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DEVELOPING A MODEL FOR CITIZENS' SATISFACTION WITH PUBLIC SECTOR SERVICES BASED ON ROUGH SETS THEORY: A CASE STUDY OF TEHRAN MUNICIPALITY

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Original scientific paper

Developing a model for citizens' satisfaction with public services is one of the effective factors for improvement of service quality. In recent years, many studies have been carried out to identify a model for citizens' satisfaction with public sector services. In the structure of the presented models in the literature, one of the most important issues regarding organizations giving public services is identification of service scopes that have the most impact on citizens' satisfaction. This paper aims to develop a model to identify citizens' satisfaction status with public services. To do so, first, key factors influencing citizens' satisfaction with public services are identified using the rough sets theory. Then, the citizens' satisfaction tree is presented according to the identified key factors. As a case study, citizens' satisfaction model with services of Tehran municipality, one of the biggest Iranian public organizations, is evaluated. Finally, the citizens' satisfaction tree with municipality services is presented.

Keywords: *business intelligence, citizen satisfaction model, public organization, rough sets theory, Tehran municipality*

Razvoj modela za zadovoljstvo građana uslugama javnog sektora utemeljenog na teoriji grubih setova: analiza slučaja gradske uprave Teheran

Izvorni znanstveni članak

Razvoj modela za zadovoljstvo građana uslugama javnog sektora je jedan od učinkovitih faktora za poboljšanje kvalitete usluga. Zadnjih su godina provedena mnoga istraživanja kako bi se pronašao model za određivanje zadovoljstva građana uslugama javnog sektora. U strukturi modela ponuđenih u literaturi, jedno od najvažnijih pitanja u odnosu na organizacije koje se bave pružanjem javnih usluga je pronalaženje onih područja koja najviše utječu na zadovoljstvo građana. Cilj ovoga rada je razvoj modela za prepoznavanje stanja zadovoljstva građana javnim uslugama. U tu su svrhu najprije identificirani ključni faktori koji djeluju na zadovoljstvo građana, primjenom teorije grubih setova. Zatim je predstavljen dijagram zadovoljstva građana u skladu s identificiranim ključnim faktorima. Kao analiza slučaja, izvedena je procjena modela zadovoljstva građana uslugama u gradskoj upravi Teherana, jednoj od najvećih iranskih javnih organizacija. Konačno, dijagramom je prikazano zadovoljstvo građana uslugama gradske uprave.

Ključne riječi: *javna organizacija, gradska uprava Teheran, model zadovoljstva građana, poslovno izvješćivanje, teorija grubih setova*

1 Introduction

Public organizations may be the most important and biggest available institutions in the world [1]. These organizations have different financial resources to be able to do their duties. Thus, these organizations need a decision making process in their financial resources scope. Complexity of financial decisions made in public organizations originates from a broad range of their functional scopes and their big sizes [2]. Complexity of decisions made in public organizations is clearer when their financial decisions and investments include matters such as health, welfare, and security which are important for survival of human societies [1].

Customers of public organizations are usually people and citizens. Many researchers consider citizens' role for these organizations as customers' role in other organizations [3 ÷ 6]. These studies mention that citizens usually expect receiving services in turn of the money that they pay as a tax and any other kind to public organizations. Although there is still much dispute among experts as "government can be looked at as a business unit or not", almost all agree that investments made by public organizations should (in short- and long-range) be along with the citizens' satisfaction and benefits [3]. Customer behaviour is one of the most significant subjects of modern marketing field. Customers' opinions usually show the future consumption and hence guarantee the business units long-term profit. Thus, customer satisfaction with products and services is usually one of the most important issues of available research [7]. To measure customers' satisfaction with products and services of an organization, expectancy disconfirmation theory is a fundamental theory to be applied. The gap between customers' expectation and the real performance is called expectancy disconfirmation [7 ÷ 9]. This theory begins with the idea that people's judgment about different products and services is formed according to people's expectation from the product/services specifications [10]. After realization of performance, such expectation plays a role as a reference comparison to form the satisfaction [9]. It should be noted that the expectancy disconfirmation can be either positive or negative. Therefore, performance can be either beyond the expectations (positive expectancy disconfirmation) or be less than the expectations (negative expectancy disconfirmation). Expectancy disconfirmation theory, since its development, has been applied to measure people's satisfaction with public services [11 ÷ 13].

