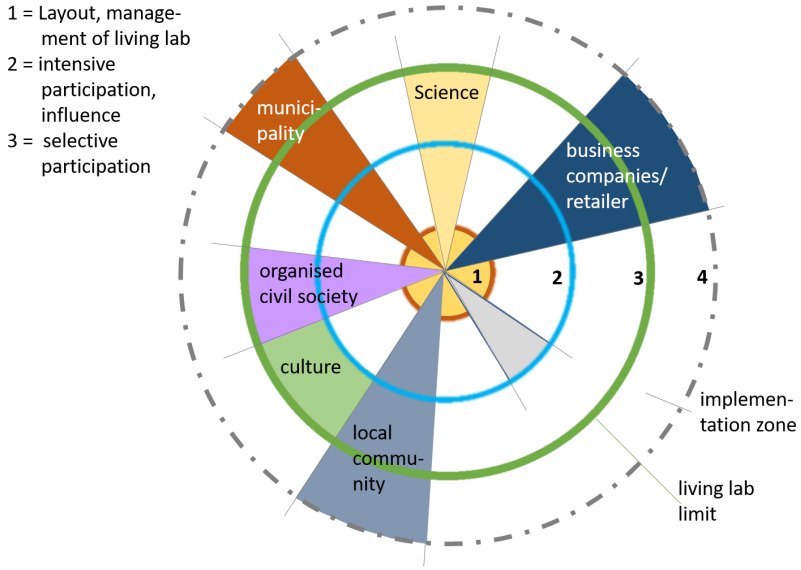

Fig. 5. Three-circle model of the stakeholder constellation in a living lab (own elaboration based on Seebacher et al., 2018).

In addition, living labs take place in concrete locations. The choice of location is therefore an important success factor in connection with the research aims (Marquardt, 2019). The biggest differences emerge regarding how living lab processes are actually carried out. Since living labs are used in very different contexts requiring very different questions and methodological approaches, the prospects for standardising process workflow are limited. Nevertheless, four key work modules along with their corresponding design criteria can be identified (Defila and Di Giulio, 2018; Beecroft, 2018, figure 6).

The theoretical frameworks were applied by way of example to the implementation of the new service sector and retail structure systems in Leipzig. The objective of the living lab process was to develop a corresponding reference procedure model including practical guidelines.

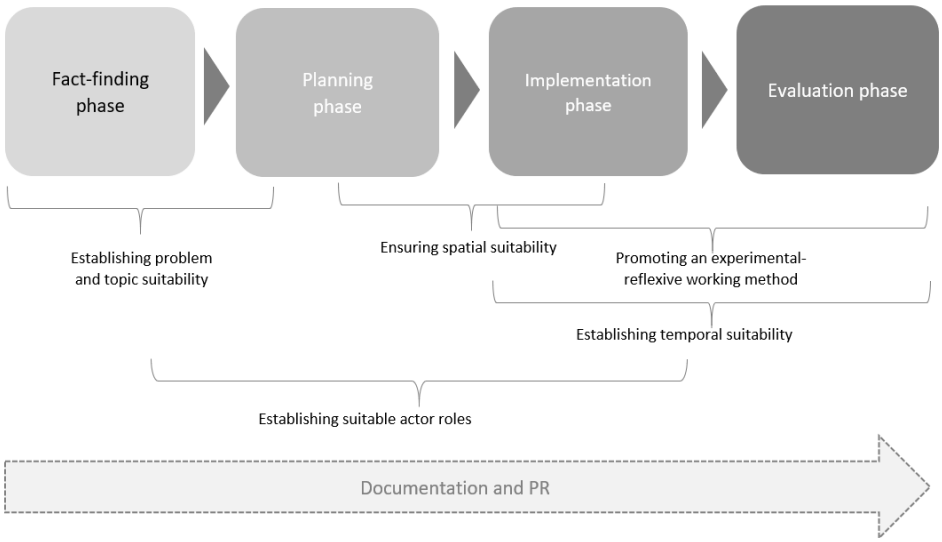

Fig. 6. Diagram of a living lab and design criteria (own elaboration based on Beecroft, 2018).

