Measuring policy debate in a regrowing city by sentiment analysis using online media data: a case study of Leipzig 2030

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ABSTRACT
In a time of data science, online crowdsourced data and advanced data analytics would be a waste of resources and knowledge if these tools wouldn't assist urban planning. This paper uses sentiment analysis to understand policy debates' present in online media in a re-urbanized city and discusses how these tools and new datasets can help planners and inform new waves of policy by including groups that tend to be underrepresented in traditional consultation meetings. Modern reurbanisation is an emergent phenomenon occurs in cities that experienced urban shrinkage in the past decades. Urban policies proposed to the 'new' regrowing cities should meet challenges of old shrinking consequences and new regrowing demands. Nowadays, policymakers need to hear the voice from different age groups, some use new, non-traditional media in policy debates. Online media data has the potential to provide quasi-live feedbacks, to supply the traditional opinion surveys. We applied sentiment analysis in the selected case - the Integrated Urban Development Concept (INSEK) Leipzig 2030 – to evaluate public opinion. While results show that public attention was low, the policy seems to be welcome, with the public showing more interests in regrowth topics than shrinkage issues.

KEYWORDS
sentiment analysis; urban regrowth; public opinion; online data, social media

1. INTRODUCTION

As crowdsourced online data is increasingly used in urban planning, researchers have applied many data analytical techniques to harvest new data such as social media in recent years. Online media data is one kind of new data sources that show its unique value in providing quasi-real-time information (Silva et al., 2020). Guided by collaborative planning, urban planning nowadays aims at gathering more opinion from different stakeholders in many different types of media. The means of public participation can be improved during the data science era. For instance, the voice of the youths would be underrepresented if the public opinion is only collected through traditional media such as citizens' meeting and public workshops because the young populations tend to be absent from these public involvement events (Loader et al., 2014). The online social media has an overrepresentation on the younger

generation. For example, around 60 % of social media users in Germany are from 18 to 34 years old (We Are Social and Hootsuite, 2020). The discussions from online media have the potential to supply conventional public participation. Apart from the new data source, new data analytic techniques such as sentiment analysis can be used to explore new insights into conventional issues (e.g. politic acceptance) in cities. Sentiment analysis has been applied to quasi-real-time datasets for providing quick data analytics results. Thus, it can contribute to smart governance through effectively revealing the opinion towards policies in cities (Niu and Silva, 2020; Silva et al., 2020). In policy analysis, sentiment analysis can be used to quantify the satisfactory level of policy discussants and identify hot topics in urban policy debates. Positive public sentiment means a higher level of policy acceptance while negative public sentiment demonstrates a lower policy acceptance. Policy acceptance can further influence on the actual impacts of a policy (Wlezien, 2017; Jaeger et al., 2017).

Cities in Europe are in many cases confronted with urban shrinkage and regrowth, which increases the complexity of planning and raises policy debate with unpredictable outcomes as population, stakeholders and local authorities in growing areas will emphasize issues that are different from those in shrinking and regrowing areas. Apart from the continuous growth in some cities, an increasingly frequent urban trajectory is urban regrowth after a phase of urban shrinkage, which can be observed in many German and British cities (Haase, 2015; Haase et al., 2018). Urban shrinkage is characterized by being a phenomenon that a densely populated urban area (more than 10,000 people) has experienced a population loss and associated economic problems for over two years (Pallagst, 2009). Urban regrowth usually refers to the population increasing process after urban shrinkage; however, it can occur simultaneously in different areas with other processes such as urban shrinkage in a national, regional, or city scale (Wolff et al., 2017). For example, we can observe both regrowing districts and shrinking areas in a regrowing city such as Leipzig (Wolff et al., 2017). These processes are happening all over the world and Europe seems to be actively pursuing policies and programs to tackle the shrinkage and regrowth (Mace and Volgmann, 2017). The post-shrinkage regrowth stage is both challenging and opportune. The urban strategies in the regrowth process need to respond to shrinking impacts such as brownfield and regrowing requirements such as new housing demand, which could raise sometimes conflicting policy debates because different stakeholders have various interests in this process. Thus, it is important to analyze the policy debates in order to better understand the public interests.

The long-term shrinking city Leipzig now is regrowing. Its urban policies have shifted from shrinkage-oriented in the 2000s to regrowth-oriented in the 2010s. The shrinkage-oriented policies since the beginning of the 21_{st} century included Redevelopment East (Stadtumbau Ost), the Urban Development Plan (Stadtentwicklungsplan STEP), and Integrated City Development Concept (SEKo Leipzig 2020) (Florentin, 2010; Green et al., 2017). Now

Leipzig enters a stage that planning policies need to address the previous shrinking impacts and current regrowing challenges (Wolff et al., 2017; Florentin, 2010). The new urban planning policy in the regrowing city Leipzig - Integrated Urban Development Concept (INSEK) Leipzig 2030 – was passed by Leipzig city council on May 31st, 2018 (Template No. VI-DS-04159-NF-01) (Leipzig, 2018). In this research, we analyze the policy debate and acceptance of INSEK Leipzig 2030 and link it with shrinking and regrowing strategies - trying to evaluate how the public interacted with it before/after implementation and how can we use new information and communication technologies (ICT) and data in the planning system, improving the policy development and implementation.

In this study, we collected live data, including online news and social media posts (tweets), on the policy INSEK Leipzig 2030 to discover the public opinion in terms of attention and sentiment. This research aims to measure the policy debate in the case of the policy Leipzig INSEK 2030 using online media data. The online media platforms provide channels for different stakeholders to debate on specific topics. Harvesting the sentiment of the online policy debate can generate valuable insights from discussants using the Internet. The sentiment and key themes from policy debate can indicate whether the policy is well accepted. Furthermore, the finding could show potential policy effectiveness and impacts.

