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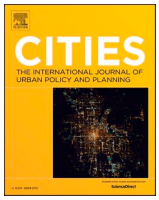

Measuring factors affecting local loyalty based on a correlation network

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ABSTRACT

Understanding the level of local loyalty is crucial for urban planners, as individuals who exhibit higher levels of loyalty are more likely to adopt a "voice" strategy and act in the interest of their community, while being less likely to relocate. This study aims to develop a methodology for assessing and determining the factors influencing local loyalty levels. It is presumed that different factors contribute to each level of local loyalty. Through the identification of loyalty components and potential drivers, a data-driven approach based on correlation networks was employed to identify critical factors influencing loyalty at varying levels. The methodology was applied in Veszprém, Hungary, the European Capital of Culture in 2023, using a representative survey. The findings reveal that while demographic variables exhibit a weak correlation with loyalty levels, residents living in the city centre tend to show higher loyalty. Factors associated with high local loyalty include well-being, employment opportunities, healthy social relationships, and strong family ties. Conversely, the least loyal group is characterized by weak connections with friends, neighbours, and colleagues, as well as living in unsafe environments.

1. Introduction

Loyalty implies steadfastness regarding the support and commitment to a specific object (Shaykh-Baygloo, 2020), e.g. brand, group or person, which is closely connected with trust and confidence (Barbalet, 1996). The formation of loyalty is complex and can emerge from inner convictions like satisfaction and be influenced by external forces, e.g. a duty or pledge (Buhalis et al., 2020; Duffy, 2003; Withey & Cooper, 1992). The complicated nature of loyalty forces researchers to treat it as a composite indicator in order to reduce its level of complexity (Abu-Alhaija et al., 2018; Ranganathan, Madupu, Sen, & Brooks, 2013). Since loyalty influences one's future decisions, attitudes and behaviors, e.g. rebuy something (Oliver, 1999) or revisit somewhere (Chatzigeorgiou & Simeli, 2017; Mercadé Melé et al., 2020), the executive of the object must be aware of the degree of loyalty of those associated with it in order to make better decisions.

Even though every person live somewhere, it matters how much a resident feels at home and relates to their city. Those who have a good relationship with their settlement may promote their environment and contribute to its development. One of the best emotional expressions of someone's relationship with their settlement is the local loyalty described in the present work. However, loyalty is spatially scaled and the loyalty of individuals to their settlement is slightly decreasing. People are most loyal to their country and least loyal to the city where they reside (Bowd, 2010; Shaykh-Baygloo, 2020). Local loyalty to one's city changes over time (Devine-Wright, 2013) and globalization allows people to be cosmopolitan, enabling loyal ties to extended to more cities (Bell & De-Shalit, 2013) and varies by culture and personal attitude (e.g. towards mobility).

Local loyalty means a binding force to the settlement where one lives. In our context, it motivates residents to live and act in their settlement (Brown et al., 2003) and facilitates their intention to stay. Local loyalty is influenced by place attachment (López-Mosquera & Sánchez, 2013; Shaykh-Baygloo, 2020) and antecedents (Yuksel et al., 2010), moreover, is strongly related to satisfaction (Lee, 2003; Sui & Baloglu, 2003).

This study considers local loyalty as a latent factor of engagement, consisting of rational ties, relevance and future intentions to understand this multifaceted, complex phenomenon. It might be best to regard loyalty as an index of composite measure that summarizes various indicators about the same phenomenon (Cosso-Silva et al., 2019; Gonring, 2008), the variables of which are also closely related to each other (Jain

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et al., 1987) but not identical. This mindset is consistent with other composite loyalty indices (GfK, n.d.; Auh & Johnson, 2005; Burgartz & Krämer, 2016; Foote et al., 2001; Striteska & Jelinkova, 2015). We clustered people with different degrees of loyalty because, as a social sensor, they indicate the factors associated with loyalty.

We aim to explore the factors that significantly influence local loyalty using a new correlation network-based methodology and thus provide novel insights. Since the associated factors are also correlated, a correlation network can ensure that a comprehensive amount of information is obtained. Furthermore, we believe that other factors influence the most and least loyal people. Traditional correlation analysis correlations between variables and usually start with setting up hypotheses and testing them. Here, contributing to this article, we looked for related factors at different levels of local loyalty with response categories of variables without modeling. The most frequently co-occurring answers corresponding to each loyalty level were calculated and the most related ones were obtained in this data-driven exploration. This technique can define more detailed significant relationships and association chains to explore phenomena.

The information obtained is essential for making development decisions, moreover, in order to understand the inhabitants of a city better as well as their relationships with the settlement and region.

This paper contributes to a deeper understanding of components of local loyalty and related factors provided by an advanced data science methodology. The elements and novelties provided by the new method are listed below:

- We considered local loyalty to be a resultant force of engagement, rational ties, relevance and future intention as well as have shown that latent class analysis (LCA) is suitable for separating respondents with different degrees of local loyalty. Using this method, we have seen that the various components do not decrease simultaneously with loyalty.
- We have shown that the main determinants of high and low degrees of loyalty are different. We identified frequently co-occurring responses in each group and created a network of significant correlations. The network showed that different life situations and circumstances underlie the differences in loyalty. The results were validated with the strongest predictors obtained from a machine learning classification procedure.
- The data science tool used to determine correlations, that is, association rule mining, can be used in several dimensions. We have shown that quite detailed information about small groups can be extracted. The quality of solid family ties determines the degree of loyalty. We have identified a group where the opposite occurs, namely a very loyal group despite the lack of family ties. The excellent quality of services in the city influences their loyalty.
- The demonstrated procedure is suitable for monitoring the stratification of society and its various needs in detail.

This paper is organized into the following sections. Firstly, the article describes the measurement of local loyalty with regard to a city and its antecedents according to the literature and data analysis methods by analyzing the complexity of local loyalty, that is, mainly the components, antecedents and consequences of it depending on the degree of loyalty. We reviewed the vitality indices of the settlements, explaining what factors were examined in relation to local loyalty. This section is followed by a presentation concerning the application of methods containing the data collection and results. Respondents were clustered according to their degree of loyalty, which is presented in one of the subsections. We describe variables related to local loyalty in order to provide insights at the societal levels. Important variables with high predictive powers were specified with machine learning algorithm and compared to answer categories of variables directly associated with each level of loyalty. Moreover, although we have identified and analyzed in one of the subsections a group of people with poor social relations, they are very loyal. This case study demonstrates that the application of association rules is capable of highly sensitive detection. Finally the Discussions and Conclusions of the study are outlined.

2. Methods - measuring the degree of local loyalty and its drivers

The purpose of this research is to understand the loyalty to a city and the factors affecting it using data-driven methods. In this section, we show that local loyalty is an appropriate indicator of a healthy degree of attachment to a city, which triggers positive actions and provides essential information about the inhabitants for the leaders of a municipality. However, it is difficult to determine the level of local loyalty and increase it by providing actionable information to decision-makers. In Fig. 1, we show the steps we have taken to explore the topic of measuring local loyalty and its drivers.

This section is structured to provide a clear and replicable manual-like description of the local loyalty measurement process. Each subsection begins with a literature review, laying the foundation for understanding local loyalty measurement and its influencing factors. Additionally, it introduces the data mining methodology employed in the analysis. The subsequent two main subsections sequentially address the measurement of local loyalty and the identification of drivers. This is achieved through the application of machine learning classification techniques and a newly developed response category-level correlation network. Notably, the latter allows for the individual characterization of different loyalty groups, highlighting the distinct factors associated with high and low loyalty levels. Findings are validated using established methods where applicable. However, it's important to note that there is no applicable method to validate the results of the answer category-based correlation network, which is a unique contribution of this work.

The analyses were performed in R, and the corresponding code is available in a structured Rmd file (Laszlo Gadar, 2023), which also contains an English version of the questionnaire.

2.1. Determining the degree of local loyalty

In the literature, the perception of loyalty can stem from various sources. Depending on its intended application, different approaches and measurements are available, which we will review in this section. This is essential because it helps us select the most appropriate components of local loyalty. We also distinguish between local attachment, local belonging, and local loyalty, underscoring that local loyalty, as a proxy indicator, is closely linked to future intentions to act compared to the other two. From a data analysis perspective, local loyalty is a latent variable, and its quantification can be achieved through latent cluster analysis (LCA). In LCA, the degree of local loyalty results from patterns of responses to related variables.

2.1.1. Previous research on the complexity of loyalty

People can be loyal to different objects. In a study a model linking festival authenticity to festival quality, value, satisfaction, trust and loyalty to a given festival was tested (Akhoondnejad, 2016) in which it was found that perceived authenticity influenced perceived quality, value and satisfaction. Perceived quality was found to have a direct effect on perceived value, satisfaction and trust. Perceived value affected satisfaction, trust and loyalty. Satisfaction had a direct effect on loyalty, as did trust. Another study aimed to provide a deeper understanding of local merchant loyalty (Noble et al., 2006), their results of which indicate that gender significantly influences shopping motives and differences in shopping motivation influence local merchant loyalty.