One other developed model for customers' satisfaction with public services is SERVQUAL. This model which is formed based on customers' evaluations about quality of services does the gap analysis of customers' expectations quality from services and customers' evaluations of services. In SERVQUAL, service quality is measured by five factors: 1- services tangible specifications (appearance, physical facilities, equipment, personnel, materials, and communication), 2 - reliability (ability to carefully do promised services), 3 - responsiveness (tendency to help customers and fast services), 4 - assurance (knowledge and ethics of personnel and their self-confidence), and 5 - empathy

(closeness, ease of accessibility, and attempt to understand customers' needs) [14, 15]. SERVQUAL has been applied as an evaluation model for customers' satisfaction in sectors healthcare [16], public transportation [17], banking [18], graduate education [19], police services [20], and municipality (city) services [21].

To develop SERVQUAL, Cronin and Taylor [22] showed that customers' satisfaction correlates significantly with customers' evaluation from services; hence they concluded that there is no need to analyse gap between customers' evaluation and expectation from services levels. Therefore, a new concept called SERVEPERF was presented. SERVEPERF has been applied to evaluate municipality services by different researchers such as Kelly and Swindell [23] as one of the most significant research projects.

Organizations give services in different scopes [24]. One of the most important issues in modelling the customers' satisfaction about services is paying attention to service scopes that have the most impact on customers' satisfaction. For example, a municipality gives services in different sectors such as culture, social, transportation and traffic, and urbanism. Hence, citizens' satisfaction is influenced by performance of municipality in above-mentioned sectors [25].

Identifying a combined model of performance and citizens' satisfaction is important where it determines sectors that the organization should focus on to improve citizens' satisfaction. For instance, Van Ryzin et al. [24] showed that the scopes "public schools development", "police services", "streets development and maintenance", and "subway services" have the most impacts on New York citizens' satisfaction about the Federal government services. In such research, interrelations of performance scopes are ignored. In fact, performance scopes are considered completely independent in such research while citizens may not consider those scopes independent from each other. For example, public transportation development cannot be assumed independent from street development and maintenance because citizens may think there is no need to focus on streets development if the city focuses on public transportation development.

Recently business intelligence has received much attention for evaluation of customers' opinions. Business intelligence has a key role in marketing evaluations and analysis of customers' behaviour [26 ÷ 28]. However, business intelligence has not been applied much for evaluation of citizens' opinions about public services. Basically business intelligence tools seem to be helpful in evaluation of citizens' satisfaction with city services and development of citizens' mentality about the city services while they do not have problems of parametric methods. Some advantages of using these tools can be obtained as follows: 1- Parametric models are usually formed based on the parameter's independency, where in real word problems this assumption is not too accurate. 2 - In parametric methods, at the first usually, the model is constructed and then the model parameters are estimated based on data. These models often associated with many errors for subjective judgments. 3 - With the passage of time, BI tools reflect changing the mentality of the citizens, better than parametric methods and so they are more dynamic [28].

In the present paper an algorithm based on rough sets theory is developed to assess and develop citizens' satisfaction from the public services. The proposed algorithm includes processes of information collection, identification of key factors of satisfaction, and providing the satisfaction tree. The city of Tehran is considered as the case study.

2 Rough Sets Theory

Rough sets theory can be regarded as a new mathematical tool for defective data analysis. Rough sets viewpoint is founded on the hypothesis that with every object of the universe of discourse some information (data, knowledge) is associated. Objects characterized by the same information are indiscernible (similar) in view of the available information about them. The indiscernibility relation generated in this way is the mathematical basis of rough sets theory [29].

Matrix $\boldsymbol{PIE}_{m\times(n+1)} = [\boldsymbol{C}_{m\times n} \quad \boldsymbol{D}_{m\times 1}]$ shows status of n informative features (citizens' evaluation from the city services in n work scopes) and citizens' satisfaction of m citizens. To identify factors with the most influence on citizens satisfaction, the relationship between sets of results of citizens' satisfaction about the city services and informative features (citizens' evaluation from performance in different scopes) by different citizens. These features are called "critical performance scopes". Critical performance scopes are those scopes that by controlling them a high confidence level of citizens' satisfaction can be achieved.