4 Conducting a living lab in the city centre of Leipzig

The following research questions were addressed within the scope of the living lab in the city centre of Leipzig as part of a research project: How can the opportunities that digitisation offer be used for the transformation of urban retail locations? How is it possible to apply universally valid research findings on current adaptation strategies in retail in relation to a city type? Which specific parameters (e.g. in the constellation of stakeholders) must be taken into account? As the living lab was conducted over a period of approximately nine months (2018 to 2019), a variety of methods was applied in order to address the research questions listed above. The methodology was composed of semi-structured interviews, group discussion, focus group interviews and participatory observations. Initial findings are presented below.

4.1 Living lab Leipzig city centre

With a current population of just under 600,000, Leipzig is a large city in Germany (cf. Cluster 2) that has been growing dynamically over the past years. The retail structure is characterised by a centrally located city centre and several district centres. With approximately 193,000 m² of retail space (representing approximately 44 % of the total retail space and 30% of the shops in Leipzig; Stadt Leipzig, 2013), the city centre plays an important role in the retail landscape of Leipzig. The retail structure in the city centre is still characterised by a comparatively high proportion of individual specialist retailers (approximately 50 %) (Stadt Leipzig, 2013). However, it is precisely the owner-managed

specialist retailers, which need specific support in adapting their business strategies to digitisation processes. The focus of the living lab was therefore on the city centre. The specialist retailers also played an instrumental role in carrying out the living lab.

Identification stage

Based on the research interest (cf. Point 1), the subject to be investigated was narrowed down during the identification phase. Using real-world application examples and digital tools, the living lab Leipzig was to investigate the degree of their acceptance, feasibility and practicability in the context of the retail structure of Leipzig.

An initial stakeholder analysis identified the central partners to be involved in the process. The broad constellation of stakeholders reflects the mix of uses of inner-city retail locations and takes into account possible synergetic effects between the different uses. At the same time, it became clear that the living lab Leipzig could play a mediating role between the city administration (and its offices) and individual stakeholders, public institutions, associations and the individual stakeholders from retail, food service and the hotel industry. Until then, cooperation had only taken place on a project-related or event-related basis (e.g. for the annual Leipzig Passagenfest, cf. existing stakeholder constellation).

Planning stage

At the centre of the planning stage was the establishment of a task group, which would continuously exchange information on the goals and the implementation of the living lab and accompany the living lab process through to the evaluation stage. The objective was to bring as many stakeholders involved in the subject matter as possible into contact with each other and, if necessary, to initiate possible co-operations that would discuss the central challenge of digitising local, urban retail stores and develop joint solutions.

In preparation for the living lab test phase (09 November to 17 November 2018), the task group inner-city stakeholders met approximately every three months. Additional individuals according to specific requirements supplemented the group. In order to find answers to specific questions, further smaller task units were formed, such as the delivery logistics group, in which selected retailers were involved as well as LVZ Post GmbH as a logistics service provider and the project partner check mobile as a software developer. For greater public awareness, a public participation event was held in April 2018 to which retailers, service providers, stakeholders etc. from Leipzig city centre were invited (figure 7).

The content of the living lab was designed with regard to the application examples and tools to be tested, focusing on their possible use in stationary retail: mixed reality hololens, virtual reality headset, beacons, delivery logistic app and digital city platform. For the living lab testing stage, vacant retail space in a prime location in the city centre of Leipzig was selected (the space was provided free of charge by Karstadt Leipzig). The key factors for this choice were a high customer frequency and large display window areas facing the public space so that a high level of visibility of the living lab area was ensured.