Loyalty is also crucial for companies, stores and brands. A study on emotional attachment and loyalty of consumers in coffee shops to green stores showed that highly environmentally conscious consumers are more strongly attached to stores and exhibit a higher level of loyalty (Jang et al., 2015). Another study aimed to examine the moderating

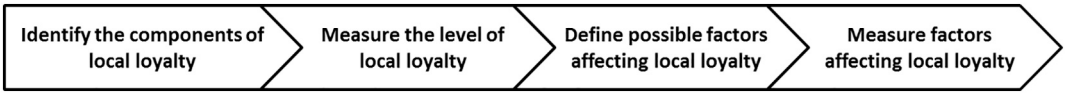


Fig. 1. Steps to define local loyalty and the factors affecting it.

effects of gender, income, age, customer involvement and length of relationship on the customer satisfaction and customer loyalty in the contexts of a contractual service (Gonçalves & Sampaio, 2012). It was found that demographic and relational variables are important in terms of explaining the relationship between customer satisfaction and customer loyalty.

The classic exit-voice-loyalty framework (Hirschman, 1970) as well as applications (Sharp, 1984; Shinohara, 2018) states that customers or members of an organization behave and act differently as consequences of loyalty. The concerns were that the two possible answers can be given by a member to a managerial dysfunction, namely exit or voice. By increasing the availability of the exit, e.g. by leaving the organization or boycotting a product, making a choice might lead to a decline in voice activities, e.g. expressing dissatisfaction. The choice may be made because citizens do not learn how to use the political process to make demands since they always utilize exit strategies. Once possibilities to exit become available, they will not express their voice, but rather choose to exit, leaving poor services. Another aspect of Hirschman's original framework was to include the concept of loyalty. Hirschman argued that if customers were loyal to a given product, they might be more motivated to voice complaints rather than to seek another provider.

Hirschman's ideas have been comprehensively discussed theoretically and occasionally used to illustrate empirical case studies, however, few have systematically and empirically tested the relationships he discussed. In addition, it has been the subject of much criticism, especially on the object of loyalty. In a study, the subject of loyalty was altered from a product to an area and the original theory further developed (Dowding & John, 2008), suggesting that households are less likely to exit from the jurisdiction of one local authority if they have social ties to that area. If residents were born and brought up in the area or have family and friends there, they are less inclined to move, arguing that local networks or ties (a form of social capital) will lead more activity concerning voice rather exit.

One study believes that Hirschman's schema is more complex than it first appears, moreover, different aspects of exit and voice as well as empirical foundations of loyalty need to be analytically distinguished in order to produce testable empirical hypotheses about their relationships (Dowding et al., 2000), suggesting that the degree of loyalty that one has depends first and foremost on one's identification with the object of loyalty and secondly on the amount an individual has invested in that object. This can also be true of a local community or geographical region, especially if someone was born and grew up happily there. Standing up for one's nation, that is, fighting for it, or one's community by buying a house, supporting the improvement of local schools, making a large number of friends may increase the loyalty of an individual to that particular object, namely the nation or local community. They might say that the social capital of a particular group or community is a function of all the individual investments in that group or community. The authors suggest that loyalty should be seen as a psychological variable.

In marketing research, the last major advancement in the field of customer satisfaction involved the introduction of loyalty. The Customer Loyalty Index (CLI), a standardized tool which captures the complexity of loyalty, is often used to track customer loyalty over time (Allen et al., 2000) taking into consideration multiple factors like behavioral, emotional and future intention as well as rational ties. This method facilitates a more comprehensive understanding of customer loyalty than a singular metric approach. Apart from this, it can also predict future retention rates, recommend a product or service to others and help to build loyalty profiles for customers. Moreover, CLI highly correlates with the performance of a company (Kroenert et al., 2005).

Why someone becomes loyal or not is an evergreen research question. Researchers have uncovered numerous components of loyalty, but many questions still need to be answered.

2.1.2. *Defining the degree of local loyalty*

In this research, we present a novel method for measuring local loyalty by first defining local loyalty itself in order to analyze the determinant factors. Quantifying the level of loyalty as well as the most and least loyal residents of a city is not an easy task since loyalty is a complex and multifaceted phenomenon. Furthermore, previous studies have shown that behavioral measurements of loyalty are insufficient because they can identify loyalty patterns by repetitive purchasing that do not imply a real commitment to the service or product (Berné, 1997; Jacoby & Chestnut, 1978).

There exist subtle conceptual similarities and distinctions among the notions of local attachment, local belonging, and local loyalty. They all involve individuals' connections to a specific locality or community, but they focus on different aspects and may be measured by different variables.

2.1.2.1. Local attachment. Neural mechanisms activate the sense of engagement (Porges, 2003), a concept closely akin to attachment. Place attachment, on the other hand, encompasses and reflects stability (Brown & Perkins, 1992), representing a subjective commitment to one's neighbourhood and neighbours (Fischer et al., 1977). Individuals continually navigate towards the path of least effort, factoring in their interest in commitment (Zipf, 1949). Neighbourhood attachment involves a web of institutional ties, involvement in social networks, and positive emotional connections (Brown & Perkins, 1992).

To summarize that, the local attachment refers to an individual's emotional or psychological connection to a specific place or community. Local attachment can be influenced by personal experiences, cultural factors, and the quality of interactions within the community. It's about an individual's emotional connection to a place. Variables associated with local attachment may include feelings of pride in the local area, a sense of identity with the place, and emotional bonds to the community.

2.1.2.2. Local belonging. The intricate concept of ‘belonging’ encompasses interrelated dimensions, as highlighted by Tomaney (2015). Belonging can be expressed at both individual and collective levels, intertwining with identity narratives and practical commitments and investments. The construction of place identities and senses of belonging remains in constant evolution, reflecting shifts in population dynamics and the built environment. Therefore, investigating the urban and regional dimensions of belonging holds pivotal importance, considering both its physical manifestations and perceptual aspects (Antonsich, 2010). By providing an analytical framework that acknowledges the multidimensional nature of belonging, it distinguishes between feeling ‘at home’ (place-belongingness) and the role of belonging as a resource in socio-spatial discourses and practices, particularly in the context of inclusion and exclusion dynamics (politics of belonging). This distinction becomes increasingly relevant in light of rising international migrations and its implications for fundamental issues such as social cohesion and loyalty (Antonsich, 2010).

In summary local belonging also relates to an individual's connection to a specific locality or community. It encompasses the feeling of being a

part of that place and having a role within it. Local belonging often involves a sense of integration and participation in local life. It can be influenced by social interactions, community engagement, and the extent to which one feels accepted within the local context. Variables associated with local belonging might include a person's perception of being included in local social networks, their involvement in local activities, and their sense of fitting into the community.

2.1.2.3. Local loyalty. In a related study, Babalola (2022) investigated how various dimensions of tenure security impact residents' loyalty and satisfaction towards their locality. They perceive the city as a multifaceted entity, or in other words a 'bundle of products' (Cozmiuc, 2011; Van Den Berg & Braun, 2017), which can be marketed effectively. According to Babalola (2022), it is the sense of loyalty that instils in local residents a profound feeling of belonging. This, in turn, fosters citizens' active participation and engagement in matters concerning their community. Additionally, loyalty can be viewed as an outcome of satisfaction (Shankar et al., 2003).

In summary local loyalty refers to an individual's commitment and dedication to supporting and contributing to a specific locality or community. It involves a willingness to invest time, resources, and effort in the betterment of the local area. Local loyalty often implies a sense of responsibility and reciprocity towards the community. It can be influenced by factors such as a person's values, perceived benefits of loyalty, and the perceived impact of their actions on the local area. Variables associated with local loyalty may include civic engagement, support for local businesses, and active participation in local initiatives or organizations as well as future intention.

In our perspective, the extent of local loyalty serves as a proxy indicator not only for well-being but also for future intentions regarding residence - whether one intends to stay or relocate and relationships to services and institutions of the city. Our conceptualization of loyalty closely aligns with the concept of CLI, which acknowledges that loyalty stems from a multitude of variables. An integrated methodology, as introduced in prior research (Varela Mallou et al., 2008), has proven effective in categorizing consumers into various loyalty segments based on their affinity towards a particular service. We apply a similar approach to assess the local loyalty of residents towards their city, considering relevant variables in this determination process in the next subsection.

2.1.3. Data analysis perspective of local loyalty

The perceptions of engagement (I am engaged with the city.), rational ties (I aspirate to use local services), relevance (I feel good in the city.) and future intentions (I plan to settle down here in the long term.) were measured as appropriate antecedent indicators of local loyalty. Respondents were asked to rate relevant statements on a 4-point Likert scale. This study considers these indicators to be essential dimensions of loyalty to the city. The three-component model considers emotional, rational and moral attachments (Lariviere, Keiningham, Cooil, Aksoy, & Malthouse, 2014), moreover, is widely used in the social sciences. In this study, two emotional factors (engagement and relevance), rational ties, and moral variable (future intentions) are considered components of local loyalty.