The problem of identifying critical performance scopes from n present scopes can be modelled by methods of data dimension reduction. Reducing the dimensions of data is an important approach in knowledge discovery process which is used when a high volume of data is present. Rough sets theory is one of data dimensions reduction methods which was initially developed by [29] as an extension of sets theory for studying intelligent systems with insufficient and imprecise data. In the present paper, critical performance scopes are identified using rough sets theory. Also, this theory is used to model citizens' satisfaction with the public services.

The rough sets theory is applied on the information table. The information table has different records resulting from data of recorded states and defined variables. The columns of information table include system variables which have different values for different records that are called features. The rows of this table stand for different records of system states. Tab. 4 is a sample of an information table. An information table is defined as a quadruple $S =< U, A = C \cup D, \{V_a | a \in At\}, \{f_a | a \in At\})$ where U is a non-empty set of records and A is a non-empty set of features. A is defined by union of two sets informative features (Condition attribute: C) and results features (Decision attribute: D) by discretion of analysers. C is set of features of which the most informative subset for set of features D. V_a is a non-empty set of values for each feature and $f_a: U \rightarrow 2^{v_a}$ is an information function of features $a \in A$. Using rough sets theory, identifying a subset of information features which are the most informative (called reduction) is possible. Other informative features can be eliminated with the least loss

of information. The bases of identifying these features are concepts of lack of distinction, upper and lower approximations of the set, and reduction which are defined in rough sets theory [30].

Some basic definitions in the rough sets theory are as follows:

Indiscernibility: two records of a feature *a* are indiscernible if and only if there exist similar values in this feature. In mathematical form:

$$\forall x, y \in U x R_a y \Leftrightarrow f_a(x) = f_a(y) \quad (1)$$

For a subset of features like $P \subseteq A$, this definition can be extended as follows:

$$\forall x, y \in U \; x R_P y \Leftrightarrow \forall (a \in P) f_a(x) = f_a(y) \quad (2)$$

For member $x \in U$, the equivalence class than a set of features *P* is defined with following equation:

$$IND(P) = [x]_P = \{y | x R_P y\}. \quad (3)$$

This set is formed by records whose values of their features *P* are similar to *x*. for example, records of 100 and 432 (Tab. 4) are indiscernible from the point of view of features {parking development and organizing, demand management, traffic control} because their values in these features are the same.; hence, these two records then these two features are placed in an equivalence class. The partitioning of set *U* which is done by relation R_P is shown by U/P.

Lower approximation of set of features: using above symbols for each subset $X \subseteq U$, lower and upper approximations than the set of features *P* is as follows:

$$\underline{P}(X) = \{x | [x]_P \subseteq X\}. \quad (4)$$

Suppose, *P* and *Q* are two subsets of set of features *A*, positive area of *Q* than *P* is defined as follows:

$$POS_P(Q) = \bigcup_{X \in U/Q} \underline{P}(X). \quad (5)$$

In above equations, *X* is each of subsets of partition *U* then *Q*. Positive area *Q* then *P* includes records that values of features *Q* are determined according to values of features *P*.

Features dependency: set of features *Q* is completely dependent on set of features *P* and is shown by $P \Rightarrow Q$ if value of any feature of *Q* can be determined by values of set of features *P*. the concept of dependency can be defined as follows:

For $P, Q \subseteq A$, *Q* depends on *P* in degree *k* ($0 \leq k \leq 1$) if

$$k = \gamma_P(Q) = \frac{|POS_P(Q)|}{|U|}. \quad (6)$$

This concept is shown by $P \Rightarrow_k Q$. If *k*=1, *Q* is completely dependent on *P*. If *k*<1, *Q* is partially dependent on *P* with degree k. if *k*=0, *Q* is independent from *P* (Jensen and Shen, 2001). If *Q* is subset of features of results, *P* a subset of informative features, degree of dependency *Q* on *P* is one, results of each record in information table can be determined by values of set of features *P*. Therefore, with determining operational scopes on which citizens' satisfaction is completely dependent on them, critical performance scopes can be determined. Also, values of these features which lead to desirable results can be considered as desired factors. Then, set *P* is a reduction of information table features which degree of dependency of results on them equals to desired value (usually one). In the example of citizens' satisfaction from the city services, *Q* would be the result or citizens' satisfaction in which set *U* can be partitioned to five following subsets according to different states of *Q*:

$$B_1 = \{X | V_{\{\text{satisfaction from city services}\}} = 1\}$$
$$B_2 = \{X | V_{\{\text{satisfaction from city services}\}} = 2\}$$
$$B_3 = \{X | V_{\{\text{satisfaction from city services}\}} = 3\}$$
$$B_4 = \{X | V_{\{\text{satisfaction from city services}\}} = 4\}$$
$$B_5 = \{X | V_{\{\text{satisfaction from city services}\}} = 5\}.$$

Now, with determining the lower approximation of each set B_1 to B_5 than different subsets of informative features and positive area of each subset, degree of dependency of results of process on the subset of informative features can be determined.

