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A Comparative Study Employing CIA Methods in Knowledge-Based Urban Development with Emphasis on Affordable Housing in Iranian Cities (Case: Tabriz)

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Abstract. The majority of this research has been situated in the methods of crisp Micmac and Fuzzy Linguistic Micmac as systematic modeling tools under CIA method. In the current study, both Micmac and Fuzzy linguistic Micmac methods are applied and also compared to analyze the interrelationships between the KBUD and affordable housing variables in Tabriz city, Iran. The obtained results and the rankings taken from both crisp Micmac and FL Micmac are almost the same but few cases, which indicates accuracy of the employed methods. This little variation happens due to the using fuzzy values in FL Micmac that is more precise. One of the advantages of the fuzzy linguistic Micmac is its capability in employing heat maps. The heat maps show whether the system's variables has great influence/dependence on each other or has not. In other words, these maps enable the decision maker to look the strength of the system in a glance, from the existing relations between the factors. The other advantageous of the heat maps is, clustering the factors in an optical mode, because the factors with the same range of influence/dependence may have same role in the system. In our analyzed system, despite of being superior of some variables, the strength of the whole system is in the middle and lower.

Keywords: Knowledge-based · Urban development · Affordable housing · CIA methods · Tabriz

1 Introduction

The growing complication and uncertainty of various developments in future of towns as well as the broad span of key variables from local stages to worldwide levels enforce planners and practitioners adapting a recent approach besides engaging new theories and paradigms in urban planning. The intended paradigm, named knowledge-based urban development (or KBUD), has been presented at the end years of 20th century regarding the effectiveness of knowledge economy on urban communities (Yigitcanlar et al. 2008a). In this regard, KBUD, is considered as a strategic management policy or

approach applicable to human dwellings, has reached renown as a strong strategy for sustainable social, urban and economic growth, and for the post-modern development of urban areas and also for competition in all levels (Yigitcanlar et al. 2008a). In this case, in addition to employing new paradigms for coming future of cities, planners or city authorities need future-based methods to utilize the intended theories in proper manner and select best options to plan for coming age.

Futures studies are a knowledge which is able to illustrate the coming events including opportunities and different conditions. It calms concerns, doubts and ambiguity and enables the community to make clear where we can or should go by employing conscious and smart choices, and likely the possibilities appear. In other words, futures-based methods and studies should be noticed as an attempt in forming the future in a dynamic and conscious way (Alizadeh et al. 2008). According to Bell 2003 Futures studies means taking some steps for: “(1) interpreting the past; (2) understanding the present; (3) making decisions and taking action at present; and (4) balancing present and future use of resources” (Bell 2003). It could be concluded the most important aims of such studies that are supported by most researchers are recognition, evaluation, experiment, and recommendation of feasible, possible, and desired futures. Nowadays an increasing number of authority centers are employed in future studies and reinforce this scope of profession. This is due to that making scenarios and future studies are related to creating inspiring perspectives and discovering unknown strategies to perform them.

In this manner, city planners are not exceptions and increasingly apply the futures-based methods in long term urban planning. The various options for the future of the city are formed based on different set of factors/variables from local to global levels in terms of knowledge-based urban development (One of those variables is affordable housing which itself, has 13 sub-criteria that will be indicated in the following). Therefore, planning for the future affordable housing within KBUD framework can be seen as an important challenge especially in Iran with growing rate of urbanization. In the recent 30 years, the population of urban areas has increased from 25 million people to 59 million. The mentioned condition has resulted the scarcity of lands in urban scales for new developments. Shortage of land in urban areas moved cities toward adopting excessive density policies to respond the growing demand of housing especially in big urban areas. In this research, we have chosen Tabriz city as one of the big cities of Iran. In addition to what was mentioned about big towns of Iran, we should add creation of slum areas in city borders of such cities. In this case Tabriz city is not an exception. According to Tabriz municipality estimates, close to 500000 residents of Tabriz (of 1600000 populations), are living in slum areas with ill-conditioned houses. In the other hand, according to future perspective document of Tabriz development (2025), Tabriz city in order to compete in all scales (local, national and global) should be moved toward knowledge-based urban development concept. To achieve the mentioned goal, researchers must have a basis. In the research, in addition to use 32 knowledge-based urban development variables driven by Yigitcanlar and Lönnqvist (2013) theory, researchers employ 13 sub-variables regarding affordable housing within a system framework (45 variables) to analyze impacts which both KBUD and affordable housing variables may have on each other. In other words, one of the objectives of the research is prediction of knowledge-based urban development impact on affordable housing to

make clear vision for policy makers of urban authorities from future urban development of Tabriz city by employing two new methods.