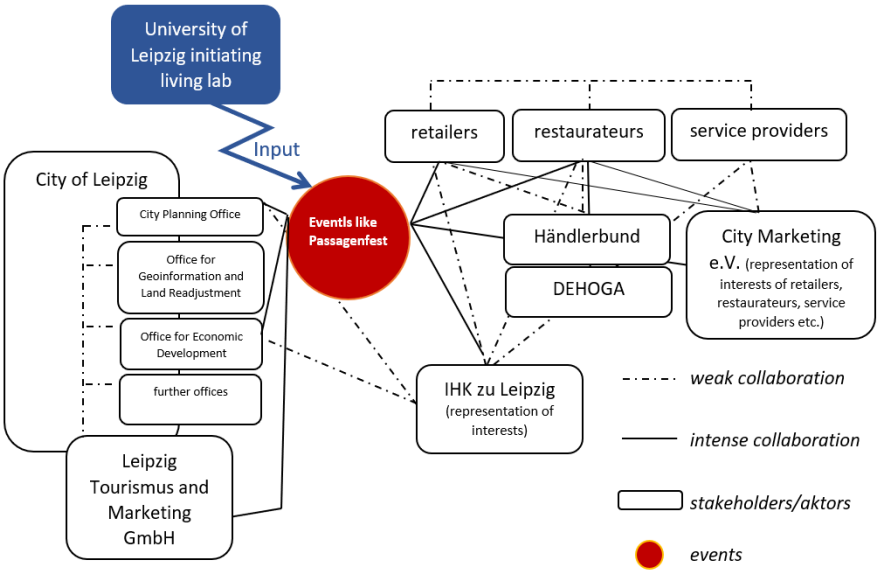

Fig. 7. Existing stakeholder constellation with regard to the development of the inner-city retail location (own elaboration).

Implementation stage

The living lab testing stage took place from 09 November to 17 November 2018. The living lab was open from 10:00 am to 20:00 pm corresponding to the usual shop opening hours. The testing area was deliberately designed as a modern and contemporary retail fair space (figure 8).

The testing stage was promoted through an opening event and extensive public relations (local press, radio, etc.). All stakeholders involved were invited to participate. The period of just over one week deliberately included two Saturdays, the days with the highest revenues. This resulted in a high level of customer response.

The living lab test area was provided with assistance to explain the tools and to support testing as well as the direct exchange with the test subjects. The results were documented. A significant benefit of the living lab test area was the direct involvement of citizens, customers and city visitors as key stakeholders in retail. As a result, it was possible to incorporate this perspective into the research approach. Relevant findings were gathered through qualitative interviews, a quantitative survey and observation during testing. Retailers also took the opportunity to find out more about the digital tools presented and to test them. For the members of the task group inner-city stakeholders, the testing stage was essential in enabling them to further deal with the challenge of digitisation for the stationary inner-city retail.

Evaluation stage

The analyses of the application of the actual tools (such as mixed reality hololens, virtual reality headsets and digital city map) showed that their use met with great interest on the part of the potential users. These and other digital tools thus have significant potential in increasing the appeal of stationary retail. They foster the trend towards city centre shopping, especially regarding medium- and long-term demand.

The test of the delivery logistics app revealed several pending questions that will need to be addressed in further detail (e.g. insurance regulations for the interim storage of purchased goods when various retailers are involved). In addition, it became clear that there is not enough demand for the delivery of goods purchased on-site. Rather, there is greater demand for online ordering options in combination with pick-up options from the shop (click and reserve or click and collect). From this follows a need for action for the implementation of such services by owner-managed specialist retailers. A joint approach would be a unique selling point to increase the attractiveness of the retail location in the city centre.

In addition, it became clear that the implementation of individual digital tools (such as mixed reality hololens, virtual reality headsets, etc.) strongly depends on the interest and the financial resources as well as the product range of the respective retailers. This means that individual solutions need to be found.

There is also great interest on the part of retailers in increasing the digital visibility of the retail range on offers in the city centre. However, implementation requires a comprehensive coordination process and support from higher-level structures (such as the city administration, central city marketing, etc.). Furthermore, an appropriate solution must be flexible enough to be able to respond to the highly individualised initial conditions of a single retailer. The findings from the living lab in the city centre of Leipzig prove that even in smaller cities, local retailers are aware of the pressure of digitisation, but also of its opportunities. However, to what degree large cities already have already adopted to these aspects is researched within the second living lab in Hamburg (cluster 1).

Fig. 8. Impressions of the living lab testing stage in Leipzig city centre (photos: the authors).