Variables consider local loyalty are reduced to a latent variable in the data model. LCA provides an applicable tool for answering many research questions in the social and behavioral sciences (Hagenaars & McCutcheon, 2002). In most applications of LCA as a measurement model, the latent variable is regarded as a "cause" (or consequence) of the indicators. An application of LCA is the Latent Class Cluster Analysis (LCCA) that provides a classification method for grouping similar objects in which the number of groups is unknown (Hagenaars & McCutcheon, 2002). LCCA is a measurement model in which individuals can be classified into mutually exclusive and exhaustive types or latent classes based on the pattern of answers concerning a set of categorical indicator variables. LCCA is a model-based form of clustering which assumes that the data are generated by a mixture of underlying probability distributions and is advantageous in terms of its utilization (Magidson & Vermunt, 2004; Vermunt & Magidson, 2000). Many business research topics have successfully applied this method to differentiate between consumers, to decrease their complexity and thus understand them better (Castro et al., 2007; Guerrero et al., 2007; Picón-Berjoyo et al., 2016; Wedel & Kamakura, 2012).

One advantage of LCA is that it is a suitable tool for measuring local loyalty. Since the Likert scale measures the extent to which the respondent considers the variables to be true of him/herself, the response patterns to the four variables considered for LCA will measure the degree of local loyalty. The poLCA package in R (Linzer et al., 2011) was used to differentiate between clusters with various degrees of local loyalty.

2.2. Measuring the influencing factors of local loyalty with a correlation network

2.2.1. Potential related factors affecting local loyalty derived from vitality indices

If the level of loyalty can be analyzed in terms of territories or places, the question regarding what kinds of factors should be taken into consideration arises. The question concerning what makes places, cities and settlements attractive as well as the functions different cities should provide are extensively discussed in urban and regional studies. A study differentiated between seven factors which are the basic societal functions of cities, namely the provision of employment opportunities, housing, learning and training capabilities, communication platforms, consumption, leisure and recreational facilities as well as ways for inhabitants and visitors can feel that they belong to a community (Partzsch, 1964). Nowadays, more and more research concerns why some cities are more attractive from economic, social or natural equity points of view than others. Several indices have been developed in order to assess both the material and immaterial assets of various cities. Often, not only do the indices aim to assess the performance of various territories but provide information concerning long-term development policies and practices. The Eurobarometer survey in 2015 (D.-G. f. R. European Commission, U. Policy, 2015) and 2020 (D.-G. f. R. European Commission, U. Policy, 2020) assesses the satisfaction of urban residents with various aspects of urban life, providing a tool for comparing around 80 European cities based on 30 perception criteria related to social, economic, cultural, and environmental factors, thus promoting a holistic approach to sustainable urban development. In China, the The Urban Sustainability Index (*Urban sustainability index*, 2010) published by the Urban China Initiative provided a comprehensive analysis of the shifts in sustainability taking place in cities throughout China in terms of economy, society, resources, and environment, while the Urban Vitality Index (UVI) (Yang et al., 2010) emphasizes that urban ecosystems run in parallel to vital organisms in terms of structure, function, performance and evolution. The Winnipeg Quality of Life Indicators draw attention to the compliance requirements concerning human needs, such as to what extent residents value their quality of life (QoL) in their settlement; how they appreciate the size and pace of the city as well as its amenities; to what extent they are attached to their neighbourhoods; and whether they feel that Winnipeg is a great city in which to raise a family (Hardi & Pinter, 2006).

Although, what makes people content varies from cultures, several initiatives exist to determine QoL levels. The 'Quality of Living City Ranking' published by Mercer (Mercer, 2019), a leading American provider of data on the quality of live of employees sent to work abroad, evaluates the performance of nearly 500 global assignment destinations in terms of recreation; housing; economic environment; the availability of consumer goods; public services and transport; political, social, natural and socio-cultural environments; schools and education; as well as medical and health considerations. The Arcadis Sustainable Cities Index

2018 (SCI) (Arcadis, 2018) analyzed 'Citizen Centric Cities' based on the ranking of citizens in 100 cities worldwide in terms of the three pillars of sustainability: People - social, Planet - environmental and Profit – economic. The research and analysis division of The Economist Group compiled the Economist Intelligence Unit's survey on livability to assess which locations worldwide provide the best or worst living conditions based on more than 30 qualitative and quantitative factors across five broad categories: stability, healthcare, culture and environment, education and infrastructure (T. E. I. U. (EIU), 2019). Although the overall research report is available for customers, the free overview of the 2019 version lists the five biggest improvers as well as decliners on the top of the ten most and least livable cities worldwide. The report states that half of the most livable cities are in Europe and Vienna ranked as first (T. E. I. U. (EIU), 2019). As can be seen, these indices often use data from general national statistics and surveys.

Beyond the conventional aspects of a livable city, it's imperative to recognize that the allure of a place, whether it's a city or a neighbourhood, is intricately linked to the appeal of its community, even in instances of segregated areas (Okulicz-Kozaryn, 2019). This concept aligns with the psychological attraction theory (Byrne, 1971), which suggests that individuals are naturally attract to those who share similarities and are well-connected within social networks (McPherson et al., 2001). The preference for residing among individuals with similar characteristics holds significant sway in neighbourhood selection (Krysan et al., 2009), thereby increasing the likelihood of choosing to live in an area where people with akin preferences reside (Bell, 2014). Ultimately, the contentment derived from one's neighbours and their broader community often serves as a compelling motivator for individuals to either relocate or remain in a particular locale (Okulicz-Kozaryn, 2019).

2.2.2. *The questionnaire design to obtain influencing factors of local loyalty*

The questionnaire of this research was designed to cover as many factors related to loyalty as possible. From the factors described above, a total of 126 candidate explanatory variables and 1 dependent variable were included in the database. To make the full questionnaire public would be very long. The use of a machine learning algorithm also provides, among other things, a selection of variables. The topics show what can make a city attractive to its inhabitants and are potentially related to local loyalty. Questions were asked about

- **Economic Development**: Income level, entrepreneurship, savings.
- **Local Governance**: Information openness, involvement in decisions, performance of local representatives, engagement in local affairs.
- **Social Vitality**: Quality of life, intention to move, public trust in institutions, volunteering, perception of corruption, community belonging, identity.
- **Health**: Health status, hospital visits, health screenings, smoking, alcohol consumption, physical activity.
- **Cultural Activity**: Attendance at theatre, cinema, museums, libraries, reading books, participation in music and sport events.
- **Social Networks**: Trust, tolerance, reliance on family, neighbours, friends, NGOs, preference for local products and services.
- **Natural and Built Environments**: Air quality, waste collection, environmental conditions, parks, use and perception of public transport, local government's role in preventing climate change, public cleanliness, maintenance of historic sites.
- **Education and Learning**: Education, IT skills, smart device usage, participation in lifelong learning, foreign language skills.
- **Satisfaction with City Services and Facilities**: Learning, work, health, recreational opportunities, public safety.

In the case of evaluations, a 4-point Likert scale was applied, where one denotes the strong disagreement and four strong agreement. One of the aims of this work is to highlight the most important explanatory factors among the many variables measured.

2.2.3. *Data mining approaches in determining the factors that influence local loyalty*

The challenge of this research is to identify the factors that influence loyalty, for which we have developed a novel high-resolution method. Classes of loyalty levels (groups of respondents) were added as dependent variables to the topics surveyed by the questionnaire. All other variables were used as explanatory factors, except for those used to determine loyalty groups, that is, to examine what factors determine membership to one of the groups with different loyalty levels.

Firstly, a machine learning prediction method was used to create a classification model for membership to loyalty group as the dependent variable. We used a Random Forest (RF) approach (Breiman, 2001) because it is not a black-box model. The feature importance computed by the RF provides information on variables that effectively classify the respondents into loyalty groups by specifying the variables with the most important predictive power. In this way, RF meets the criterion of Explainable Artificial Intelligence (XAI) (Arrieta et al., 2020; Molnar et al., 2020) and which variables provided the strength of the predictive model identified.

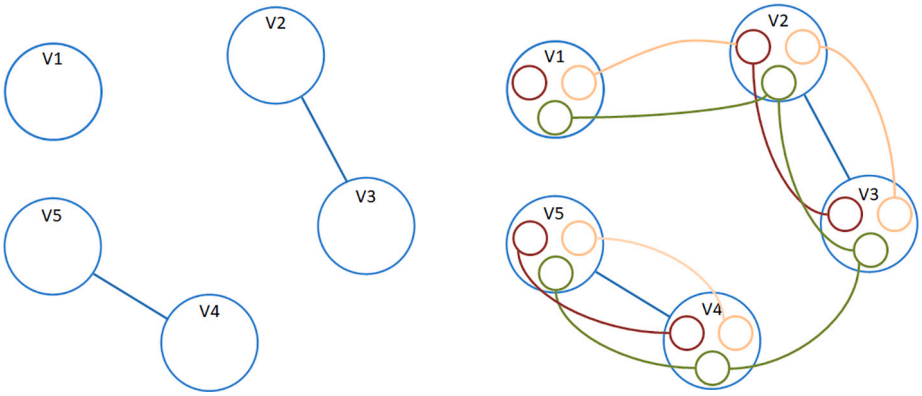
Secondly, in this study, we presumed that different degrees of loyalty are associated with other factors. The research question of the investigation is whether a significant difference is found between the explanations for high and low levels of loyalty. Our focus of the analysis deepened from correlated variables to correlated response categories.