Accordingly, it is broadly comprehended as a group of methods to be applied by various authorities predict coming futures by motivating innovation to observe a wide range of possibilities and scenarios (Amer et al. 2013, p. 25). Such scenarios are regarded as logical definitions of alternative hypothesized futures which indicated various perspectives on different periods of past, present or future developments, that can be considered as an important basis for accomplishing actions (Van Notten 2005), in each scale or stage especially in city developments. Scenario systems are employed in making of various feasible models of the coming future; and their target is to produce a figure of oriented knowledge that can be served as a powerful guidance for lines (Kosow and Gabner 2008). Among the most popular methods in terms of qualitative methods TIA¹, FCM² (Jetter and Schweinfort 2011) Interpretive Cross Impact Simulation (Enzer 1980) and CIA³ are considered as the most effective methods. In the current research, we focus on two CIA methods within category of structural analysis. One popular method which was introduced by Godet is Micmac (Godet 2000; Duperrin and Godet 1973). This method has gained much notion. Many researches have been accomplished on it and hence, most of them have developed the method to be more applicable (Duperrin and Godet 1975; Helmer 1977). It should be stated, the prosperity of employing cross-impact analysis is related to systematic analysis of interrelated functions between feasible future developments. Godet recommends employing the mentioned method as the first step in the process of Scenario Planning. In this stage, the specialists define the group of variables related to the subject and afterward, they determine interactions among the variables to recognize the role of different variables in the system. As MODO (2014) describes: "MICMAC analyses the importance of a given set of variables through a matrix that contains the influence that each variable has on the others". The global influence is indicated by using values between 0 and 3. The main characteristic of the process depends on its capability to discover both direct/indirect influence/dependence between factors. This method has been applied in many fields successfully.

Despite being very successful tool, it is not lack of defect. The given values are ambiguous due to the subjective characteristic of these data, impreciseness on the given ideas, not compatible opinions among the experts and so on. In this regard, the existed vagueness is not well-addressed when using these methods, because they employ integer numbers in modeling and also aggregating specialists' opinions. Another disadvantage is low possibility of interpretation of the obtained outcomes, which due to being valued numerically, it does not present proper meaningfulness answers and etc. (MODO 2014). In this manner, to resolve these stated problems and reach a more powerful approach besides compare the obtained results from two methods (Micmac and fuzzy linguistic Micmac), researchers are intended to use Computing with Words (CW) techniques which was proposed by MODO (2014). This technique is called Fuzzy Linguistic Micmac.

¹ Trend Impact Analysis.

² Fuzzy Cognitive Maps.

³ Cross Impact Analysis.

Researchers to choose a robust and optimum method in terms of selection of key variables of the knowledge-based urban development which have more impacts on the affordable housing variables need to compare these methods in Tabriz city.

In the current study, both Micmac and Fuzzy linguistic Micmac methods are applied and also compared to analyze the interrelationships of the KBUD and affordable housing variables in Tabriz city. Here we should answer the following questions?

1. What future-based method is more proper to use for city development plans?
2. What variables of knowledge-based urban development play key role in making better future for building affordable houses in Tabriz city?

2 Methodology

The objective of this research is to employing two future-based methods and also comparing the obtained results by them. Our motivation is necessity of using such methods in urban studies to predict the future condition of cities. As mentioned before, Tabriz city in order to be well-located in the knowledge-based urban development path needs to utilize new future-based methods to clarify its development priorities. In this regard, we have used both Micmac and Fuzzy linguistic Micmac in terms of structural analysis to reach a logical way to be applied in Iranian cities to assess most influential/dependent variables.