4.2 Reflections on the living lab Leipzig city centre

The task group inner-city stakeholders discussed the results of the living lab. A reflection of the results took also place within the research group. These discussions resulted in three main aspects:

- In the future, the use of digital tools in stationary retail will become part of everyday life. Given Leipzig's city size (cluster 2), there is a comprehensive need for adaptation on the part of stationary retailers, especially regarding owner-managed specialist retailers. This includes both individual solutions and concepts that should be understood and endorsed as a collaborative task. This common task does not only relate to inner-city retailers but also to central players including restaurateurs as well as hoteliers and others.
- The awareness of the city administration of being an important player in the digitisation process has increased. This also includes stronger cooperation of various public authorities in the future. Authorities such as the city planning office, the office for geoinformation and land readjustment, the office for housing construction and urban renewal as well as the office for business development will need to work together closely to establish an urban data platform. In the future, this digital infrastructure could serve as an interface between the city, its retailers, restaurateurs, cultural institutions etc. The department for digitisation, a newly established unit in Leipzig's city administration, could play a strategic role as a mediator in this regard.
- In view of potentially conflicting interests of retail development and urban development, the involvement of the implementation level stakeholder in the living lab process will be essential for successful stakeholder involvement. In addition to generating valuable research data, a living lab thereby offers the opportunity to provide targeted impulses for practical application.
- Regarding the period, it became clear that a minimum of nine months appears to be necessary for a living lab process.

On the one hand, the living lab testing stage provides essential insights into the long-term viability of digital tools in stationary retail. On the other hand, the implementation of this process highlights the opportunities associated with a transdisciplinary and transformative research method.

5 Conclusions

This paper discusses how digitisation contributes to urban transformation processes in large cities. We argue that the impact of digitisation differs between large cities according to their overall development and dynamic. They focus on second-tier large cities because there is a lack of solutions and research so far. Furthermore, retail is part of the analysis as a relevant field of urban development and digitisation dynamic.

A cluster analysis of large cities is applied as the first methodological approach to analyse different dynamics and development. Two clusters are identified with more intensive and

less intensive development, regarding aspects such as demography, economy, tourism, retail and sustainability. It is particularly interesting that the cluster analysis left out the cities' sizes and yet clusters emerged that ultimately correspond to this variable. When it comes to digitisation in particular, it seems that cities of the first cluster are more dynamic than cities of the second cluster. Leipzig, as a city of the second cluster, shows a high dynamic but a lower innovative activity than cities of the first cluster. The city is set into focus for further analysis during a living lab.

A living lab in Leipzig is applied as the second methodological approach in order to analyse digitisation activities within urban development in second-tier large cities. The living lab consists of four relevant stages that include an Identification stage, Planning stage, Implementation stage and Evaluation stage. The overall process took nine months and proofs to be just enough time to successfully contribute to all four stages. Nevertheless, certain processes such as the delivery logistics app could not be completed. The phases of the living lab in Leipzig confirm the theoretical approaches. For example, the interdisciplinary context laid the foundation to get in contact with diverse relevant stakeholders (Identification stage) that helped to set the opportunities and limitations (Planning stage), which would otherwise not have been possible within the relatively short amount of time. It turns out that it is of elementary importance to conduct research in interaction with practice over a longer period, in order to realise practicable solutions. The living lab in Leipzig made this possible and made clear that transformative approaches are valuable from science into practice and vice versa (Implementation stage). Given the fact that the period of the living lab in Leipzig could not possibly be extended over nine months, it was only possible to release an impulse for the need of successful stakeholder involvement in the line with digitisation. Furthermore, the amount of people visiting and commenting on the digital tools (Evaluation stage) remains extremely relevant, due to the good location of the living lab in the Petersstrasse, one of the main retail locations in the city centre of Leipzig (Schade and Hübscher 2018). A second living lab based on the final results of the research project would be interesting. In general, the living lab in Leipzig has shown the gap between the period of time of research projects and development processes for retailers and cities. In addition, there are limited experiences with living labs in the context of retail and inner-city development. Therefore, further research projects have to deal with useful project periods and have to point out the possibilities and limits of living labs for science and practice.

In summary, the cluster analysis reveals a basic structure and living labs prove to be an increasingly important component of research, particularly in practice-oriented topics such as retail (unlike, for example, topics with higher entry barriers). Some conclusions can already be drawn for the upcoming living lab in Hamburg, but these must be adapted individually to the development of the city.