2. PUBLIC OPINION MINING (SENTIMENT ANALYSIS), URBAN SHRINKAGE AND REGROWTH, AND LEIPZIG INSEK 2030: A REVIEW

2.1. Public opinion in the data science era – sentiment analysis as an instrument in the analysis of policy debates

Data Science is a multidisciplinary science of extracting insights from data with scientific methods, algorithms and systems (Cao, 2017). In urban studies, Data Science explores information from what is known as 'raw data pool' where data is harvested (i.e. vast amounts of data from the Internet) and produces data products (e.g. data-driven urban decisions) using data-mining techniques (Niu and Silva, 2020). More algorithms from data science have been applied in urban analytics including urban policy analysis (Richardson, 2015). Traditionally, policymakers used human contact and media outreach to collect public opinion. Tools from data science in policy analysis allow the data collection and analysis process to be more efficient (Chung and Zeng, 2016). For example, sentiment analysis, a powerful tool of data science, has been applied to detect, extract, and analyze public policy contexts and discussions (Ceron and Negri, 2016; Chung and Zeng, 2016).

Sentiment analysis, also known as opinion mining, has developed many methods to identify whether the context is subjective or objective or if the opinion is positive or

negative (Serrano-Guerrero et al., 2015; Puri et al., 2018). It has reshaped the social and political systems with the supplement of social media data in evaluating public acceptance (Serrano-Guerrero et al., 2015). Sentiment analysis has been adopted in monitoring public opinion about business analytics (Ulbricht et al., 2017; Garcia-Medina et al., 2018), political preferences (Oliveira et al., 2017; Yaqub et al., 2017), and urban studies (Estevez-Ortiz et al., 2016; Hollander and Renski, 2017). Sentiment analysis is an instrument to analyze public opinion. Public opinion can be measured by media content, including online news media and social media (Oehl et al., 2016).

For urban governance, opinion data harvesting and mining can help decision makers to justify state interventions and to detect early feedbacks of citizens towards policies. Many of the applications using these new datasets will identify the potential disruption and failure of implementing policies, which in turn warn policymakers (Osimo and Mureddu, 2012). In this era of big data, a key subset of this data that is becoming crucial is opinion miningthat is now used for smart city and smart governance, marketing, risk assessment, etc (Puri et al., 2018; Estevez-Ortiz et al., 2016; Kumar and Sharma, 2017). Thus, we intend to use sentiment analysis approach to understand planning policy discussions in this study.

2.2. Urban Shrinkage and Urban Regrowth

Urban growth often associates with increasing population, economy and expanding land use while urban shrinkage often links with decreasing population, economy and land use (Reis et al., 2016). Modern urban shrinkage has been one of the key challenges that urban governors have had to face (Radzimski, 2018). Most of the large cities have been hit by urban shrinkage in the late 20_{th} century, including Leipzig, Liverpool and Manchester (Haase et al., 2016a; Haase et al., 2018). Demographic change, economic transformation, and suburbanization have been cited as the main contributors to modern urban shrinkage (Syssner, 2016). Many researchers identified shrinking areas, summarized the characteristics and explained the shrinking trajectories (Wolff and Wiechmann, 2018; Long and Wu, 2016; Haase et al., 2016b). Recent studies explored the urban policies and strategies in shrinking cities, especially in Germany (Rall and Haase, 2011; Heinrich, 2013; Ozatagan and Eraydin, 2014; Hospers, 2014; Haase et al., 2016a; Martinez-Fernandez et al., 2016; Rink and Siemund, 2016; Mallach et al., 2017).

While many Eastern European cities are still shrinking today, some cities start to regrow since the 1990s (Haase et al., 2018). Post-shrinkage urban regrowth is defined as 'the emergence of new population growth after several decades of decline'. About 11% of European cities are undergoing regrowth. The regrowth phenomenon can be observed in the whole city or parts of a city (Wolff et al., 2017; Haase et al., 2018). The regrowth concept has been understood in various ways such as re-urbanization, re-centralization, re-concentration, re-

settlement or return of inhabitants (Couch and Fowles, 2019; Haase and Rink, 2015; Wolff and Wiechmann, 2018). Urban regrowth shares some similarities with continuous urban growth. However, the crucial and qualitative difference is that regrowing cities have shrinking legacies, positive or negative (Haase et al., 2018). Thus, regrowing cities are required to manage the consequences of long-term shrinkage and the new challenges of regrowth simultaneously. The shrinking legacies include low density, abandoned land, housing vacancies, brownfield sites, and negative city image that discouraged investment (Mallach et al., 2017; Boland, 2008). The new challenges of regrowth contain reuse of brownfields, gentrification, new housing and new infrastructure demands in fast-growing inner cities (Wolff et al., 2017; Kabisch et al., 2019b). The research and policy debate on urban regrowth is rather new (Kabisch et al., 2019b).

We broadly classify urban policies as growth-oriented, shrinking-oriented and regrowth-oriented policies based on previous articles (Haase et al., 2018; Reis et al., 2016). Most of the policy research focus on growth-oriented policies while shrinking-oriented and regrowth-oriented policies have only been analyzed by a small number of studies. A small number of researchers such as Hollander and Wiechmann have carried out research analyzing shrinking-oriented policies in long-term shrinking regions such as Baltimore, Youngstown and Leipzig (Bontje, 2018; Wolff and Wiechmann, 2018; Johnson et al., 2015; Wiechmann and Bontje, 2015). Many cities are actively planning for the regrowth process. Nevertheless, the characteristics and influences of regrowth in cities are not clearly understood and the assumptions in many regrowth-oriented planning strategies may be questioned (Couch and Fowles, 2019). For example, policymakers assume continuous regrowth in some cities, but some researchers doubt that the regrowth phase could be a transitory phase before the next shrinkage caused by the general ageing issue (Kabisch et al., 2019a). Also, the spatial unevenness of the regrowing districts within a city or region level makes it difficult to set strategic priorities in the policymaking process (Haase, 2015). Thus, regrowth-oriented policies require further demonstration.