2.1 Study Area

City of Tabriz is one of the big cities in Iran and capital of east Azerbaijan province. The latitude and longitude are respectively $38^{\circ}8'N$ and $46^{\circ}15'E$. Tabriz is the biggest city in the northwest side of the Iran and it is known as culture, politics, commerce, official pole of the country. Due to the accommodating many industrial factories and companies (and also 600 manufactures company), Tabriz is regarded as the second big industrial city following the capital city Tehran. University of Tabriz located in east part of the town is established as the 2nd university after Tehran University. Additionally this town is celebrated as “City of initials” and “safest city of Iran”. After Tehran, this town is known as the second in building towers, therefore it is regarded as the skyscrapers city in the Iran. Population rate of Tabriz city is estimated 1,700,000 persons.

According to studies by the United Nations about different cities across the world published in an online magazine, Tabriz is the most beautiful and developed Iranian. This should be noted that, World Health Organization named Tabriz as the healthiest and most hygienic city in Iran two years ago. Tabriz has also been identified as an Iranian city at the forefront of private investment and the most successful in fulfilling the provisions of Article 44 of the Constitution [which deals with privatization of state companies]. The provincial capital of East Azerbaijan was also named as the World’s Carpet Capital in 2015 by UNESCO and the World Crafts Council. Only 11 cities have been designated as a World Crafts City. As the representative of Muslim cities on that list Tabriz is in the lead. Additionally, this city has been selected as the tourism capital of Islamic nations in 2018 (Fig. 1).

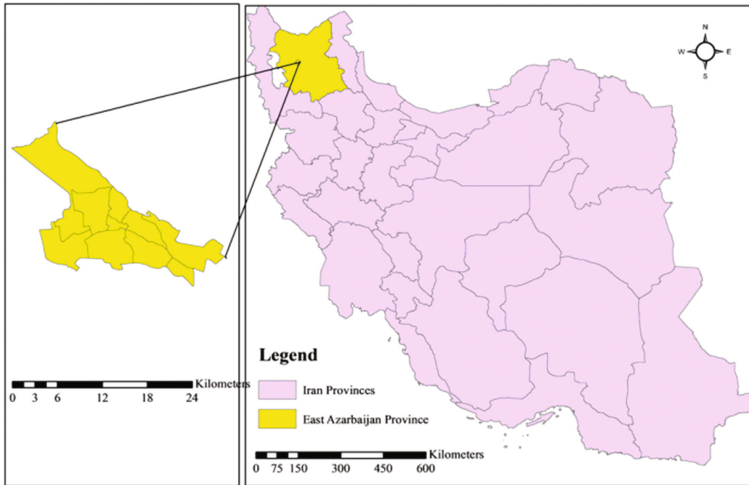


Fig. 1. Study area

3 Results

3.1 Structural Analysis

In this method (structural analysis) we move from the description of the system's indicators and also their interrelations, that both of them are given by specialists. In MICMAC method, three types of relations or influence are described (0 = no influence, 1 = weak influence, 2 = medium and 3 = strong). From our data, the global dependence and influence (direct/indirect) for any indicators are computed by sum the columns and rows. The obtained results of numerical values taken from experts are then employed to rank the indicators and to make the dependence/influence map by drawing the pair influence/dependence for each variable. This resulted map categorizes the indicators in 4 classes that each side has its own interpretation. The quadrants permit the recognition of the various aspects of the system including: inputs, linkage, excluded and resultant indicators of the global systems (Castellanos et al. 2013).

The aim of intended method is determining the key factors, among set of factors distinguished by specialists. Basically, crisp Micmac has three stages:

- **Defining** set of factors
- **Specifying** the various relationships among the factors.
- **Identifying** the most important (key) factors between all the factors.
- **Defining set of factors.** The factors in complicated systems are determined

With the idea of several specialists, literature review and brain storming. An unarranged factor is indicated as an output in this phase. In the current study, we use a set of KBUD variables derived by (Yigitcanlar and Lönnqvist 2013) and affordable housing factors extracted by researchers from relevant literature review which is known as the main source of knowledge-based urban development (Table 1).

Table 1. Factors and sub-factors of knowledge-based urban development. Source: Yigitcanlar and Lönnqvist (2013, p. 6.)