A novel methodology is presented in this study which identifies significantly associated categories of answers. We drew all correlations with regard to the categories of answers and the retrieved information was networked. In the correlation network generated, the nodes are the response categories with edges between them if a significant correlation was detected. The results of traditional correlation search algorithms, e.g. Cramer's V, Pearson's correlation can also be viewed as a network if all the correlations between all the variables has been identified. However, by taking a closer look and searching for correlations in terms of categories of answers, we obtained a much more detailed picture of the correlations as illustrated in Fig. 2.

We sought a method that examines the responses and regards them as a projection of behavior (Berry et al., 2021). The network approach is confirmed by the nature of the neurological representation of the associations underlying the observed behaviors. At the perceptual level, any object - a city or a brand - is a set of associations mapped in an individual's brain, which is a network of information recorded in brain cells that can be measured by brain imaging techniques (Schaefer, 2009). Since the presented method uses data science methodologies to explore association sets, it can reveal new dimensions, being more accurate than existing methods when applied as a standard procedure.

Association rule mining (ARM) (Agrawal et al., 1994) provides an appropriate data mining method to determine the level of significance of coexisting categories of answers. By mining association rules, 'if-then' response patterns are revealed. IF one response category for a variable is chosen by many people in the questionnaire, THEN how confidently is another response category answered? The implementation of ARM to analyze questionnaire data defines edges in the correlation network of the response categories. The edges, which represent strong associations, are directed, where the starting node is referred to as an 'antecedent' or 'left-hand side (LHS)', and the endpoint is a 'consequent' or 'right-hand side (RHS)'. Association rules can be represented as A1,A2,A3 ⇒ C1, where A denotes antecedent(s) (LHS) and C stands for consequent (RHS), which also indicates the direction of the edges.

The challenge of using ARM on questionnaire data is that the method was originally developed for sparse databases. Questionnaire data are dense because the respondents answer almost all of the questions. Therefore, when mining correlated information from the database, a huge amount of information concerning relationships was extracted rendering it difficult to filter out useful information. The most important point of development was to identify the most interesting correlations between categories of answers. Statistically significant association rules



(a) Let correlations between variables (circles denote variables). Correlations between variables V2 and V3 as well as V4 and V5 illustrated.

(b) Correlations between categories of answers can identified by association rule mining algorithm (circles denotes categories of answers, red circles = low level, yellow = average level, green = high level). Correlation between categories of answers shows a more detailed picture.

Fig. 2. An example network of the correlations.

were filtered out with the hyperconfidence measure (Hahsler & Hornik, 2007) and associations ranked with a confidence measure (Agrawal et al., 1993) by taking into consideration the null-invariant cosine measure (Tan et al., 2004).

2.3. Data collection

2.3.1. Methodology of data collection

An essential element of the methodology involves collecting data from a representative sample. This sample was stratified to account for age, gender, and neighbourhood, ensuring that it accurately represented these demographic factors within the city. Only adults over 18 years of age were included in the sample. The comparison of the demographic factors of the sample and the residents is represented in Table 1. The population figures for the neighbourhoods and the sex ratios were derived from the 2001 census data provided by the Hungarian Central Statistical Office, which are considered highly reliable and assumed to have experienced minimal changes over time. As no more recent official data were available, the 2001 census data was utilized. To estimate generational proportions, the recent municipal population register was considered.

Table 1
Sample and population distributions by demographic variables.

Demographic factor	Sample (%)	Residents (%)
Age groups by year of birth		
Veterans (1946 and earlier)	6.1 (46.6 % male, 53.4 % female)	6.2 (42.0 % male, 58.0 % female)
Generation Baby boomers (1946–1964)	31.4 (37.1 % male, 62.9 % female)	31.8 (45.3 % male, 54.6 % female)
Generation X (1965–1979)	32.8 (50.1 % male, 49.9 % female)	32.6 (50.6 % male, 49.3 % female)
Generation Y (1980–1994)	21.8 (52.3 % male, 47.7 % female)	21.7 (50.8 % male, 49.2 % female)
Generation Z (1995–2010)	7.9 (55.8 % male, 44.2 % female)	7.7 (50.5 % male, 49.5 % female)
Gender		
Female	53.2	53.2
Male	46.8	46.8
Neighbourhood		
Downtown	8.6	8.6
Dozsa	8.3	8.3
Iparvaros	2.5	2.5
Jeruzsalem	4.6	4.6
Egyetem	11.0	11.0
Cholnoky	19.5	19.5
Jutas	37.4	37.4
Kadarta	8.1	8.1

The data comes from an on-site survey conducted in 2017 in Veszprém, Hungary. Trained interviewers conducted the survey using Computer-Assisted Telephone Interviewing (CATI) techniques. The use of CATI ensured that the responses were complete, eliminating the need for data imputation during analysis.

In total, 1200 individuals, representing 2.14 % of the city's population of around 56,000 inhabitants, responded to the questionnaire. Completing the questionnaire typically required around 45 min.

2.3.2. About the field of data collection

The methodology was applied, and a representative questionnaire survey was conducted in Veszprém, Hungary, the European Capital of Culture 2023. Veszprém city region has been selected as a test area for the survey, since it is one of the oldest urban areas in Hungary, has a special locational advantage since it is situated 15 km far from the largest lake in Hungary, called Balaton, considered as a gateway of the Bakony mountains. Veszprém has an outstanding cultural heritage: as a historic town it has many memorial buildings (Castle, churches), it is the regional centre of the catholic church, a place, where the first institution of higher education was established in the country that taught the seven liberal arts as early as the 13th century. After World War II, the number of inhabitants has tripled in the town due to its industrial role. Although the city has a strong and diversified local economic base, the share of jobs supply with high value-added components is a goal. The municipality considered the title of European Capital of Culture as a possible alternative to strengthen the role of the city in creative domains, which would contribute to the repositioning of the settlement. The survey was carried out as a decision-making support to explore the possible involvement of the population to act for their environment and city.

The title of European Capital of Culture is awarded by the EU's Directorate-General for Education, Youth, Sport and Culture in order to highlight the cultural richness of its Member States. The title is an

excellent opportunity both for raising the international profile of cities and enhancing the image of cities in the eyes of their own inhabitants. Since its foundation in 1985, more than 60 cities have been awarded and the focus from large cities turned to small- and medium-sized ones. In 2023, there are 3 European Capitals of Culture: Elefsina (Greece), Timisoara (Romania) and Veszprém (Hungary).

3. Results - understanding local loyalty with a correlation network

Without a hypothesis, we determined the levels of loyalty and the factors influencing them using machine learning and a high-resolution correlation network. In order to present the results, first the local loyalty levels were measured. The following subsection describes the correlation network for all the response categories of every variable in the questionnaire, by focusing on local loyalty. Finally at the end of the results section, we demonstrate how sensitive the novel method is to small groups.

3.1. The degree of local loyalty

Local loyalty is considered to be a latent factor of engagement (I am engaged with the city.), relevance (I feel good in the city), future intentions (I plan to settle here in the long term) and rational ties (I aspirate to use local services) to formulate a multifaceted, complex phenomenon of local loyalty.

The respondents were clustered using the commonly used LCA to differentiate between respondents with various degrees of loyalty based on their response patterns. Clustering using LCA was compared with clustering by adopting Manhattan-based similarities and Partitioning Around Medoids (PAM). It was found that respondents were very likely to be grouped in the same way by applying both procedures. The distribution of responses to each question by separated clusters is shown in Fig. 3.

The clustering method categorized people into very loyal, loyal, semi-loyal and vacillating or least loyal group. The size of each group provided interesting information. Most respondents in Veszprém (78 %) were categorized into the loyal and very loyal groups, which is good news for the municipal council. The average values of rational ties decrease the most as the degree of local loyalty reduces. The average values of relevance decrease the least as loyalty reduces. Rational ties yielded the lowest average value in each loyalty group, while relevance showed the highest.