In the German context, debates and policies can shape each other. For example, policies such as Redevelopment East was adjusted by the shrinking debates in the late 1990s. The hot debates on urban shrinkage in German reached its peak in the turning of the 21$_{st}$ century (1999 – 2002) (Nelle et al., 2017). Public opinion can shape the formation and outcome of public policy (Jaeger et al., 2017). Responding to the hot debate and negative public mood, a set of shrinkage-oriented policies (e.g. the STEP) were put forward since 2002 to manage urban shrinkage (Nelle et al., 2017). Hot topics in shrinking debates include out-migration, demographic change, deindustrialization, property restitution, political changes, job loss, suburbanization, housing oversupply and vacancy, worn-out infrastructure, demolition, disinvestment, environmental devastation, decay and urban crisis etc (Nelle et al., 2017; Haase and Rink, 2015). Since 2010, the shrinking trajectories in German cities started to differentiate – large cities such as Leipzig regrow while medium-sized cities continuously shrink. Debates

and policies shift to regrowth paradigm (Nelle et al., 2017). Hot topics in regrowing cities include in-migration, re-urbanization, rejuvenation, densification, gentrification, upgrading, displacement, development, reused brownfields, inner-city transformation, segregation, fragmentation, investment, attractions, transport hub, jobs, constructions, and affordable housing, etc (Haase and Rink, 2015; Wolff et al., 2017). Based on these key themes, we can figure out whether the current debates are more relevant to urban shrinkage or to urban regrowth.

2.3. Leipzig Initiatives and INSEK Leipzig 2030

Leipzig experienced urban shrinkage for decades and managed to deal with it at an early stage in around 2000. The strategies in Leipzig included urban renewal projects, temporary use of vacant properties, active inner-city development, and unique integrated planning (i.e. the STEP and SEKo Leipzig 2020) (Audirac, 2018, Bartholomae et al., 2015, Florentin, 2010). The integrated approach coordinated separate sectoral concepts/ plans to fit in a more collaborative big picture (Power and Herden, 2016). In 2005, the new city-level integrated planning STEP adopted strategies to improve competitiveness in the inner city, re-use vacant areas, and conserve the urban fabric with the priority in the reconstruction of the declined neighbourhood (Rink and Siemund, 2016). In 2009, the SEKo Leipzig 2020 faced the challenges of social and demographic changes and aimed to enhance city status and competitiveness, ensure high quality of life and promote social cohesion and stability (Power and Herden, 2016, Green et al., 2017). After the implementation of policies and subsidies in the past two decades, Leipzig is no longer a shrinking city when counting the total population. A relatively new integrated planning is the INSEK Leipzig 2030 that replaced the SEKo Leipzig 2020, which is a regrowth-oriented policy rather than shrinkage-oriented policy.

The INSEK 2030 is a collaborative plan covers over sixty sectoral plans. It emphasised the key challenges and priorities in Leipzig until 2030. The main goal is to balance ecological, social, and economical urban growth (Heinig et al., 2018). The strategical goals include strengthening its competition and internationality, improving quality of life, and creating social stability (Heinig et al., 2018). Among the key challenges, 'green spaces in the city and quality of the built environment' and 'precautionary land and property management' are strongly associated with the shrinkage consequences and could be seen as regrowth-related issues (Heinig et al., 2018). The INSEK Leipzig 2030 points out the relationship among 'densification, vacancy and space potential' when dealing with the challenge of land and property management (Stadt Leipzig, 2018). The balance between open space, new constructions, and the demand for an increasing population is a typical regrowth challenge. The deputy mayor of urban development and construction also highlights that the urban structure needs to adapt to the changing development trend (Heinig et al., 2018). The INSEK

Leipzig 2030 also mentions the uncertainties of long-term population and considered the challenges of a new wave of urban shrinkage (Heinig et al., 2018).

The INSEK Leipzig 2030 is a product of collaboration among different departments, offices, and the public in Leipzig. Public opinion is one of the priorities in the decision-making process (Heinig et al., 2018). The public participation concludes the following formats in different phase: citizen discussion with 260 people in November 2015 (i.e. assessment phase), workshops, forums, meetings during November 2015 to August 2017 (i.e. core work phase), and exhibitions, online participation and forums (about 50 participants in each forum) from August 2017 to May 2018 (i.e. draft phase) (Heinig et al., 2018, Stadt Leipzig, 2018). The officer from city of Leipzig stated that "the age group of 51-65 (year old) being most strongly represented" among 260 participants in the kick-off event in 2015. The age of participants in other event was not released because of data protection (Richert, 2020).

The online discussion included social media of its official account City of Leipzig, but it did not contain other discussants on Twitter and online news media(Stadt Leipzig, 2018). All these phases can be categorized into the pre-implementation stage in this study and the opinion after the policy's implementation has not been released yet. Thus, it is valuable to see the opinion change before and after its implementation as it has the potential to supply the existing documents using an innovative method and provide new insights. Against these backgrounds, this study intends to explore the policy debate in Leipzig through online media.

3. RESEARCH DESIGN: MINING PUBLIC SENTIMENT IN LEIPZIG'S REGROWTH POLICY 'INSEK LEIPZIG 2030'

Leipzig's shrinkage started in the 1930s and, as stated in the previous sections, many shrinking-oriented policies, such as the STEP and the SEKo Leipzig 2020, have been adopted to create the 'Leipzig model' in managing urban shrinkage (Green et al., 2017). The 2000s witnessed population growth in Leipzig but the uneven growth was concentrated in a few districts while many buildings remained vacant (Mace and Volgmann, 2017). In the 2010s, Leipzig sees population stabilization and growth in many districts, undergoing a process of regrowth (Kühn and Bernt, 2019). Of particular interest for this research is the INSEK Leipzig 2030 in the current phase with an objective to plan for regrowth, which was launched on May 31st, 2018. The INSEK Leipzig 2030 have several regrowing relevant focuses such as developing residential housing for the growing population and post-shrinking themes including brownfield revitalization, inclusion and integration for improving life quality in Leipzig (Leipzig, 2018). The INSEK Leipzig 2030 is a new plan to both address the regrowing issues and continuously cope with shrinkage legacies in Leipzig.