In the rough sets theory, the reduction with the least number of members is important. Such reduction is called the minimal reduction. One way to determine the minimal reduction is to calculate dependency of set of results features on all possible subsets of informative features. Each subset with $\gamma(D) = 1$ is a reduction and the smallest subset with this specification $\gamma(D) = 1$ is the minimal reduction. This way is not a good solution for a huge volume of data because there would be $(2^n - 1)$ non-empty subsets (*n* = number of features) which would be very time-consuming to consider interdependencies among all $(2^n - 1)$ subsets if *n* is very large.

The Quick Reduction Algorithm (QRA) is able to calculate the minimum reduction without producing all possible subsets. This algorithm starts with the empty subset and then adds features that increase $\gamma_P(Q)$ most. This process continues until the desirable value of data set, usually one, is resulted. The steps of this algorithm are as follows:

1. $P \leftarrow \{\}$
2. *Do*
3. $T \leftarrow P$
4. $\forall x \in (A - P)$
5. *If* $\gamma_{R \cup \{x\}} > \gamma_T(D)$
6. $T \leftarrow P \cup \{x\}$
7. $P \leftarrow T$
8. *Until* $\gamma_P(Q) = \gamma_C(Q)$
9. *Return P*.

This algorithm does not necessarily produce the minimal reduction and it is just a heuristic method that generates a reduction near to the minimal reduction [31]. In the present paper, to identify the critical performance scopes, variable precision rough sets model is applied.

This model is an extension of rough sets theory [32] which lets different issues classified with as error less than a predetermined level. Suppose $X, Y \subseteq U$ the relative error of classification is defined as follows:

$$C(X,Y) = 1 - \frac{|X \cap Y|}{|X|}. \quad (7)$$

The rough inclusion is determined by letting a certain level of error in classification. In this definition, X is $-\beta$ subset of y if and only if

$$X \subseteq_\beta Y \; if \; C(X,Y) \leq \beta \quad 0 \leq \beta \leq 0{,}5. \quad (8)$$

This is called the rough inclusion concept. Using $\subseteq_\beta$ instead of $\subseteq$, $-\beta$ the lower approximation of X is defined as [33]:

$-\beta$ approximation of X than a equivalence relation P is as follows:

$$\underline{P_\beta}(X) = \{x | [x]_P \subseteq_\beta X\} = \left\{x \middle| \frac{|X \cap [x]_P|}{|[x]_P|} \geq 1 - \beta\right\}. \quad (9)$$

Lower approximation of set X is a set of records which its equivalence class than the set of features P, is $-\beta$ subset of X. the positive area is defined according to β as follows:

$$POS_{P,\beta}(Q) = \bigcup_{X \in U/Q} \underline{P_\beta}(X). \quad (10)$$

Where P and Q are subsets of features. With above definitions, if β=0,3, the positive area of set X then features P is the union of equivalence classes which 70 % of their members are in set X. In this model, the dependency function is defined as follows [33]:

$$\gamma_{P,\beta}(Q) = \frac{|POS_{P,\beta}(Q)|}{|U|}. \quad (11)$$

3 Research methodology

Tehran is the capital and the biggest city of Iran. Tehran population is eight million [34]. The Tehran municipality is a public organization which is supposed to manage Tehran affairs. The municipality naturally has different missions and work scopes in management of the city. Tab. 1 shows different scopes of Tehran municipality.

The first step in identifying the citizens' satisfaction mental model is the modelling and preparing data in a suitable format. To identify the effects of work scopes on citizens' satisfaction, a questionnaire is designed. In this questionnaire, Tehran citizens are asked to evaluate different scopes of municipality performance in terms of linguistic terms very good, good, medium, bad, and very bad. Also, Tehran citizens are asked to state their overall satisfaction status about the municipality activities in terms of very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, and very dissatisfied. To identify citizens' mentality of satisfaction, the relationship between citizens' evaluation from the municipality performance in different scopes and their satisfaction can be analysed.