3.2. Factors affecting the degree of local loyalty

3.2.1. Relationships with demographic variables

What factors classify respondents into groups with different levels of local loyalty? We begin by examining each loyalty group according to their demographic variables and in search of significant differences. Demographic variables were widely interpreted and included financial circumstances, commuting, individual happiness, satisfaction with job

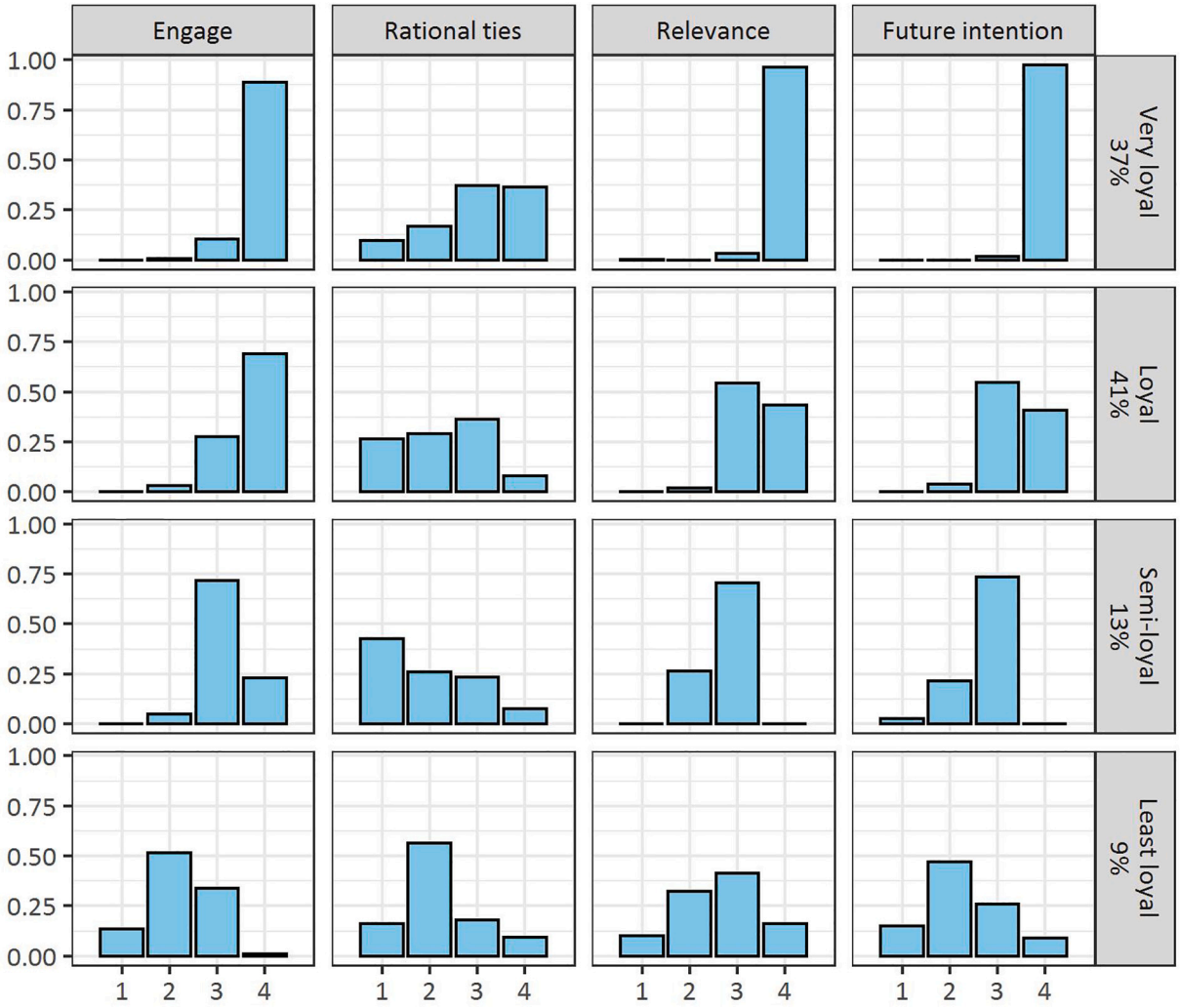


Fig. 3. Distribution of responses according to the components of loyalty components in each cluster. Clustering method: Latent class analysis.

and time spent in the settlement. The significant relationships between loyalty and demographic variables are listed below. The significance of all relationships was evaluated using statistical tests χ^2, with p-values approaching 0 in all cases.

- The younger the respondent, the less loyal they are considered to be.
- The less loyal someone is, the more likely they live in poor financial circumstances.
- Interestingly, often the more loyal someone is, the less likely they are to state how much they earn.
- As loyalty decreases, satisfaction with job decreases.
- Since the likelihood of being a commuter is significantly greater in the least loyal group, this group can be considered to consist of commuters.
- The proportion of unhappy people increases as loyalty decreases.
- As loyalty decreases, respondents are more likely to regard others in their local network as more unhappy, especially in the least loyal group.
- A significant correlation is found between local loyalty and neighbourhoods. The closer someone lives to downtown, the more loyal they are. The dated neighbourhoods with few services and facilities are the least loyal to the settlement, moreover, a difference is observed between the two large housing estates. The residents of 'Cholnokyváros', who live in a housing estate that is more involved in the governmental housing renovation programme, full of stores and restaurants, are particularly more loyal.

Established methods were employed to validate these findings, including the use of Structural Equation Modelling (SEM), a commonly utilized approach in the fields of social and behavioral science, especially to quantify relationships of latent variables. In this instance, we integrated the four constituent factors of loyalty into our model and systematically assessed their relationships with demographic variables. To assess the impact of demographic attributes on local loyalty, the following procedure was used: a demographic variable category was selected as a reference point and then examined how the level of local loyalty differed concerning groups characterized by other demographic properties. To determine the significance of these relationships, we performed bootstrapping procedures. All calculations were executed using R with the SEMinR software package (Hair Jr et al., 2021). The summarized results can be found in Table 2.

The reference category was consistently positioned at one end of the range of demographic variables, except for the neighbourhood. As the study moved towards the opposite extreme of this variable, local loyalty exhibited a decrease in accordance with the path coefficient. In almost all cases, the observed change in local loyalty with respect to the demographic characteristic of reference is considered significant, as indicated by the T statistic falling below −1.645. The local loyalty remains statistically nonsignificant in the 'Iparvaros' and 'Cholnoky' neighbourhoods, indicating a comparable level with the Downtown.

There is no correlation between the education level, job, the number of children, and the degree of local loyalty.

3.2.2. Finding the key influencing factors

Membership in a particular loyalty group was determined using machine learning. The important variables calculated by Random Forest (RF) are shown in Fig. 4, which shows the ten most important features that effectively predict the loyalty group of the respondents. The contribution of the variables to the accuracy of the prediction is shown in Fig. 4. The contribution is measured by how much the accuracy of the prediction would be reduced if the variable were removed from the model. By removing any additional variables not shown in the figure, the accuracy of the model decreases by less than 0.4 %, a negligible amount, therefore, the first ten important variables are only included in Fig. 4.

Several variables of the top ten predictors are directly correlated with variables considered as components of local loyalty, namely engagement, relevance, future intention and rational ties. Both loyalty to a subregion and a region resemble loyalty to a city. The factors relevance (I feel good in the city.) and "I want my children to live here." also have similar meanings. What is good for me is also suitable for my loved ones. Given that rational tie was measured by the variable "I aspirate to use local services.", which has a very similar meaning to the variable "I try to hire a local entrepreneur to do tasks at home", they do not provide too much additional information with regard to the analysis of loyalty.

However, it is surprising that living in a neighbourhood is an efficient predictor of the degree of local loyalty. The city studied in this research is comprised of very different neighbourhoods. Two housing estates, two suburban zone, university quarter and downtown, are the most populated in the city. The provision of services, population density, quality of

Table 2
Assessing the impact of demographic variables on local loyalty by SEM.

	Path coefficients (original estimates)	Path coefficients (bootstrap estimates)	T statistics
Age (reference: elderly and boomers)			
Generation X → Local loyalty	−0.067	−0.068	−2.062
Generation Y → Local loyalty	−0.175	−0.177	−5.637
Generation Z → Local loyalty	−0.181	−0.183	−5.200
Financial circumstances (reference: affluent)			
Average → Local loyalty	−0.142	−0.143	−4.716
Poor → Local loyalty	−0.208	−0.211	−6.560
Satisfaction with job (reference: very satisfied)			
Satisfied → Local loyalty	−0.293	−0.293	−10.928
Unsatisfied → Local loyalty	−0.480	−0.481	−15.906
Commuting (reference: work in the city where the respondent lives)			
Commute → Local loyalty	−0.074	−0.085	−2.236
Happiness (reference: very happy)			
Happy → Local loyalty	−0.360	−0.361	−14.094
Unhappy → Local loyalty	−0.446	−0.447	−14.002
Neighbourhood (reference: downtown)			
Dozsa → Local loyalty	−0.457	−0.458	−10.770
Iparvaros → Local loyalty	0.012	0.011	0.465
Jeruzsalem → Local loyalty	−0.089	−0.089	−3.068
Egyetem → Local loyalty	−0.183	−0.182	−4.195
Cholnoky → Local loyalty	−0.054	−0.054	−1.273
Jutas → Local loyalty	−0.233	−0.234	−4.259
Kadarta → Local loyalty	−0.303	−0.304	−7.126
Time spent in the city in a year (reference: whole year)			
7–11 months → Local loyalty	−0.201	−0.201	−5.286
0–6 months → Local loyalty	−0.344	−0.346	−9.972

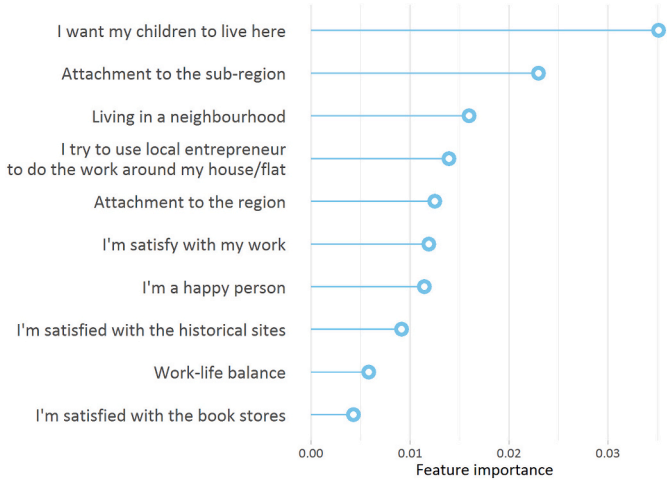


Fig. 4. Important variables for classifying respondents by loyalty.

educational institutions, quality of life and the living standards of its residents vary from neighbourhood to neighbourhood. The variables job satisfaction, "I am a happy person" and work-life balance strongly predict membership to loyalty groups. Satisfaction with local services and historic sites, perhaps unsurprisingly, strongly correlated with loyalty.