The previous sections containing the literature review and description of public opinion, sentiment analysis and urban regrowth, which produces the background that allowed us to implement the methodology of sentiment analysis of public opinion towards the urban policy.

The policy debate can be measured by public opinion through sentiment analysis. We designed the methodology (sentiment analysis of the public opinion) using two sub-indicators: public attention and public sentiment. After capturing more than 14000 samples of data from Twitter posts and Google News on both the INSEK Leipzig 2030 and random topics in five months, public opinion can be measured.

Three measures are used to evaluate public attention: (1) comparison with historical data, (2) calculation of policy proportion, and (3) comparison of high-frequency keywords in random topics. The overall result is categorized into a low or high level of attention in **table 3-1** and the following sections. Next, public sentiment is analyzed by the AFINN sentiment analysis. Follow Hollander and Renski's (2017) research of twitter sentiment in growing and shrinking city, this research uses the same approach to analyze public sentiment. In sentiment analysis, a scoring system is applied so every tweet and news headline is given a unique mark. If the mark is larger than 0, the sentiment is positive. The sentiment is negative when the mark is less than 0.

Given that the INSEK Leipzig 2030 was launched on the 31_{st} May, policy-related news and tweets in May to September were compared to reveal the differences in public attention and sentiment before and after the implementation day. The tweets and news in May reveal the opinion in the pre-implementation stage and those in June to September show the public opinion after policy implementation. The four scenarios below could occur: (1) high in pre-implementation and high in follow-up phase - the public pay considerable attention to the policy before and after the implementation; (2) high in pre-implementation and low in follow-up phase - public attention decreases after the implementation; (3) low in pre-implementation and low in follow-up phase - little attention is paid to the policy in these five months; and (4) low in pre-implementation and high in follow-up phase - the INSEK Leipzig 2030 policy draws more attention after the implementation [**table 3-1**, columns 1 and 2].

Similarly, there are also four possibilities for public sentiment in before and after the launch of the policy [table 3-1, columns 3 and 4]: (1) positive in pre-implementation (May) and positive in follow-up phase - the public is satisfied with the policy before and after the launch; (2) positive in May and negative later - public sentiment changes from positive to negative after the launch of the policy; (3) negative in May and negative afterwards - the policy is unwelcome in both time periods; (4) negative in May and positive in follow-up phase - public sentiment changes from negative to positive after the launch of the policy.

INSERT TABLE 3-1

3.1 Data Collection and Harvesting

With the case study city and policy selected, we captured the relevant news and tweets posted within the city and about the policy, spending over 200 hours in setting up the program,

collecting data, and processing data. The information relevant to the INSEK Leipzig 2030 from the online newspapers was extracted using Google News Search. The historical policy-related tweets were collected by Twitter advanced search. Then real-time dataset that contains the policy-related tweets and randomly collected geotagged tweets sample was collected by Tweepy. Tweepy is an open-source tool that allows Twitter posts that are geotagged in a specific location to be collected within a limited period (seven days) (Roesslein, 2016). The coordinates of Leipzig (51°20′N 12°23′E), the language (German), and its radius (10km) were set to capture the selected geotagged tweets in Leipzig. Over 40000 raw tweets were continuously collected over a five-month period from the 1_{st} of May to the 30_{th} of September 2018, which is one month before and four months after the policy enactment. Then we applied the keywords 'Leipzig 2030' and 'INSEK' to the Twitter search setting to capture policy-related tweets in Leipzig. With duplicates removed, the raw data was then translated into English and anonymized. The data anonymization is to protect personal data and reduce the error in the sentiment scoring process. By the end of this process, the data size of random tweets was 14,336 and that of policy-related tweets was 37.

The collected data can be broadly categorized into three groups: (1) random tweets geotagged in Leipzig from May to September 2018; (2) historical tweets and filtered tweets that are relevant to the INSEK Leipzig 2030 policy from May 2015 to September 2018; and (3) policy-related news from July 2017 to September 2018. Each category was then divided into smaller groups to run statistical tests. The detailed data groups are listed in **table 3-2**.

INSERT TABLE 3-2

Four-part data analytics is conducted to answer the research question. First, the study calculated public attention on the INSEK Leipzig 2030 by three methods: (1) a trends analysis to compare public attention in each month from May 2015 to September 2018; (2) a calculation of policy-related tweets proportion in the Twitter pool; and (3) a comparison of keywords by word cloud outputs. WordClouds (www.wordclouds.com) is an online word map-creating tool that analyses high-frequency words and generates a word map. We input the news and tweets contents to generate word clouds. Three word clouds were generated to compare keywords in policy-related news, policy-related tweets and random tweets.

Secondly, we compared word clouds to identify the key themes in the public debates on the INSEK Leipzig 2030. Main themes of shrinkage and regrowth that mentioned in the literature review can be used as a reference to see whether the public discussions are more relevant to the shrinkage topics or the regrowth topics.

Thirdly, we evaluated public sentiment to evaluate the public opinion of the collected data. The AFINN dictionary was applied (Nielsen, 2011), through python package afinn 0.1 (https://pypi.org/project/afinn/). This method scored all news headlines, all policy-related tweets, policy-related tweets and the random tweets sample in May and the follow-up phase.

After scoring the collected data, descriptive statistics and correlation tests were run for all groups in **table 3-2** in SPSS. The descriptive statistics includes numbers, range, minimum, maximum, mean, standard deviation and mode. Means were then normalized to the average scores of random tweets in the corresponding month (i.e. normalized sentiment scores of random tweets = 0). In this way, the normalized means can fit the criteria of the sentiment results of the AFINN dictionary. Note that the average mean of random tweets in the pre-implementation to the follow-up stages was used as the neutral value to normalize the policy-related historical data. The descriptive results were used to compare the differences among each group.