In large cities, municipalities tend to become key stakeholders in digitisation processes. For years, cities have gathered information of public concerns for research and development strategies. Due to digitisation, smart cities are now able to allow open data use and support citizen involvement. In order to do that, municipalities, businesses, research institutes, interest groups and the public need to work together and create interfaces with each other (Barns et al., 2017). The development of so-called urban data platforms leads to smart cities

becoming cross-channel service providers, enriching the built city with digital information. Hamburg is one of the first large cities in Germany that is developing an urban data platform, which is why another urban living lab is conducted there. Leipzig, as a second-tier German city started to set the goals towards such a platform. In both large cities' platform planning strategies, retail does not play a role yet, even though digital solutions fit perfectly to retail in the city. In order for retail to find its way into the development of the urban data platform in Leipzig, it is necessary to bring different stakeholders together. A start is the described living lab that is enabled through a research project which addresses both the city administration with its various relevant offices, as well as retail companies, service providers and the general population in the form of city centre visitors.

In the future, digital cities have to develop according to people's needs (Graham and Peleg, 2016). Retail can possibly be one of the urban functions that allows diverse interfaces with the smart city to develop cross-channel retail and obtain city centres' attractiveness and liveliness.

References

Arlott A, Henike T, Hölzle K (2019) Digital Entrepreneurship and Value Beyond: Why to Not Purely Play Online. In Digitial Entrepreneurship (Baierl R, Behrens J and Brem A (ed.)). Springer, Cham, CHE, pp. 523-545.

Bacher J (1989) Einführung in die Clusteranalyse mit SPSS-X für Historiker und Sozialwissenschaftler, Historical Social Research 14: 6-167.

Backhaus K, Erichson B, Plinke W and Weiber R (2016) Multivariate Analysemethoden. Eine anwendungsorientierte Einführung. Springer, Berlin/Heidelberg, GER. Vol. 14.

Bakdash J and Marusich L (2017) Repeated Measures Correlation. Frontiers in Psychology 8(465): 1-13.

Barns S, Cosgrave E, Acuto M and Mcneill D (2017) Digital Infrastructures and Urban Governance. Urban Policy and Research 35(1): 20–31.

Beecroft R, Trenks H, Rhodius R, Benighaus C and Parodi O (2018) Reallabore als Rahmen transformativer und transdisziplinärer Forschung: Ziele und Designprinzipien. In Transdisziplinär und transformativ forschen (Defila R and Di Giulio A (eds.)). Springer Fachmedien, Wiesbaden, GER, pp.75–100.

Berger S, Koppel O and Röben E (2017) Deutschlands Hochburgen der Digitalisierung. IW-Kurzberichte, Institut der deutschen Wirtschaft (IW), 42. See https://www.econstor.eu/bitstream/10419/162543/1/890553629.pdf (accessed 18/07/2018).

BIAJ Bremer Institut für Arbeitsmarktforschung und Jugendberufshilfe (2017) Entwicklung der registrierten Arbeitslosigkeit in den 15 Großstädten von 2008 bis 2016. See http://biaj.de/images/2017-01-25_biaj-grossstaedte-ranking-alo-quoten-2008-2016.pdf (accessed 19/07/2018).

BBSR (Bundesinstitut für Bau-, Stadt- und Raumwirtschaft) (ed.) (2017) Online-Handel – Mögliche räumliche Auswirkungen auf Innenstädte, Stadtteil- und Ortszentren. BBSR-Online-Publikation 08/2017, Bonn, GER.

Bundesinstitut für Bevölkerungsforschung and Destatis Statistisches Bundesamt (2016) Zahlen und Fakten: Alterung regional unterschiedliche weit fortgeschritten. Bevölkerung im Alter von über 65 Jahren nach Kreisen, 2015. See https://www.demografie-portal.de/SharedDocs/Informieren/DE/ZahlenFakten/Aeltere-Bevoelkerung.html (accessed 19/07/2018).