An established method was used to analyze the differences between local loyalty groups in relation to important predictor variables. Given that the variables on the Likert scale are more appropriately treated as ordinal rather than continuous, the significance of differences between loyalty groups was assessed using the Kruskal-Wallis test. The results, presented in Table 3, indicate that the p-value is lower than the significance level of 0.05. This suggests that there are indeed significant differences among the local loyalty groups in terms of important variables.

Since a non-standardized questionnaire was used in this research, the literature sources for the important indicators from which the variable was derived are specified in Table 3.

The confusion matrix of 300 respondents unknown to the classification model (test set) is shown in Table 4. The average error rate is 32.3 % and the model correctly classifies two-thirds of the respondents. The error rate varies from group to group and is much smaller for the two large clusters. These results suggest that the important variables only provide the correct classification for large groups and least loyals affected by other factors.

We went deeper by identifying the influencing factors of belonging to

Table 3
The significance of important predictors with local loyalty groups tested.

Important predictor	Kruskal-Wallis χ^2	df	p-Value
I want my children to live here (Stipak, 1980)	246.06	3	<2.2e−16
Attachment to the sub-region (I. I. of Sustainable Development (IISD), U. W. Winnipeg, n.d.)	307.18	3	<2.2e−16
Living in a specific part of the city (P. R. Associates, 2021a)	47.99	3	2.145e−10
I try to use local entrepreneurs to do tasks around my home (Stipak, 1980)	171.18	3	<2.2e−16
I'm satisfied with my work (D.-G. f. R. European Commission, U. Policy, 2015)	220.36	3	<2.2e−16
Attachment to the region (I. I. of Sustainable Development (IISD), U. W. Winnipeg, n.d.)	212.62	3	<2.2e−16
I'm a happy person (*Ipsos global happiness report*, 2013)	219.61	3	<2.2e−16
I'm satisfied with the historical sites (P. R. Associates, 2021b)	194.65	3	<2.2e−16
Work-life balance (I. L. Office, 2011)	177.64	3	<2.2e−16
I'm satisfied with the book stores (P. R. Associates, 2021b)	183.28	3	<2.2e−16

Table 4
Confusion matrix of the prediction on the test set. Bold font indicates cases that have been correctly classified.

		Predicted groups				
		Least loyal	Semi-loyal	Loyal	Very loyal	Error rate
Real groups	Least loyal	**12**	1	14	1	57.1 %
	Semi-loyal	3	**11**	25	1	72.5 %
	Loyal	4	1	**97**	21	21.1 %
	Very loyal	0	0	26	**83**	23.9 %

the different loyalty groups and determined the response categories most associated with each group by searching for association rules. It is obvious to examine loyalty as a consequent or right-hand side (RHS) and investigate what factors correlate with different degrees of loyalty as antecedents or left-hand side (LHS). Antecedents and consequences are the nomenclature of association rule mining and do not imply cause and effect relationships, as shown in the Methods section. Response categories for each variable were ranked based on the likelihood of predicting membership to a loyalty group. In Table 5, it is presented how the important variables obtained by RF actually predict membership in the loyalty groups. An example illustrates the table.

Job satisfaction (fifth row of Table 5) is the 5th strongest predictor of membership to a loyalty group on average, calculated by RF. Focusing on the very loyal group, we can find that those who answered with four (strongly agree) to the question about job satisfaction with 55.2 % probability belonged to the very loyal group, namely 270 individuals from 436 in total. The columns entitled 'Count' denote how many people responded to LHS and RHS together, indicating the support of the association rule. The column 'Confidence' shows the proportion (55.2 %) of those who are strongly satisfied with their job belonging to the high loyalty group. The high job satisfaction response category is only the 13th best predictor of being in a high loyalty group, shown in column 'Rank'.

The variables that best predict membership of the **very loyal** group are also considered to be important by the RF with "strongly agree" responses to these questions. Two-thirds of respondents in downtown are very loyal, which is the third most important factor in achieving a high level of loyalty. Another important response category was shopping in a local store; 72. 8 % of such responses predicted a high level of loyalty. In addition, members of a small group cannot rely on their friends to solve financial or psychological problems. Although more than 60 % of those who cannot rely on their friends to solve problems (answer 1) are very loyal to the city, only about 50 of the 1200 respondents were such people.

Confidence values for factors predicting members who are **loyal** are lower than factors predicting those who are very loyal. However, several factors are variables considered to be important by the RF and significant in terms of the association rules. The responses to questions by those belonging to the loyal group were typically "agree (3)". Table 5 not contains significantly related factors, namely expecting help from colleagues, NGOs and churches with health and financial, psychological problems. These responses indicate that members of the loyal group have healthy social ties but for some reason they answered with "agree (3)" instead of "strongly agree (4)". These respondents are 53–57 % likely to belonging to the loyal group. In addition to issues concerning social relation, those who refuse to attend regular medical check-ups are also important. 52.7 % of such respondents belong to the loyal group (126 persons) who do not take regular health screening tests.

The confidence values are very low for the **semi-loyal** group and the important variables of the RF are not the most important ones. However, variables not included in Table 5 and the responses to them have a predictive power of only 26–30 %, suggesting that no strong collective

Table 5
Factors determining grouping by loyalty groups. Rows are related variables, the answer is the response category of the given variable closely related to the loyalty group.

Variable as an antecedent	RF	Least loyal (111 persons)				Semi-loyal (161 persons)				Loyal (492 persons)				Very loyal (436 persons)			
	Rank	Rank	Answer	Confidence	Count	Rank	Answer	Confidence	Count	Rank	Answer	Confidence	Count	Rank	Answer	Confidence	Count
I want my children to live here	1	27	2	0.280	40	30+	2	0.231	33	5	3	0.531	230	6	4	0.606	336
Attachment to the sub-region	2	11	2	0.438	49	30+	3	0.230	106	30+	3	0.460	212	25	4	0.536	331
Living in a specific part of the city	3	10	Dozsa	0.450	45	30+	Jutasi	0.169	76	12	Jutasi	0.514	231	3	Downtown	0.689	71
I try to use local entrepreneurs to do tasks around my home	4	30+	2	0.200	61	22	1	0.246	79	30+	3	0.468	182	1	4	0.730	135
I'm satisfied with my work	5	23	2	0.288	38	2	2	0.303	40	8	3	0.521	238	13	4	0.552	270
Attachment to the region	6	22	2	0.301	53	30+	2	0.233	100	24	3	0.497	206	16	4	0.551	305
I'm a happy person	7	30+	2	0.264	33	20	2	0.248	31	16	3	0.498	272	8	4	0.586	297
I'm satisfied with the historical sites	8	30+	2	0.246	34	15	2	0.254	35	11	3	0.516	231	10	4	0.562	308
Work-life balance	9	28	2	0.276	40	28	2	0.234	34	23	3	0.479	218	19	4	0.543	255
I'm satisfied with the book stores	10	30+	2	0.201	31	30+	2	0.208	32	30+	3	0.459	216	14	4	0.551	291

response pattern applies to the cluster. Factors contributing towards the dissatisfaction of underlie membership of the semi-loyal group membership. In general, "disagree (2)" are correlated with this group. Between 26 % and 30 % of those who are dissatisfied with the natural environment, air quality, cultural institutions, cinemas, leisure facilities, interurban transport, and their household's financial situation belong to the semi-loyal group. It is interesting to note that no pattern in responses indicating social relational factors for the semi-loyal group, unlike in the loyal and very loyal groups.

As shown in Table 5, the neighbourhood in which residents live is an important factor in predicting membership of the **least loyal** group. Residents in the neighbourhood "Dozsa" which is characterized by most old detached houses and the least local services due to the low population density over a large area, were 45 % likely to belong to the least loyal group. The main factors that characterize the least loyal group are not presented in the table. Based on the responses of a small minority of 10 respondents, those who do not feel safe in settlements are 90 % likely to be disloyal. Those who have resided in the settlement for less than six months are 61. 4 % likely to belong to the least loyal group. Since a lack of family roots is an important factor, residents who cannot expect help from their family with everyday, financial, health and psychological problems, as well as have very weak social connections, namely a sample of 13–17 respondents, are 46–55 % likely to be disloyal.