Lastly, the study compared the differences between policy-related data before and after the launch of the INSEK Leipzig 2030. The policy-related tweets and news in May were combined into a May policy group. The policy group of the follow-up phase was the combination of policy-related tweets and news in the follow-up period. To uncover the differences before and after the launch of the INSEK Leipzig 2030, we first compared the descriptive results (numbers and means) of the two new groups. A two-sample T-test in SPSS was then run to analyze whether the scores of policy-related groups before and after the policy implementation were significantly correlated.

3.2 Hypotheses

Having established that the goal of data analytics is to evaluate public sentiment towards the regrowth-oriented policy, investigate the difference before and after the policy implementation, and anticipate the acceptance of the INSEK Leipzig 2030, we formulated the following hypotheses to be tested in the result section:

- H1: The public has many interests in Leipzig 2030 and the proportion of tweets related to the INSEK Leipzig 2030 is high.
- H2: Both sentiment scores of the media are positive, which indicates a positive public opinion towards the INSEK Leipzig 2030.

- H3: The public pays more attention to shrinkage-related themes in the policy debate.

- H4: There is no significant difference between sentiment results before and after the implementation.

4. CASE STUDY AND RESULTS

4.1 Public attention on the INSEK Leipzig 2030

The public attention on the regrowth-oriented policy is low, according to all three methods in detecting public attention. First, the trends of both news and tweets were calculated to compare the discussions of the policy in May, June to September and previous months. As shown in **figure 4-1**, the peak discussion can be found around the policy implementation at the end of May and the follow-up stage witnessed the decreasing trend of discussing the policy. Compared to all the collected tweets that mentioned the INSEK Leipzig 2030, May and June 2018 witnessed an increasing number of tweets regarding the policy, meaning people were paying more attention to the policy when the policy was implemented.

For policy-related tweets, Stadt Leipzig, Participant 1, Leipzig City for Everyone (Stadtfüralle), LVP, and L-IZ.de were the users that dominated the INSEK Leipzig 2030 discussions on Twitter. Stadt Leipzig is the official website of the city of Leipzig. The opinion and responses to this account are included in the official public participation process. Participant 1 is an urban researcher and consultant. Leipzig City for Everyone is a group that is committed to social and democratic urban development. LVP is the official Twitter account of the Leipzig People Newspaper (Leipziger Volkszeitung), a local newspaper in Leipzig. L-IZ.de is the official account for the Leipzig Internet Newspaper (Leipziger Internet-Zeitung), another local newspaper in Leipzig. The discussions are more prominent in the more professional groups such as city governors and urban researchers. Since professional users have a strong impact on the public by influencing the mainstream media and ideas, they can lead public sentiment towards specific urban governance (Tumasjan et al., 2010).

For online news, the trends show that public attention was increasing as the implementation was approximating. The end of May had increasing discussions on the passing of the policy by the city council and the argument during the passing process. Most of the news was reported by Leipzig Internet Newspaper and Leipzig People Newspaper, two local newspapers in Leipzig. Overall, the reports on INSEK Leipzig 2030 were scarce.

INSERT FIGURE 4-1

Secondly, the proportion of the policy-related tweets among the geotagged tweets in Leipzig was calculated. The result showed that policy-related tweets were in a low proportion of all geotagged tweets in Leipzig of 0.02%. Although there is no definition of the low-frequency tweets proportion, 0.02% is a small proportion and the word cloud further proves that policy-related topics were not popular themes on Twitter in May to September in Leipzig.

To calculate the policy proportion indirectly, as all policy-related tweets included the keyword 'Leipzig', we first calculated the ratio of the keyword 'Leipzig' in all raw data of the sample tweets. Then, the keywords 'Leipzig 2030', 'INSEK', 'Stadtentwicklung', and 'Stadtentwicklungskonzept' were applied to filter the tweets related to the policy among a

sample that contained the keyword 'Leipzig'. In an indirect method, the policy proportion is 0.02%. The calculating process is as below:

$$Policy/Leipzig = 11/13455 = 0.08\%$$

$$Leipzig/All\ tweets = 7044/30612 = 23.01\%$$

$$Policy/All\ tweets = 0.08\%*23.01\% = 0.02\%$$

Thirdly, word clouds were generated to compare the keywords in Leipzig policy discussions and random topics. In the random tweets word map [**Figure 4-2**], no high-frequency vocabulary was relevant to urban policy or urban planning because urban planning was not a popular topic on social media and other events attracted more attention from the public. People in Leipzig did not have many discussions about any urban policy on Twitter. Therefore, public attention othe INSEK Leipzig 2030 was low.

INSERT FIGURE 4-2

For the random sample of geotagged tweets in Leipzig **[figure 4-2]**, the most tweeted words are related to good emotions, time, football, and social events. People in Leipzig focused on sports, holidays, and major news events from May to September. Many keywords can relate to some short-term, high-intensity discussions of interests or events (Kirilenko and Stepchenkova, 2014). For example, the good emotion and thankful expressions were related to the Mother's Day on the second Sunday of May and Father's Day on the 10_{th} May. Negative emotions were expressed when a refugee boat was sunk on 19_{th} June. All such events can affect the dataset and high-frequency words. Therefore, citizens in Leipzig paid little attention to urban planning and urban policy, let alone the discussion on a specific urban policy.

4.2 Main themes in the policy-related online discussions

We found that the main themes in the policy-related debates are more regrowth-oriented. The two word clouds of policy-related discussions were compared. The first word cloud **[Figure 4-3]** is generated from all text mentioned INSEK Leipzig 2030 on Twitter and the second word cloud **[Figure 4-4]** is generated from all news content from Google News.