Burth, Andreas (2016) Rankings über das Pro-Kopf-Bruttoinlandsprodukt der kreisfreien Städte und Landkreise in Deutschland. See https://www.haushaltssteuerung.de/weblog-rankings-ueber-das-pro-kopf-bruttoinlandsprodukt-der-kreisfreien-staedte-und-landkreise-in-deutschland.html#hoechstes-bip (accessed 19/07/2018).

Cardullo P, Kitchin R and Di Feliciantonio C (2018) Living labs and vacancy in the neoliberal city. Cities 73(2018): 44–50.

Chatfield C and Collins A (2000) Introduction to Multivariate Analysis. Texts in Statistical Science. Chapman & Hall/CRC, Boca Raton, USA.

Cosgrave E, Arbuthnot K and Tryfonas T (2013) LivingLab, Innovation Districts and Information Marketplaces: A Systems Approach for Smart Cities. Procedia Computer Science 16(2013): 668–677.

Defila R and Di Giulio A (2018) Transdisziplinär und transformativ forschen. Springer Fachmedien, Wiesbaden, GER.

Destatis Statistisches Bundesamt (2018a) Ausländerstatistik. See https://www-genesis.destatis.de/genesis/online/data;jsessionid=B0706E3D4D878297F150ED7813BD10DD.tomcat_GO_2_1?operation=abruftabelleBearbeiten&levelindex=1&levelid=1529425573646&auswahloperation=abruftabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&selectionname=12521-0040&auswahltext=%23Z-31.12.2017%2C31.12.2007&werteabruf=Werteabruf (accessed 19/07/2018).

Destatis Statistisches Bundesamt (2018b) GENESIS-Online Datenbank: Bevölkerung, Kreise, Stichtag, Geschlecht, Altersgruppen. Bezogen von Govadata - Das Datenportal für Deutschland. See https://www.govdata.de/web/guest/daten/-/details/destatis-service-12411-0017 (accessed 19/07/2018).

Destatis Statistisches Bundesamt (2018c): Regionalatlas Deutschland: regionale Daten in interaktiven Karten visualisiert. See https://www-genesis.destatis.de/gis/genView?GenMLURL=https://www-genesis.destatis.de/regatlas/AI-N-10.xml&CONTEXT=REGATLAS01 (accessed 19/07/2018).

GfK Geomarketing GmbH (2017): Pressemitteilung: Kaufkraft der Deutschen steigt 2018 um 2,8 Prozent. See https://www.gfk.com/fileadmin/user_upload/dyna_content/DE/documents/Press_Releases/2017/20171212_PM_GfK_Kaufkraft_Deutschland-2018_dfin.pdf (19/07/2018).

Gondringer H (2004) Immobilienwirtschaft. Handbuch für Studium und Praxis. Verlag Vahlen, München, GER.

Graham C and Peleg A (2017) Will a Smart City Have a High Street? In Sustainable Smart Cities: Creating Spaces for Technological, Social and Business Development (Peris-Ortiz M, Bennett D and Pérez-Bustamante Yábar D. (eds.)). Springer, Cham, CHE, pp. 143–157.

Greenpeace e.V., Moser D (2017) Städteranking zur nachhaltigen Mobilität. See https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/20170322_greenpeace_mobilitaetsranking_staedte.pdf (accessed 19/07/2018).

HDE (Handelsverband Deutschland) (2018) Online Monitor 2019 Germany. See https://einzelhandel.de/online-monitor (accessed 03/06/2019).

Hesse S (2014) Clusteranalyse und Display-Methoden. See http://www.lbua.uni-jena.de/umweltanalytik_multimedia/Praktikum+UA+II/Clusteranalyse.pdf (accessed 03/08/2018).

Koppel O (2016) Digitalisierung: Defizite bei Informatikern und Internet lähmen ländliche Regionen. IW-Kurzberichte, Institut der deutschen Wirtschaft (IW), 74. See https://www.econstor.eu/bitstream/10419/157580/1/IW-Kurzbericht_2016-74.pdf (accessed 18/07/2018).

Korzer T (2013) Learning from shopping centres: Perspectives for retail development in the centres of towns. Revista Lusófona de Arquitectura e Educação 8: 321-340.