3.3. *Driving forces of a very loyal group of residents with weak social ties*

Healthy social ties have a positive effect on loyal behavior (Woisetschläger et al., 2011). In the very loyal group, we identified a social minority with weak social ties and examined them more closely with the association network consisting of categories on answers presented in Fig. 5. The quality of the social networks of the respondents is evaluated by the answers to a set of questions (8 items) "How much can you count on help from your family OR friends OR neighbors OR colleagues with everyday OR psychological problems?". In Fig. 5 the nodes denote the categories of answers to eight variables and the edges represent significant relationships between them uncovered by association rule mining. The nodes are labelled with the codes of variables and answers. The shapes of nodes refer to the type of problem, namely everyday or psychological ones that can be solved by social relationship. Colours are associated with the Likert scale answers. The quality of social relationships is an indicator of who the respondent can count on to help solve problems. It is shown that those who can rely on family members are also very likely to rely on friends and neighbours, because the "strongly agree" response categories are located in a cluster in Fig. 5. Other response categories are also found in different groups. It is interesting to observe how the levels of loyalty are connected to this correlation network and what relationships influence the degree of loyalty.

Three major interconnected parts can be found in the figure. The top-right side of the figure shows the correlation between those with poor social ties but a high degree of loyalty. Many respondents who cannot count on family members to help with everyday and psychological problems also cannot count on friends, neighbours, and colleagues. Although some of them are the least loyal, a significant group (121 people, 10 % of respondents, 28 % of the very loyal group) are very loyal.

The following question arises: if someone has bad human relationships, then what can make them very loyal to the settlement where they live? The method presented in this article can investigate a second dimension as well as the variable indicating the poor quality of a social network, which together are strongly related to the very loyal category. The most related factors, albeit simplified, can be seen in Table 6 The term "poor quality of social network" refers to a deficiency in both a type of relationship and problem. The "Added value" column shows how much the factor in LHS increases the likelihood of people with poor social ties belonging to the very loyal group.

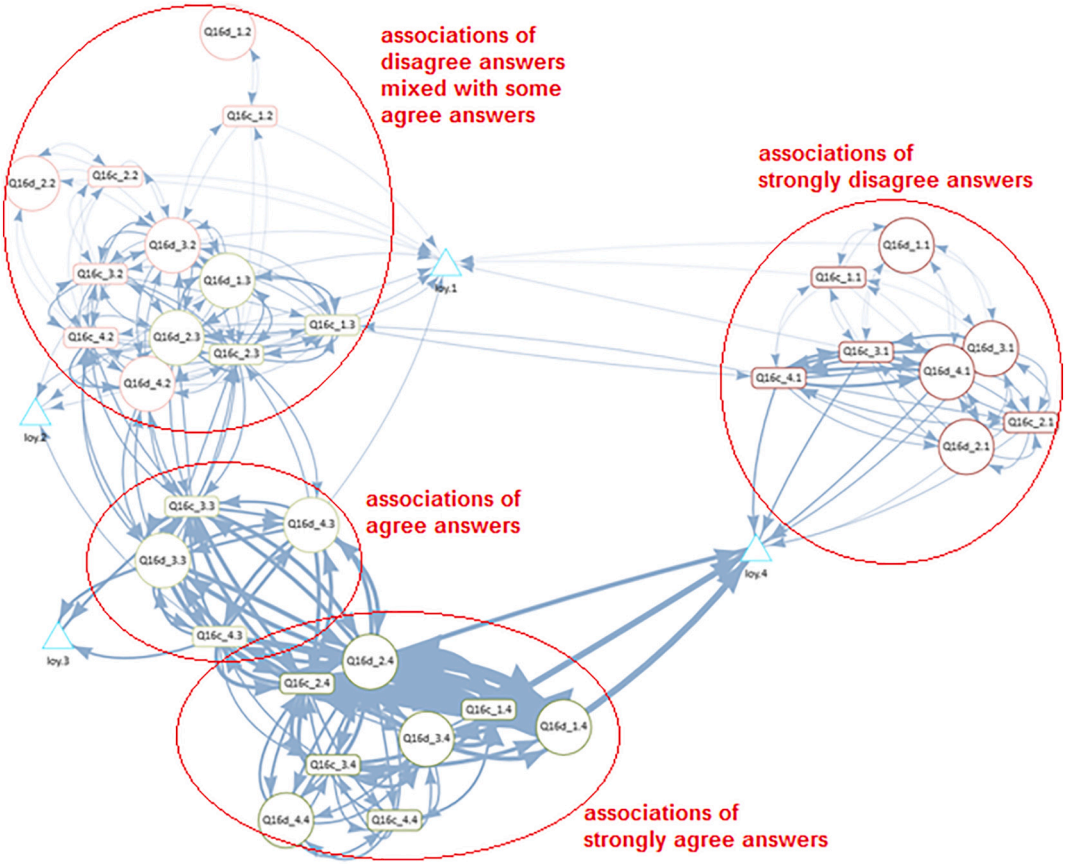


Fig. 5. Association network of degree of local loyalty and quality of respondent's social network (circle: help in everyday problems variable, box: help in psychological problems variable, triangle: local loyalty variable; the number after '_': 1 – help from member of family, 2 – help from friend, 3 – help from neighbour, 4 – help from colleague); the number after '.': 1 – strongly disagree, 4 – strongly agree.

Table 6
Factors related to the very loyal behavior of respondents with poor quality of social networks (4 denotes strong agreement with the statement in the question).

LHS		RHS	Count (persons)	Added value (%)
Poor quality of social network AND …	…satisfaction with music events (4)	Very loyal (36 %)	85	23
	…feel safety (4)		85	20
	…satisfaction with cinemas (4)		79	24
	…satisfaction with restaurants (4)		78	27
	…satisfaction with sport facilities (4)		77	25
	…satisfaction with air quality (4)		74	27
	…satisfaction with entertainments (4)		70	33
	…living downtown		47	38
	…satisfaction with bookstores (4)		41	44
	…availability of services (4)		24	46
	…satisfaction with public services (4)		23	43

These results show the significant added value of the services provided by the municipality or entrepreneurs in rendering someone who has deficient social ties very loyal. The most related factors are those that the local government or entrepreneurs can act on. Factors that are specific to the city, e.g. environment or location, are only somewhat present in Table 6 and services are more likely to contribute to higher loyalty.

4. Discussions

A city is an expression of multifaceted and strongly intertwined complex systems that depend on factors varying from the social ties and behavior of residents and visitors to its infrastructure as well as from its cultural heritage sites and customs to urban planning. In order for this interrelated, massive system to be well-governed, a tremendous amount of effort is required to analyze to understand. The research aimed to understand local loyalty to the city as an important proxy indicator of the behavior of residents and determine the driving forces that result in its increase and decrease. Since loyal residents are more likely to act for their local community (voice) and less likely to move away (exit) (Hirschman, 1970), it is vital to know the loyalty level of residents and how this can be affected.

The added value of this research is twofold in answering the research topic. Firstly, to the best of our knowledge, there is no studies in the literature that have considered loyalty as a latent variable nor measured it with LCA using its components. On the other hand, we have developed data mining tools to show that problem-oriented information can be extracted by creating a correlation network in a space containing many variables. Although the application of this algorithm contributes towards the exploration of deeper correlations at the level of the response categories of variables, novel results have been extracted in this way.

We developed a questionnaire that includes the components of loyalty and possible drivers derived from vitality indices to gain a deeper understanding of loyalty. Local loyalty was defined as a composite indicator and the degree of local loyalty measured by LCA via separated groups with different levels of loyalty. We showed that particular

components of loyalty do not decrease linearly as the loyalty of the composite indicator decreases.

When measuring the factors that affect the degree of local loyalty, a hypothesizes was not made, rather we searched for the strongest correlations based on data. The most influential factors that best predict membership to groups with different degrees of loyalty were sought.

Machine learning classification was used to select the variables with the strongest predictive power to indicate the strength of correlations between variables before assuming that high and low levels of loyalty resulted from different factors.

We also looked for correlations between response categories to identify factors influencing high and low loyalty. The most related response categories to each loyalty group by considering the correlation network. Since the ARM can measure the level of coexistence of response categories of several variables. Thus multidimensional correlations can be explored. This possibility was exploited in studying a group lacking social ties, albeit very loyal.

Among the composite components of loyalty, relevance is strong even among the least loyal. Meanwhile, rational ties, that is, the use of local shops and services, are relatively weak even among the very loyal. Therefore, the intention to use local shops is not a good indicator of loyalty. This phenomenon is linked to the fact that the municipality surveyed is a small town, and not all the products that residents might need are available. Moreover, environmental awareness is a factor in the purchase decisions made by a few people.

Loyalty is strongly influenced by the neighbourhood where the respondent lives, as this is also a proxy indicator of the standard of living and living conditions. Job satisfaction and happiness also determine the level of loyalty, these factors are at the core of personal needs.