In word maps that relate to the chosen policy **[figure 4-3 and figure 4-4]**, the high-frequency words were primarily relevant to the name of the policy (the INSEK Leipzig 2030). Aside from these keywords, the most frequently used words can be categorized into public services, local authority and population. For example, 'housing', 'public', 'transport', 'traffic', and 'development' are the high-frequency keywords except for the name of the policy in news. For tweets, 'mobility', 'public', 'traffic', and 'schools' are the most-occurred keywords other than 'Leipzig INSEK 2030'. The word 'shrinkage' was one of

the commonly used in policy-related tweets or news, and other shrinkage relevant keywords cannot be identified, which indicate that people may not interest in urban shrinkage in the post-shrinkage stage. Conversely, the keyword 'growth' and 'growing' is one of the high-frequent word and discussants focus on issues such as housing, transport, development and construction. These key themes are overlapping with the main topics in academic debates on urban regrowth. The main themes in the regrowing city Leipzig is more relevant to the current regrowth process rather than shrinkage. The reasons for this may because Leipzig is now experiencing the urban regrowth process and the policy itself is more regrowth oriented.

INSERT FIGURE 4-3
INSERT FIGURE 4-4

4.3 Public sentiment towards the INSEK Leipzig 2030

The public sentiment towards the INSEK Leipzig 2030 was negative in the pre-implementation stage in the comparison with random tweets and historical data. However, public sentiment has shifted to positive after the implementation. As illustrated in **table 4-1**, the original sentiment scores of all groups are slightly higher than 0, which means citizens and media in Leipzig had a slightly positive opinion towards the policy and other topics. The normalized average scores of all policy-related data, except the news in May and tweets in the follow-up phase, were negative, suggesting the public may present slightly negative attitudes to the INSEK Leipzig 2030 along time. However, the follow-up period witnessed a positive sentiment on the Twitter platform and an increasing sentiment in online news media, indicating public opinion towards the policy became positive after its implementation.

Policy-related data in May and the following months was first compared to the historical data. The scores show that people had more positive public opinion towards the policy on online news sites, compared to its historical discussions [see nominalized means in table 4-1]. The sentiment of tweets in the pre-implementation stage is lower than historical scores, indicating people may hold slightly negative attitudes toward the INSEK Leipzig 2030 and showed concerns to the policy at its implementation. However, in the follow-up stage, people have a more positive view toward the policy, with a higher mean of 0.52, which is higher than historical means (-0.15) and the means of the pre-implementation stage (-0.29). Overall, these results suggest that the policy was less unfavorable by the public after the implementation.

INSERT TABLE 4-1

4.4 Difference before and after the implementation

The difference between public attention and public sentiment towards the INSEK Leipzig 2030 before and after its passing in the city council was analyzed. Both news and tweets in the pre-implementation period were combined into the policy groups of the pre-implementation phase and the same process was applied to the data of the follow-up phase. In both policy groups, the number of the data size was used to compare the difference in public attention. The similar dataset size indicated that public attention towards the policy was almost the same, as shown in **[Figure 4-1]**. The public attention reached its peak time around the launch of the INSEK Leipzig 2030 and then decreased.

Then the difference in public sentiment was evaluated by a T-test of sentiment scores in both months. The T-test results show that there is no significant difference between the two datasets ($P = 0.776 > 0.05$) **[table 4-3]**. Nevertheless, the descriptive statistic results showed that the policy-related data of the pre-implementation stage was negative while that of the follow-up stage was positive. With higher maximum and mean **[table 4-2]**, the follow-up stage had an increasing public sentiment than that in May (the pre-implementation period). This demonstrated that after the launch of the INSEK Leipzig 2030, the public was slightly more satisfied with the policy. This indicates that the implementation process gained support to some extent.

Overall, there was only a slight difference between the public opinion before and after the implementation of the INSEK Leipzig 2030 in terms of public attention and public sentiment.

INSERT TABLE 4-2

INSERT TABLE 4-3

5. RESULTS DISCUSSION

To discuss our results, we come back to our hypotheses. Firstly, the public only pays low attention towards the urban planning policy INSEK Leipzig 2030, and the overall sentiments were slightly negative (as shown in Table 4-1). Both H1 (The public have many interests in Leipzig 2030 and the proportion of tweets related to the INSEK Leipzig 2030 is high) and H2 (Both sentiment scores of the media are positive, which indicates a positive public opinion towards the INSEK Leipzig 2030) are rejected. Secondly, the main themes in policy-related online discussions were related to public services, local authority and population, as illustrated by Figure 4-3 and 4-4. The public paid more attention to topics related to urban regrowth than issues of urban shrinkage. For H3 (The public pays more attention to shrinkage-related themes in the policy debate), this hypothesis should be rejected. Lastly, the public opinion in pre-implementation and follow up stages did not show a significant difference. H4 (There is no significant difference between sentiment results before and after the implementation) – this hypothesis should be accepted.

We analyzed the policy debate in this study, the potential implication for the policy debate or policy acceptance has to do with the fact that these methods can be a new indicator for policy effectiveness. Media studies and political research showed that public opinion has substantial impacts on public policy-making processes and outcomes (Jaeger et al., 2017; Oehl et al., 2016; Wlezien, 2017). For example, Wlezien (2017) found that public preferences and results of policy implementationhave congruence across time and space. In his study, the public opinion to change policy was largely consistent with the actual policy change. The adoption of some policies is influenced by public support (Wlezien, 2017). Thus, a proxy in evaluating public opinion is public sentiment (Kirilenko et al., 2015). Positive public sentiment can support a policy, while negative sentiments will hinder the implementation and reduce the effectiveness of a policy. Additionally, public attention has a strong influence on the policy agenda (McCombs, 2018). The high level of public attention can cause more solid changes in policy agenda setting (McCombs, 2018; Oliveira et al., 2017). According to the studies above, we can assume that a high level of policy acceptance can indicate that this policy can be more effective to some extent. In contrast, a low level of policy acceptance may refer to insufficient policy effectiveness. In this research, because of the low policy attention and the negative-positive sentiment results, we anticipate that the policy might be effective in the city because it seemed to be welcomed by the public and is likely to gain public support. In Leipzig, the debates have   shifted the urban policies from growth-oriented to shrinkage-oriented, as illustrated in the previous section. Negative sentiment in hot debates can cause substantial impacts such as decreasing housing price in cities and the public could vote for other parties or 'vote with their feet' (leaving the city) while positive sentiment may lead to public support of the policy implementation and the current leader.