Indicator categories	Indicator sets	Indicators	Descriptions
<i>Economic development</i>	Macro-economic foundations	Gross domestic product	Gross domestic product (GDP) per capita in USD purchasing power parities
		Major international companies	Number of global top 500 companies located
		Foreign direct investment	Ratio of international share in foreign direct investments
		Urban competitiveness	Global urban competitiveness index ranking
	Knowledge economy foundations	Innovation economy	International city ranking in innovation economy
		Research and development	Ratio of research and development expenditure in GDP
		Patent applications	Patent cooperation treaty patent applications per million inhabitants
		Knowledge worker pool	Ratio between professionals and managers and all workers
<i>Socio-cultural development</i>	Human and social capitals	Education investment	Ration between public spending on education and GDP
		Professional skill base	Ratio of residents over 18 years with tertiary degree
		University reputation	World university rankings
		Broadband access	Ratio of access to fixed broadband subscribers per capita
	Diversity and Independency	Cultural diversity	Ratio of people born abroad
		Social tolerance	International country tolerance ranking
		Socio-economic dependency	Ratio between the elderly population and the working age
		Unemployment level	Ratio of unemployment

(continued)

Table 1. (continued)

Indicator categories	Indicator sets	Indicators	Descriptions
<i>Enviro-urban development</i>	Sustainable Urban development	Eco-city formation	International city ranking in eco-city
		Sustainable transport use	Ratio of sustainable transport mode use for commuting
		Environmental impact	CO2 emissions in metric tons per capita
		Urban form and density	Population density in persons per sq.km
	Quality of life and place	Quality of life	International city ranking in quality of life
		Cost of living	International city ranking in cost of living
		Housing affordability	Ratio between GPD per capita and median dwelling price
		Personal safety	International city ranking in e-government
<i>Institutional development</i>	Governance and planning	Government effectiveness	Level of government effectiveness
		Electronic governance	International city ranking in e-government
		Strategic planning	Level of KBUD strategies in strategic regional and local development plans
		City branding	International city ranking in city branding
	Leadership and support level of institutional and managerial leadership in overseeing KBUD	Effective leadership	Level of institutional and managerial leadership in overseeing KBUD
		Strategic partnership and networking	Level of triple-helix and PPPs and global networking global city ranking
		Community engagement	Level of institutional mechanisms for community building and public participation
		Social cohesion and equality	Level of income inequality in Gini coefficient

Table 2. Factors and sub-factors of affordable housing

Variables of affordable housing	Source
Population density	Kontokosta 2015; Park et al. 2016
Household size	Austin et al. 2014
Energy consumption	Ren et al. 2015
Electricity consumption per capita	Yang 2010
Number of bedrooms	Davison et al. 2016
Number of bathrooms	
Land size	
Time changes for job accessibility	Zhang and Man 2015
Distance to transit stop	Park et al. 2016
Number of new housing units produced annually	Silverman 2009
Number of existing housing units rehabilitated annually	
Median household income	Schively 2008
Number of rental units managed annually	Silverman 2009

Specifying the relationships between the factors. The team of relevant specialists processes a $n \times n$ matrix that indicates the impact of factors on the others and vice versa. The mentioned matrix is known as Matrix of Direct Influence (MDI), and the main source of knowledge and expertise in determining the influence of factors are experts. Here, we have the definitions of various weights of impacts.

- 0 means no influence on variable.
- 1 means weak influence on variable.
- 2 means strong influence on variable.
- 3 means very strong influence on variable.

Based on Godet, “in real systems only about 30% of the cells of the MDI matrix have values different from 0” [4].

Identifying the key factors. It can be stated that the important step of the method is discovering the key variables. In direct method, global direct dependence and influence is directly identified based on the Matrix of Direct Influence, while the in terms of indirect global dependence and influence, it is clarified by influence of a variable through other variables of the system.

3.2 FL Micmac

In the current research, we use of linguistic factors derived from MODO (2014) to have a comparison between this method and crisp Micmac and model the interrelations. This method permits the experts to weight these interrelations by employing linguistic values instead of using numerical labels.

Initially, to employ this method, we should determine the set of linguistic values (pre-defined by triangular fuzzy numbers) which will be applied to specify the degree of influence/dependence of one factor on another (see Table 3). Afterward, the specialists utilize linguistic values to set the impact range for each pair of factors.

Ultimately, from the upper and low-order ideals a new set of linguistic value is described for the overall dependencies and influences (Fig. 2).

Table 3. Determination of global influence and dependence of each variable with numerical values (left) and linguistic labels (right) Source: (Castellanos et al. 2013).