Liedtke C, Welfens M, Rohn H. et al. (2012) LIVING LAB: User-driven innovation for sustainability. International Journal of Sustainability in Higher Education 13(2): 106–118.

Lilliefors H (1967): On the Kolmogorov-Smirnov Test for Normality with Mean and Variance Unknown. Journal of the American Statistical Association 62(318): 399–402.

Marquardt E (2019) Hochschule und Stadt als Partner. In Bayerisches Staatsinstitut für Hochschulforschung und Hochschulplanung (2019) Hochschulräume, Beiträge zur Hochschulforschung issue 01/2019, München, GER, pp. 108–123.

Marquardt E and West C (2016) Co-Produktion von Wissen in der Stadt. TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 25(3): 27-31.

Marvin S, Bulkeley H, May L, McCormick K and Voytenko Palgan Y (2018) Urban Living Labs – experimenting with city futures. Routledge, New York, USA.

Masseck T (2017) Living Labs in Architecture as Innovation Areas within Higher Eduation Institutions. Energy Procedia 115(2017): 383–389.

Millington S, Ntounis N, Parker C and Quin S (2015) Multifunctional Centres: a sustainable role for town and city centres. Institute of Place Management Manchester Metropolitan University. ESRC, High Street UK2020 project.

Monheim R (2017) Die Entwicklung des Passantenaufkommens in der Münchner Innenstadt unter dem Einfluss der Ansiedlung der Fünf Höfe und der Hofstatt und der Verkehrsberuhigung der Sendlinger Straße. Berichte des Arbeitskreises Geographische Handelsforschung. Zukunft des stationären Handels 42: 24–26.

Muncke G, Dziomba M and Walther M (2005) Standort- und Marktanalysen in der Immobilienwirtschaft – Ziele, Gegenstand, methodische Grundlagen und Informationsbeschaffung. In Handbuch der Immobilienprojektentwicklung (Schulte W and Bone-Winkel S (eds)), Müller, Köln, GER, vol. 2., pp. 129-200.

MWK (Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg) (2013) Wissenschaft für Nachhaltigkeit. Herausforderung und Chance für das badenwürttembergische Wissenschaftssystem. MWK, Stuttgart, GER. See https://www.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/Broschüre_Wissenschaft_für_Nachhaltigkeit.pdf (accessed 25/05/19).

Rogga S, Zscheischler J and Gaasch N (2018) How Much of the Real-World Laboratory Is Hidden in Current Transdisciplinary Research? GAIA - Ecological Perspectives for Science and Society, 27(S1): 18-22.

Rousseeuw P and Kaufman L (2005) Finding Groups in Data. An Introduction to Cluster Analysis. John Wiley & Sons, New Yersey, USA.

Sassen S (2007) The Global City. In A Companion to the Anthropology of Politics (Nugent D and Vincent J (eds.)). Blackwell Publishing, Malden, USA, pp. 168-178.

Schade K and Hübscher M (2018) Handelslagen der Zukunft: urban, vernetzt, digital? Ein Plädoyer für belebte Innenstädte in Zeiten der Digitalisierung. UrbanLab Magazin. Fachzeitschrift für Stadt- & Regionalplanung. 3: 128–132.

Schade K, Hübscher M and Korzer T (2018) Smart Retail in Smart Cities: Best Practice Analysis of Local Online Platforms. In: Proceedings of the 15th International Joint Conference on e-Business and Telecommunications, ICETE 2018 (Callegari C, Van Sinderen M, Novais P, Sarigiannidis G, Battiato S., Serrano Sánchez de León A, Lorenz and Obaidat MS (eds.)) SciTePress, Porto 2018, POR, pp. 147–157.

Schendera C (2010) Clusteranalyse mit SPSS. Mit Faktorenanalyse. Oldenbourg Verlag, München, GER.

Schneidewind U and Scheck H (2014) Die Stadt als „reallabor“ für Systeminnovationen. In Soziale Innovation und Nachhaltigkeit (Rückert-John J (ed.)) Springer Fachmedien, Wiesbaden, GER, pp. 229–248.