Apart from the results and implication, the new data sources and methodology have the potential for further studies in urban planning and policy analytics. One of the key discussion points to the relevance of these new methodologies and datasets for conducting pre/post evaluation of policy developments and implementations. Ideally, the public discussions from social media and news responses could be large when the public care about relevant topics because social media is usually seen as a source of big data particular when looking for the immediacy of reactions to an event/action. Although the data sample is not large to show significant impacts in Leipzig, this research as a pilot test to demonstrate the usefulness and this new dataset and data analytical tool is valuable as the method is possible to auscultate public sentiment by harvesting online live data. Twitter, along with other crowdsourced online media, becomes an immediate data source to evaluate the perceived sentiment towards a policy, which can become an instrument of good governance. This is an invaluable data source that other more long-term data collection methods cannot achieve and therefore should be used complementarily to census surveys, questionnaires, semi-structured interviews, and other conventional data sources. Online live data can provide real-time insights into public

preferences. The information from online live data can be seen as the opinion from a mixture of bottom-up and top-down processes (Prpic and Shukla, 2016). Additionally, sentiment analysis in the case study proved the methodology to be pragmatic and instructive in urban planning. Although the collection and processing were not simultaneously in this study, the data processing technique has been improved. The authors have modified the code in python, real-time posts can now be imported into a table and the sentiment analysis (i.e. AFINN dictionary and word cloud generator) can score each newly collected data and recalculate keywords instantly. For policy analysis, the method can give urban planners and researchers clues to the effectiveness of the policy. Monitoring live data can instantly provide policy-related feedback to urban governors. Besides, public sentiment is useful in identifying public preferences towards spaces, increasing the sense of place in urban design, and guiding spatial planning.

6. CONCLUSION

The INSEK Leipzig 2030 has not attracted much attention from the public, neither before nor after the implementation. Although Twitter users and news reporters in Leipzig showed increasing attention as the policy was enacted, the discussion on the policy was low, compared to other topics. In the small sample that participated in the policy discussion, both opinion leaders and ordinary citizens held a slightly negative sentiment towards the policy before its implementation while the sentiment became slightly positive after the launch of the policy. Both news and tweets started to question the policy and challenge the objectives and implementation but then somewhat accepted and supported the policy. Although the difference in the pre-implementation and the follow-up stagesre not significant, the implementation of the new policy is receiving support from the people and it is likely to be effective in Leipzig. The key themes in policy debate indicated that the new challenges of urban regrowth such as housing and infrastructure demands are more popular topics.

Urban regrowth is a new urban process in post-shrinking cities. Urban planning in these cities is required to cope with both shrinking consequences and regrowing challenges. Both shrinking-oriented and regrowth-oriented policies and planning are complex and debatable. The growing population raises new demand for housing and infrastructures, which requires the spatial plan for the built environment to be carefully balanced. Typical regrowing debates include the balance of new constructions and open space as well as the uncertainty of population trends. These challenges are highlighted in the new regrowing policy in Leipzig. The public discussion can reflect some of the challenges such as sustainable growth, space and population. This study shows that entering a new period of regrowth, people tend to focus more on the regrowth process as Leipzig's transformation from a shrinking city to a prosperous (re)growing cities has succeeded.

This study aims to better understand policy discussion on urban regrowth with the help of new data sources and data science techniques. Policy debates can be explored through public opinion, with sentiment analysis and live data harvesting. The research provides a methodology to analyze the policy debate in terms of key themes and sentiment. The live data can provide instant feedback (e.g. positive or negative sentiment in this case) on a topic. Although the online media data results can have the issues of overrepresent young population and underrepresent the children and the elderly people (as shown in social media demographic reports), the information is still valuable. Previous studies show that the overrepresented age groups (18 - 34) online are less likely to attend traditional public participation events offline. Despite some data limitation, online crowdsourced data can be a valuable supplement in evaluating public discussion and the method of sentiment analysis canbe an important way of interpreting public opinion. The methodology in this study can also be applied in other policy research and urban planning issues as stated inthe literature review and discussion.

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Table 3-1: Different scenarios

Public attention		Public sentiment	
Before implementation (May)	After implementation (June to September)	Before implementation (May)	After implementation (June to September)
High	high	+[a]	+
		+	-
		-	-
		-	+
High	low	+	+
		+	-
		-	-
		-	+
Low	low	+	+
		+	-
		-	-
		-	+
Low	high	+	+
		+	-
		-	-
		-	+

a. +: positive, -: negative

Table 3-2: Detailed data groups

Broader categories	Detailed groups	Number
random tweets	Random tweets of pre-implementation[a]	6232
	Random tweets of follow-up phase[b]	8104[c]
	All random tweets	14336
policy-related tweets	Policy-related tweets of pre-implementation	12
	Policy-related tweets of follow-up phase	12
	Historical policy-related tweets	57
	All policy-related tweets	81
policy-related news	Policy-related news of pre-implementation	3
	Policy-related news of follow-up phase	8
	Historical policy-related news	15
	All policy-related news	26

a. Pre-implementation stage refers to May 2018

b. Follow-up phase refers to June to September 2018

c. Approximately 2000 tweets each month from June to September

Table 4-3: Descriptive Statistics

		Number	Mode	Mean	Normalized Mean [a]	Std. Deviation
random tweets	pre-implementation	6232	0	0.46	0	2.22
	follow up	8104	0	0.40	0	2.32
	all	14336	0	0.43	0	2.28
policy-related tweets	pre-implementation	12	0	0.17	-0.29	1.27
	follow up	12	0	0.92	0.52	3.48
	historical	57	0	0.28	-0.15	1.69
	all	81	0	0.36	-0.07	1.98
policy-related news headlines	pre-implementation	3	-2[b]	1	0.54	2.65
	follow up	8	0	0.13	-0.27	0.35
	historical	15	0	0.13	-0.30	0.83
	all	26	0	0.23	-0.20	1.03

a. Each value is normalized to the random tweets of the month (see section 3.4)

b. Multiple modes exist. The smallest value is shown.