Table 1 Tehran municipality performance scopes

Mission	Performance	Notation
Social-cultural management	Leisure and tourism development	V_1
	Social damages decrease and control	V_2
	Social collaborations	V_3
	Public sports development	V_4
	Promotion of religious culture, national, and Islamic revolution values	V_5
	Cultural/social/recreational/arts environments development	V_6
Transportation and traffic management	City railway public transportation development	V_7
	Non-railway public transportation development	V_8
	Parking development and organizing	V_9
	Demand management and traffic control	V_{10}
	Terminals construction and development	V_{11}
	Decrease and monitoring environmental pollutants	V_{12}
	Street construction and development	V_{13}
	Traffic smoothing	V_{14}
	Highways construction	V_{15}
City services management	Parks/jungles/green spaces development	V_{16}
	City sceneries beautification	V_{17}
	Graves organization and management	V_{18}
	City disposal and compost management	V_{19}
	Rivers and aqueducts maintenance and renovation	V_{20}
	Surface waters collection network	V_{21}
	Urban environment improvement	V_{22}
	City facilities development	V_{23}
Crisis and safety management	Fire and safety services	V_{24}
	Crisis prevention and management	V_{25}
	Ravine design	V_{26}
Urbanity	City extension plans development	V_{27}
	Capital suburbs organization (integrated)	V_{28}
	Valuable and worn out area organization	V_{29}

Table 2 Combination citizens filled the questionnaire

Parameter	Class	Frequency	Percentage
Gender	Male	503	51,6
	Female	471	48,4
Age	<25	212	21,8
	26-35	333	34,2
	36-45	196	20,1
	46-55	113	11,6
	>56	120	12,3
Marital status	Single	383	39,3
	Married	591	60,7
Education	Illiterate	37	3,8
	Less than high school	392	40,2
	High school	318	32,6
	College and bachelor degree	137	14,1
	Graduate degree	90	9,2
Family monthly income	< 4 million Rials	256	26,3
	4 million Rials<<8 million Rials	397	40,8
	8 million Rials<<15 million Rials	247	25,4
	>15 million Rials	74	7,6

To collect and prepare data required for evaluation of satisfaction, 974 questionnaires were filled out. The citizens were randomly selected to answer questionnaire questions. Tab. 2 shows the statistical population classes in terms of age, gender, education level, income, and marital status. Tab. 3 presents the quantified version of collected data using the Likert scale of very good=5, good=4, medium=3, bad=2, and very bad=1.

The set of recorded data in each questionnaire including informative features (work scopes) and citizens' satisfaction can be saved in an information system database format called satisfaction matrix. This matrix shows the status of n informative features and citizens satisfaction of m citizens. Matrix $\boldsymbol{PIE}_{m\times(n+1)} = [\boldsymbol{C}_{m\times n} \quad \boldsymbol{D}_{m\times 1}]$ represents records and results of questionnaires. Some rows of this matrix showing citizens' satisfaction with the city services are shown in Tab. 4. Analysis of relationship between $\boldsymbol{C}_{m\times n}$ and $\boldsymbol{D}_{m\times 1}$ is the base of effective rules analysis for identification of citizens mentality. How to analyze this relationship using the rough sets theory is presented in Section 3.

Table 3 Summary of results of questionnaires filled by citizens

Performance scope		Average score	Standard deviation	Median
Social-cultural management	V_1	2,97	1,07	3
	V_2	2,93	1,30	3
	V_3	3,57	1,23	3
	V_4	2,25	1,14	2
	V_5	2,60	1,27	3
	V_6	2,30	1,16	2
Transportation and traffic management	V_7	4,10	0,78	4
	V_8	3,85	0,79	4
	V_9	2,70	1,00	3
	V_{10}	3,15	1,14	3
	V_{11}	2,35	1,11	2
	V_{12}	1,82	1,25	2
	V_{13}	3,13	0,99	3
	V_{14}	2,82	1,14	3
	V_{15}	3,38	0,84	3