Var	V1	V2	V3	inf
V1	0	0	1	1
V2	0	0	3	3
V3	0	1	0	1
Dep	0	1	4	0

Var	V1	V2	V3	inf
V1	Null	Null	Low	Low
V2	Null	Null	High	Med
V3	Null	Low	Null	Low
Dep	Null	Null	Med	Null

To establish the linguistic label that corresponds to each variable, an aggregation operator is applied (see Table 3 right). The information obtained from this operator allows ordering and plotting the variables in an analogous way to MICMAC. This information together with the linguistic labels associated to each variable permits to analyze the results from a relative and absolute point of view as we can see in Fig. 3.

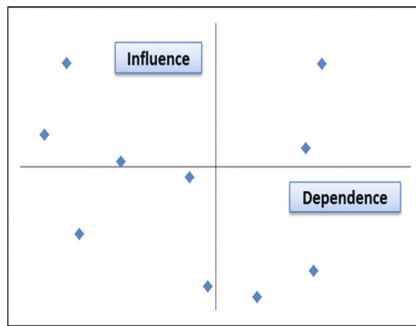


Fig. 2. Influences-dependences map in MICMAC.

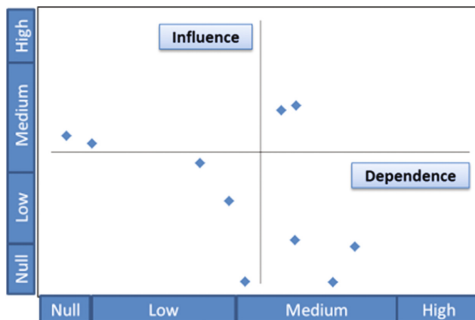


Fig. 3. Influences-dependences map with linguistic labels.

3.3 Comparison of Both Crisp and FL Micmac Methods in a Case Study

To evaluate employed methods, researchers have selected a case study to compare both methods of Micmac and fuzzy linguistic Micmac methods and also to determine the most influential factors of knowledge-based urban development on affordable housing of Tabriz. The data was obtained by using expert’s opinions about the impact of various factors on each other within a system including 45 variables of both knowledge-based urban development and affordable housing. It should be noted that the focus of this part is evaluating the obtained results in terms of urban studies besides comparing the results taken from both mentioned methods. In this research the number of 50 experts firstly confirmed the 45 variables as the basis of the study, which can be observed in Tables 1 and 2.

In the fuzzy linguistic method, researchers select $N = 3$ which were defined as fuzzy triangular numbers: (Weak = [1, 1, 2], Moderate = [1, 2, 3], Strong = [2, 3, 3]), and as it is seen, the same number engaged in the original crisp method (Micmac) by employing three values (1, 2, 3). In order to calculate the dedicated values, researchers use both crisp Micmac and fuzzy linguistic Micmac software. The summary of results are illustrated in the Table 4, that includes the factors on the first five top ranked and last five ranked of both the Micmac and FL Micmac methods.

Table 4. Top and last five positions of the global direct influence rankings, according to MICMAC and FLMICMAC

Variable (Crisp Micmac)	Micmac		Variable (Fuzzy Linguistic Micmac)	FL Micmac	
	D inf value	D inf rank		D inf value	D inf rank
27-Strategic planning	112	1	27-Strategic planning	73.5	1
25-Government effectiveness	110	2	25-Government effectiveness	71.5	2
26-Electronic government	99	3	3-Foreign direct investment	63.33	3
4-Urban competitiveness	97	4	1-Gross domestic product	62.5	4
15-Foreign direct investment	97	5	3-Urban competitiveness	62.5	5
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45-Number of rental units	62	41	9-Educational investment	35.33	41
37-Number of bedrooms	61	42	14-Social tolerance	33.66	42
7-Patent applications	59	43	13-Cultural diversity	32.16	43
35-Energy consumption	58	44	11-University reputation	43.5	44
38-Number of bathrooms	42	45	36-Electricity consumption	31.83	45

Table 5. Top and last five positions of the global indirect influence rankings, according to MICMAC and FLMICMAC

