Intelligent Managment of the Unbalance Supply Chain and Demand in the Labor Market for IT Specialists

Masuma H. Mammadova[1], Zarifa Q. jabrayilova[2], Faiq R. mammadzada[3]

[1,2,3]*Institute of Information Technology, Azerb.Nat. AcademyScience, Baku c., B.Vahabzadeh str.,9, Az1141, Azerbaijan Republic*

[3]Faiq_Mammadzada@yahoo.com

***Abstract*- Supply chain management that interrelates and integrates both consumers and suppliers into a process to make product value or service to consumers is very important and strategic. The purpose of this work is to develop models and methods to assess the supply chain imbalance and labor market demand based on intellectual control for the IT segment. The labor market operates in conditions of uncertainty and is characterized by specific management tasks, for which there are no ready-made software products and classical mathematical models. In this paper, the authors used fuzzy set theory, which allows the development of formal methods of evaluation and decision support to automate the process of analysis of the supply chain and demand in the labor market. The labor market in the model is described as an intelligent space, in which the main actors representing demand and supply interact. Based on this concept, a simulation of the supply chain interaction and micro-level demand is performed and an algorithm based on fuzzy situational analysis and fuzzy pattern recognition is developed. Suggested in the article methodological approach to the creation of the intelligent management system for the labor market of IT specialists, allows developing management decisions aimed at reducing the (qualitative) discrepancy of supply chain skills and demand.**

Keywords- *Labor market, IT specialists, unbalance supply chain, Fuzzy sets, Intelligent management, Pattern recognition.*

1. Introduction

The Information and Computer Technology (ICT) penetration into various human activity spheres and the information globalization has led to sharply increased labor market demand for specialists in information technology (IT specialists) [1], [2], [3], [4]. Today the shortage of IT specialists is observed in almost all EU countries [5]. Experts predict the increase in the number of IT jobs by 2020 (from 750 000 to 1 000 000) [6], [7], and this is happening on the background of reducing the number of people receiving education on IT profile, engineering or natural sciences worldwide [8], [9], [10], [11], [12], [13], [14]. Measures such as competence models standardization, professional educational standards development in the IT sector with the participation of employers admission expansion to IT relevant faculties, contribute to the convergence of labor markets and IT-education, however, both of these areas continue to function in parallel [15], [16].

One can note that in the conditions of rapid development of information and communication technologies and the need for continuous updating of professional knowledge and skills of IT specialists, a quantitative unbalance often results from a qualitative discrepancy between skills and the requirements of the labor market [16], [17], [18], [19]. It is often the case when there is a sufficient number of people looking for jobs (supply) and a significant need for IT specialists (demand) on the employers' part [20], [24], [25]. However, due to the qualitative unbalance, these flows fail to satisfy each other upon contact. This determines the relevance of modeling the processes of qualitative inconsistency between the supply chain and demand of IT specialists and the development of methods for the formalization and assessment of the relationships of the latter. The existing methodologies for eliminating quantitative and qualitative mismatches in the labor market involve the job qualification requirements' formulation by employers [26], [27], [28]. Competencies are a tool that aggregates

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

professional knowledge, individual experience, personal and other qualities of IT specialists [29]and [30], and determine their employment opportunities, career growth, etc [31].
The traditional methodology for eliminating the quantitative and qualitative unbalances in the labor market comes with a simple vacancies filling, and, accordingly, unemployment reduction [21], [22], [23]. This approach is not effective today, as the economic situation is continuously changing, cycles of technology and knowledge interchange are rapidly updated and reduced, a global informatization takes place, new trends in modern manufacturing occur. All these factors contribute to changing IT profile jobs' requirements and stimulate the emergence of new IT-professions. This study investigates the problem of modeling processes of interaction between supply chain and demand on the IT-specialist labor market and their micromanagement, i.e. management at the level of the company. This is explained by the fact that the structure and scope of demand for IT specialists, as well as the requirements for their professional and personal competencies, are concretized at the level of the company. In such an interpretation, the task of figuring out the degree of consistency between the demand and supply at the micro-level comes down to the development of mechanisms for the effective selection and recruitment of IT specialists. It is worth noting that the scientific literature does not pay sufficient attention to the issues of systems analysis of the IT-specialist labor market, development of adequate technologies and methods for the support of managerial decision-making regarding the qualitative and quantitative coordination of the supply chain and demand of IT specialists, with regard to the specificity of this economic sector. This is caused by the specificity of the IT-specialist labor market, the flow of information regarding its state, nonhomogeneous data about human resources in this field, and an ambiguous system of indices. These peculiarities identify the problem of managing the supply chain and demand of IT specialists as a semi-structured one and determine the diversity of possible fuzzy states of the supply chain and demand of IT specialists and the multivariate nature of their coordination. The purpose of this study is to develop models and methods of assessment of the qualitative unbalance in the supply chain and demand of IT specialists based on an original conceptual approach to intelligent labor market management [32], fuzzy situational analysis, and image recognition. Intelligent management of the labor market IT segment implies the making of optimal managerial decisions in regards to the minimization of the unbalance in the supply chain and demand of IT specialists.=