Performance scope		Average score	Standard deviation	Median
City services management	V_{16}	2,52	0,92	3
	V_{17}	3,67	1,05	4
	V_{18}	3,20	1,14	3
	V_{19}	3,63	0,76	4
	V_{20}	3,03	1,19	3
	V_{21}	2,53	1,17	3
	V_{22}	2,40	0,97	2
	V_{23}	2,10	1,13	2
Crisis and safety management	V_{24}	3,35	1,23	3
	V_{25}	3,68	1,34	3
	V_{26}	3,25	1,11	3
Urbanity	V_{27}	3,52	1,30	4
	V_{28}	3,93	1,25	4
	V_{29}	2,67	1,19	3
Overall satisfaction from the municipality services (OS)		3,43	0,96	3

Table 4 Values of informative features (performance scopes) and citizens' satisfaction in four questionnaires

Customer number	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}	V_{22}	V_{23}	V_{24}	V_{25}	V_{26}	V_{27}	V_{28}	V_{29}	OS
100	2	3	1	2	4	3	3	4	2	3	3	2	4	3	4	2	4	3	1	3	3	3	2	3	1	3	4	3	4	3
432	3	2	4	4	3	2	2	3	2	3	4	3	3	4	4	3	4	3	3	2	4	3	3	3	3	3	4	3	3	3
627	3	4	3	2	3	3	5	4	3	4	3	3	3	3	3	3	3	2	4	3	3	4	3	4	4	4	3	2	3	4
811	2	2	3	2	3	4	4	3	3	3	3	2	4	3	3	2	3	3	4	3	3	3	3	4	4	3	1	4	3	4

4 Algorithm of Extracting Key Factors of Satisfaction

In this section, an algorithm based on the rough sets theory is presented to identify the critical performance scopes of citizens' satisfaction together with a satisfaction tree. Steps of this algorithm are as follows:

Step 1: determining organization scopes and identifying features of services given to citizens. In the case study, the Tehran municipality and its services given to citizens are the scope of the problem. The performance features of the municipality are identified according to missions and major duties of the municipality. Tab. 5 presents performance features of the problem with the symbols used to identify them. It should be mentioned that the scope of the problem does not have any impact on steps of implementation of the algorithm. Also, the performance scopes are not necessarily supposed to be operational features of the organization.

Step 2: forming process execution matrix based on records of process execution. In this step, the status of n performance features is determined. Also, status of citizens' satisfaction with the public services as the performance measures is collected for m persons in form of questionnaire. Then, matrix $\boldsymbol{PIE}_{m\times(n+1)} = [\boldsymbol{C}_{m\times n} \quad \boldsymbol{D}_{m\times 1}]$ is formed. In this step, sampling of citizens should be done randomly.

Step 3: identifying critical features of satisfaction. In this step, critical features forming citizens' satisfaction are identified by analysis of the relationship between information of two parts $\boldsymbol{C}_{m\times n}$ and $\boldsymbol{D}_{m\times 1}$ of matrix ***PIE***. The information table is the first concept used in the rough sets theory which is shown by a quadruple $A = C \cup D, S =< U, \{V_a | a \in At\}, \{f_a | a \in At\}$. In the model, concepts of information table in the rough sets theory and table PIE (Tab. 5) get compatible.

Table 5 rough sets concept in table PIE

Rough sets concept	Corresponding concept in table PIE
U	Set of 800 records from questionnaires
$A = C \cup D$	C ={V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{15}, V_{16}, V_{17}, V_{18}, V_{19}, V_{20}, V_{21}, V_{22}, V_{23}, V_{24}, V_{25}, V_{26}, V_{27}, V_{28}, V_{29}}
	D ={ citizen's satisfaction}
V_a	Possible values to evaluate are different scopes: $V_a = \{1, 2, 3, 4, 5\}$
f_a	Function assigns different values to each feature for different questionnaires

As Tab. 6, V_8 or "Non-railway public transportation development" is the most significant informative feature in the first iteration. $\gamma_P(Q) = 0{,}354$ for this feature means that with knowing value of this feature, status of more than 35,4 % of records (with precision more than 70 % and β=0,3) is determined. For example, results of implementing the first iteration of algorithm show that more than 70 % of records with "Non-railway public transportation development" as five have citizens' satisfaction of five or four. In other words, more than 70 % of citizens who evaluate the "Non-railway public transportation development" of the Tehran municipality as very good are very satisfied/satisfied with services of

the city of Tehran. Finally, 35,4 % of opinions about "Non-railway public transportation development" can be modelled.