Variable (Crisp Micmac)	Micmac		Variable (Fuzzy Linguistic Micmac)	FL Micmac	
	D inf value	D inf rank		D inf value	D inf rank
27-Strategic planning	4.74	1	27-Strategic planning	38.20	1
25-Government effectiveness	4.68	2	25-Government effectiveness	38.10	2
26-Electronic government	4.18	3	3-Foreign direct investment	37.77	3
4-Urban competitiveness	4.16	4	1-Gross domestic product	37.77	4
28-City branding	4.14	5	30-Strategic partnership and networking	37.75	5
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7-Patent applications	2.63	41	24-Personal safety	35.96	41
45-Number of rental units	2.60	42	14-Social tolerance	35.84	42
37-Number of bedrooms	2.51	43	13-Cultural diversity	35.55	43
35-Energy consumption	2.50	44	36-Electricity consumption	35.54	44
38-Number of bathrooms	1.75	45	45-Number of rental units	35.12	45

A number of significant results have been reached after the employment of two intended versions to our case, as they are indicated in Tables 3 and 4. The obtained rankings have tremendous similarities but the FL Micmac is more accurate. This is counted as the first significant result (Table 6).

Table 6. Kendall’s tau-b test

Ranking (crisp vs. FL Micmac)	Kendall’s coefficient
Direct influence	0.710
Direct dependence	0.770
Indirect influence	0.823
Indirect dependence	0.810

After obtaining the results, we used a correlation Kendall’s tau-b test to check the significant variations based on the methods rankings. As it is observed in Table 5, no significant variations are seen between two employed method’s rankings. Additionally, a significant positive correlation is observed between both original crisp Micmac and

fuzzy Micmac methods. However, Fuzzy linguistic Micmac method has more accuracy, since the obtained judgments vagueness by experts' are underlined by using fuzzy sets. Now we can focus on the top ranked variables obtained from long calculations which are shown in Tables 3 and 4. As it is seen, the obtained results of five top ranked variables from both crisp and FL Micmac methods are the same, except one variable on both direct/indirect influence results. Based on the obtained results, from five top ranked variables in terms of direct influence in both methods, four variables (government effectiveness, strategic planning, urban competitiveness, foreign direct investment) are the same. These results illustrate the important role of urban authorities and also necessity of codifying strategic plans for fulfilling knowledge-based urban development and ultimately promoting affordable housing condition in Tabriz city. Such results illustrate that, Tabriz city in order to advance in providing sustainable and affordable houses must be more proactive and conscious in terms of employing strategic plans for future of the city.

3.4 Interpretation of Distribution of Various Factors in the Influence/Dependence Chart

In order to visualize the obtained results of both linguistic and crisp values, we employ two charts obtained from the mentioned methods. The left sided chart is related to FL Micmac and the right sided is corresponded to the crisp Micmac. The definition of these charts is given in the following:

Portraying interrelationships (see Fig. 4) could be accomplished in a 4 district chart. In this manner, both axes of vertical and horizontal are measured according to the violence of dependence and influence of criteria based on the overall values they gain. Of four different districts, each zone plays various roles in the system.

Determinant Factors. In crisp Micmac, north-west part of the chart is dedicated to these factors which also are known as influent variables while, for FL Micmac, these variables are located south-east. This happens because of the design of software by producers. Due to the high impact the global system and also less dependency, these variables can direct the whole system regarding the control which we can make on them. A change in these variables may have huge impact on the overall condition of this system. For the case of Tabriz city, some determinant and also common factors in both methods are: Educational investment, socio-economic dependency, Social tolerance, Socio-economic dependency Energy consumption, Electricity Consumption Per Capita.

Excluded Factors. These variables are placed in south-west zone of the chart with little dependence and influence. Obviously, these factors are known as 'out of line' variables in the system. This is because; they can neither profit from system nor stop a significant evolution of it. Albeit, there can be big difference among the variables of this group of factors. Discharged variables are placed close to the beginning of axes and with a scale of impact; they can be removed from secondary arms, while they have capability to be used as feasible supporting measures. It should be noted that the future knowledge-based plan of affordable housing will be formed by some superior factors

which mostly are related to city authorities. Nevertheless, it is considered rather influent than dependent. The lists of common factors are:

Patent applications, eco-city formations, sustainable transport use, number of bedrooms, land size, distance to transit stop.