We have shown with the correlation network that different factors affected the groups consisting of various levels of local loyalty. The least loyal people are most likely to reside in the city without family ties. A small proportion of them are only temporary residents in or commuters to the city. Although the semi-loyal group contains many individual aspects, it is mainly characterized by dissatisfaction with the services in the city. The loyal ones have good social relations and are satisfied with their working conditions, but their answers were “agree (3)” which interestingly implies that something is slightly broken. The members of very loyal group are highly satisfied with their jobs as well as the history of the city and are happy. The majority of residents in the city centre are very loyal. It aligns with the findings of (Okulicz-Kozaryn & Valente, 2018), which suggest that cities serve as hubs for various forms of power, including economic, cultural, fashion, and political influence. Cities naturally attract a diverse population, driven in part by the pursuit of power and status.

Even though a minor proportion of very loyal people have poor social networks, they are very loyal because the quality and availability of services in the settlement increase the degree of local loyalty. The phenomenon is very similar to the Frome model (Abel et al., 2018), where compassionate, kind-hearted communities have been created, leading to a significant improvement in the health of the city's residents.

The disloyal group constitutes a minority within the studied city, and they are characterized by factors such as poor social relations, a lack of family background, residing in unsafe and outdated housing, or spending less than six months a year in the city. These factors collectively indicate reduced attachment and trust among this group. This finding aligns with the research conducted by (Okulicz-Kozaryn & Valente, 2022), who have identified various challenges, such as poverty and crime, that tend to intensify misanthropic sentiments in cities. It's worth noting that, while studied city does not exhibit the typical effects of large population density and size, other variables still have a significant impact on the overall livability of the city (Simmel, 2012). This group exhibits weak social connections, making it challenging for them to connect with similar individuals in the community. This limited shared values have a somewhat reducing the extend of local loyalty. However, it's worth noting that factors related to similarity wasn't measured directly, thus it's uncertain if this pattern applies to larger, heterogeneous cities.

Our findings were obtained by considering many factors, e.g., neighbourhood, governance and health status, moreover, our methodology highlighted the most important factors affecting local loyalty. Overall, we found that the satisfaction of basic human needs, that is, livelihood, well-being, social relationships, etc., is primarily related to local loyalty and the indicators related to the city's services and institutions associated weaker with local loyalty. Where the satisfaction of needs is strongly met in a city, then people are very loyal to their settlement, maybe, because it is one's interest. These factors typically represent the personal well-being, however, there is weak correlation between Mercer livability and two subjective well-being indicators in European cities (Okulicz-Kozaryn & Valente, 2019). Sustainability factors contribute to individual satisfaction, or at least there is a correlation, and satisfaction is related to local loyalty (Lee et al., 2021), which are similar findings to ours with different methods.

Our results allow urban planners to implement targeted interventions to increase the level of loyalty. The creation of jobs would most likely enhance the satisfaction and engagement of residents. In neighbourhoods with low levels of loyalty, efforts should be made to raise the quality of local services, public spaces, leisure facilities and cultural institutions as well as the level of safety to more or less compensate for the lack of quality social interactions and increase satisfaction. Although temporary residents in the municipality are likely to be less loyal, programs and services in the city may also render the settlement attractive to them. This idea proves that the city could stimulate stakeholder cooperation based on the triple helix model to improve services in the settlement. The model has been well applied to urban development (Pique et al., 2019) and even as a local response in economic crises (Rodrigues & Melo, 2012).

5. Conclusions and future research

This paper proposes a novel methodology to measure local loyalty and the factors affected it. Previous research had shown that the loyalty indicator evaluate people's feelings of attachment to a particular object such as a city. We reviewed the related literature on the determination of local loyalty and measured it according to four components. Then we identified possible factors that could affect the degree of loyalty with a machine learning algorithm and a goal-oriented data mining approach that separately identifies influential factors of high and low degree of local loyalty.

The proposed methodology offers a distinct advantage in that it identifies various factors associated with both high and low levels of loyalty, each of which may differ from traditional strong predictors. By combining these differently revealed factors, we create an ensemble that provides a more comprehensive understanding. These factors can be identified independently of population distribution, making it possible to pinpoint relevant factors for local loyalty, whether certain groups are in the minority or majority within a city. In our research, the less loyal group was a minority, and we were able to identify factors associated with decreased attachment and trust.

Furthermore, this method excels at selecting strong associations from a high-dimensional space with numerous correlations, highlighting the most significant factors influencing local loyalty. This wealth of information allows us to gain a deeper understanding of city residents. However, it's important to note that cities can vary widely, so there are limitations to generalizing these results. The method can be used everywhere.

The methodology was applied, and a representative questionnaire survey was conducted in Veszprém, Hungary, the European Capital of Culture 2023. Veszprém is located in one of the well-developed regions of Central Europe, with plenty of job opportunities and a beautiful natural environment with traditions. In a city with different populations, leadership, and cultural environment the detailed explanations for local

loyalty may be different and results cannot be generalized.

A limitation of this research is that the causality of local loyalty was not examined because time series data were not available, moreover, no interventions were implemented to increase local loyalty in the city. The examined variables include those that are mutually related with local loyalty, they influence local loyalty but are also influenced by local loyalty. However, a causal relationship can only found between strongly correlated factors. In future research, correlation chains could be explored. In this article, we focused on the antecedents of local loyalty, however, the investigation of consequences as a future direction may also be of interesting. Moreover, the application of ARM to questionnaire databases would be worth exploring more detailed, although the method is not completely new (Burton et al., 2014).

The robust correlation between the quality of social relationships and local loyalty is noteworthy, indicating that the presence of like-minded individuals or supportive human relations can significantly influence the degree of local loyalty. In other words, healthy human relations and intentions for future action, indicated by local loyalty, are significantly related.

In this study, we evaluated the quality of human relationships based on the respondent's ability to rely on support from family members, neighbours, colleagues, or NGOs, as well as the level of support they exhibited. However, the quality of social relationships warrant further investigation in future research. It is possible that the measurable quality of social relationships may be influenced by individual personality traits, such as introversion or considerateness, which can determine one's need for social support. The inclination to provide support to others is not measured in this work, however it is also an indicator of social relationships. In addition, the concept of relationship similarity, or homophily, plays a crucial role in shaping the quality of relationships, especially in large metropolitan settings. It is important to note that this study did not measure factors related to homophily, since homophily did not emerge in this field of research. In metropolitan areas, psychological attraction (Byrne, 1971) is often associated with homophilic relationships, suggesting that local loyalty may not solely reflect attachment to the city but also to specific neighbourhoods or smaller community units.

CRediT authorship contribution statement

László Gadár: Methodology, Software, Visualisation, Writing - Original draft preparation
Mariann Szabó: Data curation, Writing - Original draft preparation
Zoltán Lantos: Conceptualization, Supervision, Reviewing
János Abonyi: Supervision, Writing - Reviewing and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix I. The correlation network in general

The complete multidimensional network resulting from the analysis of responses can be considered to be a data science-based observation, which is able to detect a large variety of behavioral patterns very accurately. A network of significant associations is presented in Fig. 6 for which the LHS contains only one variable. This association network is an analysis tool that represents all the significant relationships between the categories of answers. In Fig. 6 it can be seen that, groups of identical response categories were formed when the network was plotted because the links between nodes pull closely towards each other like magnets. Numerous respondents gave the same ratings for certain topics. The stratification of society is responsible for the groups of response categories and the similarly perceived topics outlined. The big picture shows that the same responses, e.g. those that strongly agree, are often connected.

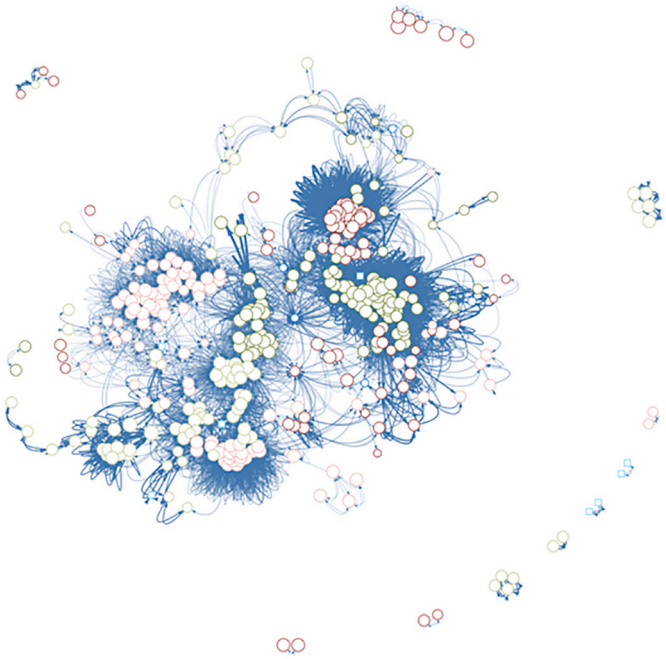

Fig. 6. Correlation network concerning the response categories of variables (dark red: strongly disagree category of answers, light red: disagree category of answers, light green: agree category of answers, dark green: strongly agree category of answers). Links between nodes denote significant associations measured by ARM.

Since the network provides much information, goal-oriented searches should be performed. In this research, our aim was to identify factors closely related to the four categories of loyalty. The network also includes correlations beyond these.

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