Tab. 7 shows the results of the second iteration of the algorithm. According to results, the features {Non-railway transportation development, City railway public transportation development} are the most significant features. Dependency of results on these features is 0,546. In other words, citizens' satisfaction of 54,6 % of all citizens can be determined by these features. For example, results show that more than 70 % of citizens whose feature "City railway public transportation development" and "non-railway public transportation development" is four, have desirable citizen satisfaction. More than 70 % of citizens, whose feature "City railway public transportation development" is either 2 or 3, have undesirable citizen satisfaction.

Step 4: building judgment mentality tree. The mentality tree is built in two steps as follows: Step 4.1. Building critical tree: After identifying critical performance scopes, inference rules are extracted using equivalence relations and positive area in the last iteration of Quick Reduction Algorithm. Fig. 1 shows a part of critical factors tree for the case study. Step 4.2: building decision tree. In this step, the decision corresponding to each leaf or satisfaction is made in the decision tree regarding being or not being consistent results with each leaf or satisfaction.

Table 6 Results of the first iteration of QRA

$\gamma_P(Q)$	P	$\gamma_P(Q)$	P	$\gamma_P(Q)$	P	$\gamma_P(Q)$	P	$\gamma_P(Q)$	P
0,146	$\{V_{25}\}$	0,279	$\{V_{19}\}$	0,182	$\{V_{13}\}$	0,266	$\{V_7\}$	0,207	$\{V_1\}$
0,188	$\{V_{26}\}$	0,062	$\{V_{20}\}$	0,195	$\{V_{14}\}$	0,354	$\{V_8\}$	0,123	$\{V_2\}$
0,070	$\{V_{27}\}$	0,102	$\{V_{21}\}$	0,188	$\{V_{15}\}$	0,212	$\{V_9\}$	0,034	$\{V_3\}$
0,117	$\{V_{28}\}$	0,187	$\{V_{22}\}$	0,243	$\{V_{16}\}$	0,139	$\{V_{10}\}$	0,207	$\{V_4\}$
0,046	$\{V_{29}\}$	0,179	$\{V_{23}\}$	0,238	$\{V_{17}\}$	0,131	$\{V_{11}\}$	0,015	$\{V_5\}$
		0,086	$\{V_{24}\}$	0,179	$\{V_{18}\}$	0,240	$\{V_{12}\}$	0,169	$\{V_6\}$

Table 7 Results of the second iteration of QRA

$\gamma_P(Q)$	P	$\gamma_P(Q)$	P	$\gamma_P(Q)$	P	$\gamma_P(Q)$	P
0,407	$\{V_{23}, V_8\}$	0,380	$\{V_{16}, V_8\}$	0,395	$\{V_9, V_8\}$	0,277	$\{V_1, V_8\}$
0,451	$\{V_{24}, V_8\}$	0,475	$\{V_{17}, V_8\}$	0,347	$\{V_{10}, V_8\}$	0,227	$\{V_2, V_8\}$
0,441	$\{V_{25}, V_8\}$	0,358	$\{V_{18}, V_8\}$	0,330	$\{V_{11}, V_8\}$	0,283	$\{V_3, V_8\}$
0,390	$\{V_{26}, V_8\}$	0,365	$\{V_{19}, V_8\}$	0,287	$\{V_{12}, V_8\}$	0,428	$\{V_4, V_8\}$
0,288	$\{V_{27}, V_8\}$	0,428	$\{V_{20}, V_8\}$	0,449	$\{V_{13}, V_8\}$	0,392	$\{V_5, V_8\}$
0,297	$\{V_{28}, V_8\}$	0,291	$\{V_{21}, V_8\}$	0,455	$\{V_{14}, V_8\}$	0,206	$\{V_6, V_8\}$
0,403	$\{V_{29}, V_8\}$	0,495	$\{V_{22}, V_8\}$	0,440	$\{V_{15}, V_8\}$	0,546	$\{V_7, V_8\}$