Relay Factors. These variables locate in north-east side of the chart, In this category, factors are both known very influent and dependent. These are also called instable variables because of having ‘boomerang effect’. Additionally, they are able to reinforce or prevent any primary strike in the system. In our case, we have common factors between both methods. These variables are: Gross domestic product, foreign direct investment, urban competitiveness, Innovation economy Research and development, city formation and density, quality of life, government effectiveness, electronic government, median household income. By looking the obtained results, it is revealed that, most of the located factors in north-west part of the chart in both methods are same. The only difference is related to different location of variables in this area. This is because of high accuracy of employing linguistic fuzzy techniques in fuzzy linguistic Micmac method.

Depending Factors. It is seen that, on side is left from four available sides in our charts. In crisp Micmac, the group of variables is located in south-east part of the chart, while in FL Micmac; it is visible in north-west side. These variables are identified as exit factors of the system which are also named as result factors. Their status in the system indicates high dependency and little influence. In our category, two variables are in common among the employed methods which composed of: Living environment, strategic partnership and networking, population density. In order to visualize the obtained results of both linguistic and crisp values, we employ two charts obtained from the mentioned methods. The left sided chart is related to FL Micmac and the right sided is corresponded to the crisp Micmac. The definition of these charts is given in the following:

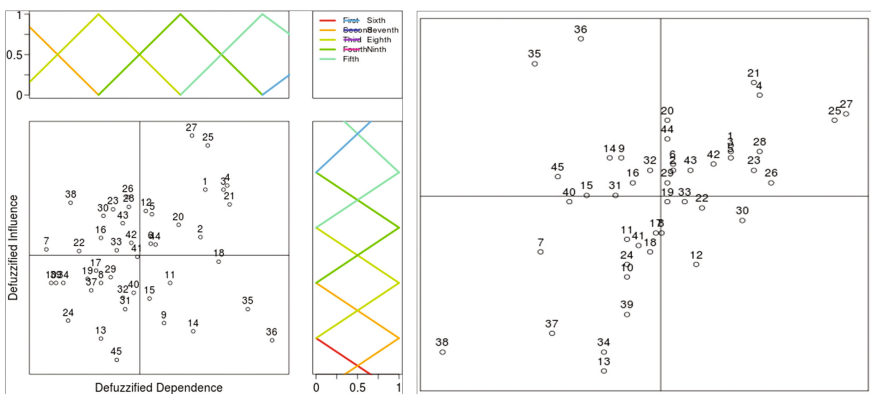


Fig. 4. Fuzzy influence/dependence planes showing the defuzzified influence-dependence pairs and the output linguistic term sets on the axes

It should be noticed that placing a variable on the top of the ranking or chart does not necessarily reflect its' high influence or dependence. In other words this means that the intended variable has higher influence within the system than others, but not necessarily high in absolute terms. This case could not be indicated in the crisp Micmac. Such matter is solved in Fuzzy Linguistic Micmac by illustrating the overall influence/dependence of variables in heat maps. It should be stated that linguistic labels are much easier to better grasp and interpretation by people.

3.5 Overall Linguistic Results Depiction in Heat Maps

Another advantage which FL Micmac can have is producing heat maps to indicate the overall influence/dependence of the variables. In this section, we have produced 2D heat maps which are shown in Fig. 5, in both direct and indirect influence/dependence. In other words, these maps are intended to indicate that despite having priority of some variables on the others; the important matter is degree of their influence/dependence overall. The Micmac method has no such capability as mentioned.

In this regard, to have a distinct map of the absolute dependence/influence of employed variables, it is feasible to brief all of the information in such maps (Fig. 5) illustrating the number of factors with each integration of absolute values of linguistic dependence/influence. In the current research, in the direct and also indirect method, these maps indicate moderate and lower than moderate linguistic terms which are visible in the obtained results. In this case, any square of the obtained map is related to a possible integration of linguistic dependence and influence, and the violence of color expresses the number of variables that have that type of integration of values at the result. Such plot can be accomplished for both methods (direct and indirect), and expresses definite information in an easy way to interpret. In addition, it gives a global perspective of how influential/dependent variables act in our system. So in this case, the overall manner of the entire system is resumed in a plot that assisting a better grasp. The detailed stage of this presentation relies on the granularity \bar{N} which is set by the specialist. For our case study, we have set $\bar{N} = 9$.