Schneidewind U and Singer-Brodowski M (2014) Transformative Wissenschaft. Klimawandel im deutschen Wissenschafts- und Hochschulsystem. Metropolis, Marburg, GER.

Schäpke N, Stelzer F, Bergmann M, Singer-Brodowski M, Wanner M, Caniglia G and Lang DJ (2017) Reallabore im Kontext transformativer Forschung. Ansatzpunkte zur Konzeption und Einbettung in den internationalen Forschungsstand, IETSR Discussion Papers in Transdisciplinary Sustainability Research 1(2017): 1-62.

Seebacher A, Alcántara S and Quint A (2018) Akteure in Reallaboren - Reallabore als Akteure. In Transdisziplinär und transformativ forschen (Defila R and Di Giulio A (eds.)). Springer Fachmedien, Wiesbaden, GER, pp. 155–159.

Stadt Leipzig (2013) Monitoringbericht Einzelhandel. Leipzig, GER. See https://www.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/61_Stadtplanungsamt/Stadtentwicklung/Monitoring/Monitoring_Einzelhandel/Monitoringkurzbericht_Einzelhandel_2013.pdf (accessed 25/05/19).

Statista (2016) Städte-Ranking: Übernachtungen im Beherbergungsmarkt und in Privatunterkünften in Deutschland 2015. Erhebung durch GBI AG. See https://de.statista.com/statistik/daten/studie/537246/umfrage/uebernachtungen-im-beherbergungsmarkt-und-in-privatunterkuenften-in-deutschen-staedten/ (accessed 19/07/2018).

Statista (2017) Anzahl der Carsharing-Fahrzeuge in ausgewählten deutschen Städten. Erhoben durch Bundesverband Carsharing. https://de.statista.com/statistik/daten/studie/460538/umfrage/carsharing-anzahl-der-fahrzeuge-in-deutschen-staedten/ (accessed 19/07/2018).

Statista (2018a) Mieten für Einzelhandelsflächen 120-260 m² in 1a-Lage deutscher Großstädte. Erhoben durch Brockhoff & Partner. See https://de.statista.com/statistik/daten/studie/377058/umfrage/mieten-fuer-einzelhandelsflaechen-120-260-qm-in-1a-lage-deutscher-grossstaedte/ (accessed 19/07/2018).

Statista (2018b) Mieten für Einzelhandelsflächen 60-120 m² in 1a-Lage deutscher Großstädte. Erhoben durch Brockhoff & Partner. See https://de.statista.com/statistik/daten/studie/377095/umfrage/mieten-fuer-einzelhandelsflaechen-60-120-qm-in-1a-lage-deutscher-grossstaedte/ (accessed 19/07/2018).

Statista (2018c) Privatinsolvenzen in den 20 größten Städten in Deutschland 2017. Erhoben durch CRIF Bürgel GmbH. See https://de.statista.com/statistik/daten/studie/182592/umfrage/staedte-mit-den-meisten-privatinsolvenzen/ (accessed 19.07.2018).

Statistische Ämter des Bundes und der Länder (2018) Einwohnerzahl der Großstädte in Deutschland 2016. Statista. See https://de.statista.com/statistik/daten/studie/1353/umfrage/einwohnerzahlen-der-grossstaedte-deutschlands/ (accessed 18/07/2018).

Stepper M (2016) Innenstadt und stationärer Einzelhandel – ein unzertrennliches Paar? Was ändert sich durch den Online-Handel? Raumforschung und Raumordnung 74(2): 151–163.

Van Winden W and De Carvalho L (2017) How digitalization changes cities – innovation for the urban economy of tomorrow. Discussion paper for a conference, Witten, GER. See https://business.metropoleruhr.de/fileadmin/user_upload/Studie__Cities_and_digitalization__Euricur_wmr.pdf (accessed 11/02/2020)

WBGU (Wissenschaftlicher Beirat für Globale Umweltveränderungen) (2011) Welt im Wandel. Gesellschaftsvertrag für eine Große Transformation, WBGU, Berlin, GER. See http://www.wbgu.de/hauptgutachten/hg-2011-Transformation (accessed 25/05/2019).

Supplementary Material

Supplementary material (Figures S1, S2 and S3) is available at:
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