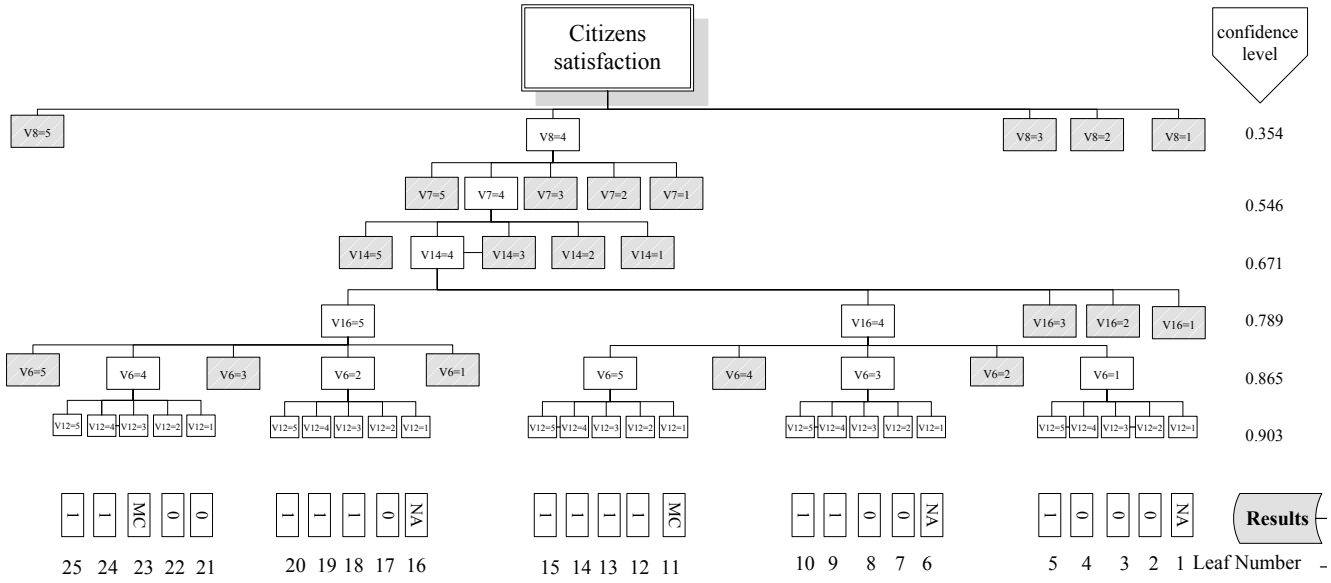

Figure 1 Part of critical factors of citizens' satisfaction from the municipality services

5 Conclusion

In the present paper, an algorithm-based rough sets theory was developed to model citizens' satisfaction with the public services. The Tehran municipality was evaluated as the case study. Factors "Non-railway public transportation development", "City railway public transportation development", "Traffic smoothing", "Parks/jungles/green spaces development", "Cultural/ social/ recreational/ art environment development", and "Decrease and monitoring environmental pollutants" were determined as the key factors of citizens' satisfaction. Finally, the decision tree of citizens' satisfaction was presented according to evaluations of citizens from the municipality performance in different scopes.

As mentioned, parametric methods are usually considered independently of the factors, while this assumption is not mentioned in presented algorithm. For example as shown in Tab. 6 if we propose independent parameters then V_{19} or "City disposal and compost

management" should be identified as a key satisfaction factor ($\gamma_P(Q) = 0{,}279$ and Second place among the scores) But in our algorithm this factor is not determined as key satisfaction factor because this factor is dependent on other factors and if other factors are well controlled then this factor will be satisfied. Vice versa factor "$_6$ or "Cultural/social/recreational/ environments development" is in 17th place in Tab. 6 but algorithm identified it as key satisfaction factor because based on citizens' judgement it will not be covered by other factors. Another advantage of recent algorithm against parametric methods is using decision trees for modelling the satisfaction of citizens which is more complex and is more like subjective judgment. Also using this algorithm on surveys of citizens it can be easily updated at any time. This is another advantage of this algorithm against parametric methods.

Identification of citizens' satisfaction model about the services given by public organizations can play key roles in improvement of citizens' satisfaction because city managers with predicting citizens' satisfaction can manage their performance to improve public satisfaction with the given services. Due to change of city population status and municipality performance, this model should be continually updated according to received data. A future research direction is extension of the proposed model for other public organizations such as healthcare, education, police and etc. moreover, focusing on the quality and specifications of services and using five features of services mentioned in SERVQUAL can also be a novel way to identify the citizens' satisfaction about city services.

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