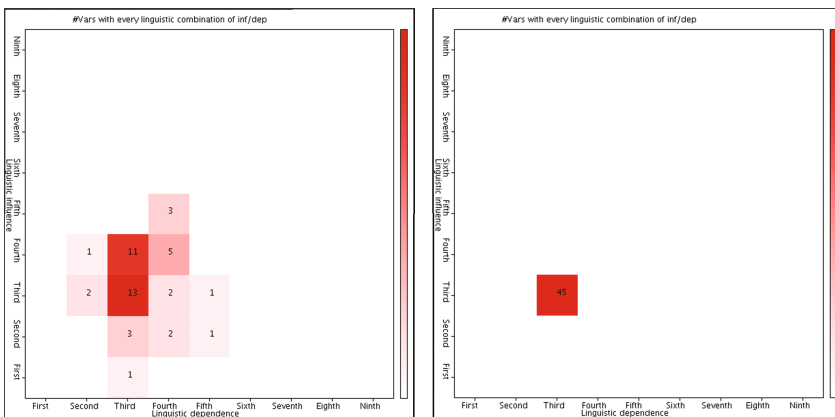


Fig. 5. Number of factors with any possible integration of linguistic influence and dependence for granularity levels at the output by researchers.

The number of various used at the result of the indirect method is small, and they are gathered around labels. This happens because of the fact that in the indirect method there is tension to decay the results after long calculations, guiding ultimately to more unified results that is a prevalent disadvantages of plenty linguistic processes. For this, the normalization accomplished here by taking the β th root tends to prevail such problem. In our case study, these plots permits the expert to check at a first look, that is, most of the factors show intermediate and lower intermediate overall dependence and influence. Additionally, heat maps also serve as a method of bunching the factors, because those with the same integration of linguistic influence and dependence can play an analogous role. In the current research, these obtained plots permits decision maker to check the whole system performance at first glance. In our plots, most of the factors are placed in a lower-intermediate district in terms of global dependence and influence. In addition, heat maps act in a way to cluster the factors, because those variables with the same integration may have a similar role.

4 Conclusions

As a result of the permanent altering of urban areas and appearing their complexity and ambiguous future, an increasing demand for various options and creative planning approaches is felt. A growing concern of practitioners and decision makers in terms of employing various types of strategies for facing the future is considered, resulting the necessity of using principled measuring the subjects corresponded to the accomplishment of future-based planning methods in regard with urban and spatial planning.

Albeit, decision-making approaches for knowledge-based urban development policies is obtaining enhanced notion and knowledge city criteria are imagined to direct decision-making for improved urban futures, the employment of knowledge-based urban development variables for policy makers is still under progress specially in terms of providing affordable housing.

The current research provides a case study of the Tabriz for examining the comparison the results obtained of two employed methods of crisp Micmac and Fuzzy Linguistic Micmac as a systematic modeling tools under CIA method. The effort can be considered a necessary, but not sufficient, condition and a first step towards future-based assessment in affordable housing within the framework of knowledge-based city assessment. The findings of this comparison are indicated in following:

- The obtained results and hence the rankings taken from both crisp Micmac and FL Micmac are almost the same but in few cases, which indicates accuracy of the employed methods. This little variation happens due to the using fuzzy values in FL Micmac that is more precise. In this manner, in both methods, of five top ranked results, we have four same variables including: government effectiveness, strategic planning, urban competitiveness, foreign direct investment. By considering the obtained results, the preference of good governance in Tabriz city to achieve knowledge-based city goals (promoting affordable housing) is hugely felt. Knowledge-based urban development and its variables like affordable housing is a complicated approach that city authorities may not have a clear background of its

long terms strategies and policies. The obtained results show that, strong correlation can be existed among these four variables. Local governments can arrange strategic plans to achieve sustainability and knowledge city objectives to be considered as high qualified region with increased gross domestic product.

- One of the advantages of the fuzzy linguistic Micmac is its capability in employing heat maps. The heat maps show whether the system's variables has great influence/dependence on each other or has not. In other words, these maps enable the decision-maker to look the strength of the system in a glance, from the existing relations between the factors. The other advantageous of the heat maps is, clustering the factors in an optical mode, because the factors with the same range of influence/dependence may have same role in the system. In our system, despite of being superior of some variables, the strength of the whole system is in the middle and lower. Therefore, the systems do not reflect a strong influence among the variables.

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