Table 4-4: Descriptive Statistics of policy-related groups of the pre-implementation and follow-up phases

Policy Group	Number	N. of tweets	N. of news	Minimum	Maximum	Normalized Mean
Pre-implementation	15	12	3	-3	3	-0.13
Follow up	22	12	8	-4	11	0.15

Table 4-5: Two Sample t-test of policy-related data

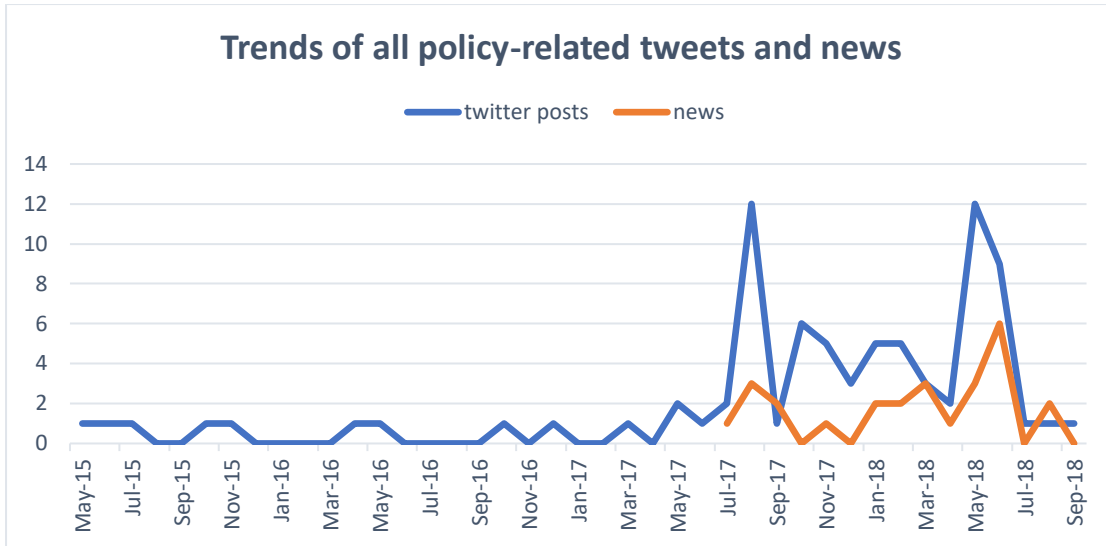| Differences between pre-implementation and follow up phase				t	df	Sig. (2-tailed)
Mean of pre-implementation	Mean of follow up	95% Confidence Interval of the Difference				
		Lower	Upper			
0.333	0.545	-1.714	1.289	-0.28678	35	0.776

Figure 4-1: Trends of all policy-related tweets and news

Figure 4-2: Word cloud of sample tweets of May to September in Leipzig
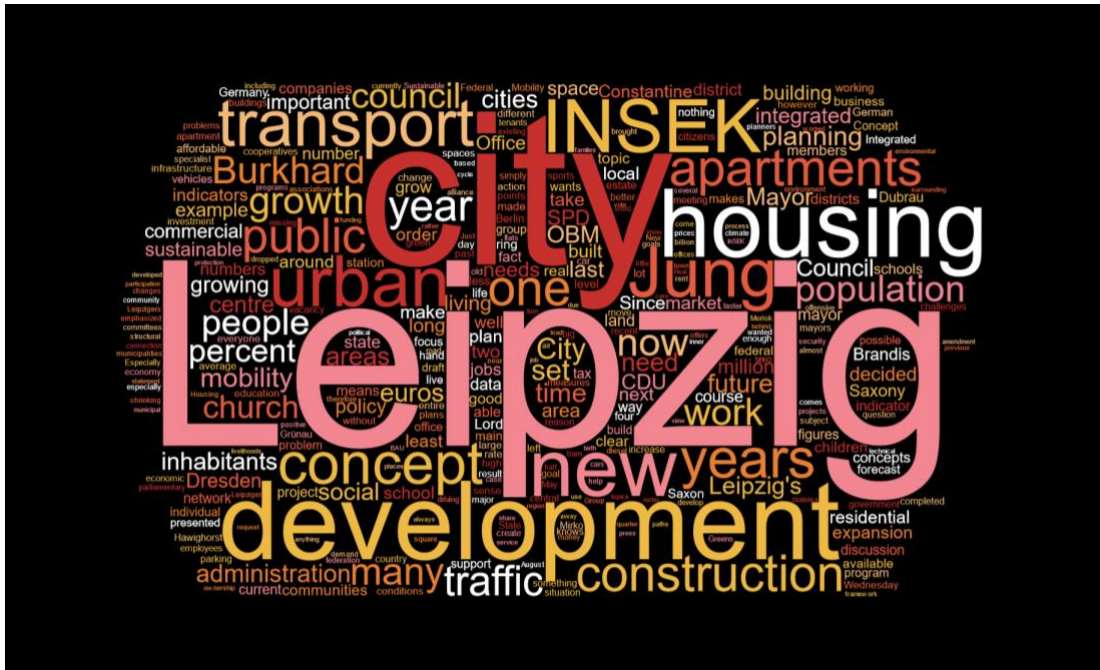
Figure 4-3: Word cloud of all policy-related news

Figure 4-4: Word cloud of all policy-related tweets