2. Preliminaries

Managing the supply chain and demand mismatch at the micro level
Let $M_V = \{V, K, G, Q, U^p\}$be a model of IT specialists' demand, which defines requirements for the applicant's competence to a particular workplace. It is a system of employers' preferences regarding a specific job applicant, which are expressed by a set of candidate's desired competencies; it forms a search image of IT specialist. Here V is a set of vacancies expressed by employers' demands for IT specialists, i.e. applicants for vacancies; $K = (L, C)$ is a set of core competencies characterizing IT specialist, which is formed by L – a set of personal competencies needed to work in the IT sector, and by C – a set of professional competences, reflecting the necessary functional abilities to occupy a particular position. G is an employer's preferences system regarding individual indicators; $Q : V \cdot K \cdot U^p \to G$ is a decisive rule (assessment model) for displaying the employer's preferences system to the competencies set; U^p is a set of conditions, proposed to the candidates for IT profile positions. The supply model $M_S = \{S, K, W, Q^*, U^s\}$ reflects the actual competencies' values and preferences of each individual IT specialists, identifying their real search image (professional portrait). Here S is a set of IT specialists looking for a job and applying for a particular vacancy; $K = (L, C)$ is a set of personal characteristics and professional competencies of a specific IT specialist, i.e. a potential applicant for a job; W is a system of IT specialist's preferences; $Q^* : S \cdot K \cdot U^S \to W$ displays the system of IT specialist's preferences on the competencies set; U^s is the IT specialist's requirements for IT-profile work place. During the interaction of demand reference states' set and the real states' set, that define the supply, many unique semistructured

(fuzzy) situations are formed. The final result of the supply chain and demand management in the IT specialists' labor market is the identification (recognition) among the real and reference search images of the exact pair, which has the greatest value of elements' conformity (proximity) both from the employer's preferences position (reference requirements), and from the standpoint of the applicant claims. Applying a mechanism for the evaluation of the supply chain and demand conditions, and the extent of their compliance through the prism of the IT specialists' labor market interests, the management decision on the best candidate for the position could be made (respectively, the choice of the most preferred workplace).
Consequently, let the market demand of IT specialists be a set:

$V = \{V_1, V_2, ..., V_k\}$ or $V = \{V_i\}, i = \overline{1,k}$

expressed by the vacancies' number;

$L = \{l_1, l_2, ..., l_n\}$ or $L = \{l_j\}, j = \overline{1,n}$ is a set of personal characteristics (features), which each candidate should have for a specific position (vacancy, job);

$C = \{c_1, c_2, ..., c_m\}$ or $C = \{c_f\}, f = \overline{1,m}$ is an open set of competencies, which each candidate should have for the IT profile position.

$U^p = \{u_1, u_2, ..., u_p\}$ or $U^p = \{u_\gamma\}, \gamma = \overline{1,p}$ is a set of conditions, which are proposed to the candidates for the vacant IT profile jobs.

Thus, demand model $V = (L, C, U^p)$ can be described by three matrices $V_L = \|l_{ij}\|_{kn}$, $V_C = \|c_{if}\|_{km}$ and $V_U = \|u_{i\gamma}\|_{kp}$, where each row V_i describes a separate position in the IT labor market; the columns (l_{kn}, c_{km}, u_{kp}) display constantly expanding base of personality characteristics and competencies; the elements l_{kn}, c_{km} describe the separate indicators' possessing level needed to occupy a vacancy at time *t*; u_{kp} – is the values of parameters characterizing the conditions offered for the applicant to occupy a particular vacancy. Here, the competencies' weight could also be taken into account, i.e. $\lambda = \{\lambda_1, ..., \lambda_n\}$ is a set of personal competences' weights $L = \{l_j\}, j = \overline{1,n}$, $\omega = \{\omega_i, ..., \omega_m\}$ is a set of professional competencies' weights $C = \{c_f\}, f = \overline{1,m}$.

Discharge rate of V_i ($i = \overline{1,k}$) vacancy to the indicators l_{ij} and c_{if} is defined as fuzzy sets with membership functions

$$\mu_{l_{ij}}(V_i): V \times L \to [0,1], \ \mu_{c_{if}}(V_i): V \times C \to [0,1] \quad (1)$$

,

which express the rate of owning individual competencies in order to occupy a vacancy, set by employers.

At the same time, the conditions offered to applicants are described by matrix $V_U = \|u_{i\gamma}\|_{kp}$ where the membership functions $\mu_{u_{i\gamma}}(V_i): V \times U \to [0,1]$ are fuzzy measures of indicator intensity, characterizing the employment conditions.

Let the IT specialists' market supply be defined by $S = \{S_1, S_2, ..., S_q\} = \{S_g\}, g = \overline{1,q}$ – a set of IT specialists and job seekers applying for a particular job. $L = \{l_j\}, j = \overline{1,n}$ is a set of personal characteristics, characterizing IT specialists; $C = \{c_f\}, f = \overline{1,m}$ is a set of real competences possessed by each individual candidate to occupy the vacancy; $U = \{u_\gamma\}, \gamma = \overline{1,p}$ is a set of IT specialist's preferences, expressed as his requirements to IT profile job.

The supply model $S = (L, C, U)$ is also described by three matrices $S_L = \|l_{gj}\|_{qn}$, $S_C = \|c_{gf}\|_{qm}$ and $S_U = \|u_{g\gamma}\|_{qp}$, where each row (S_g) ($g=\overline{1,q}$) describes a separate candidate for the job in the IT labor market; the columns (l_{gn}, c_{gm}, u_{gp}) reflect the constantly expanding base of personal characteristics and competencies; the elements l_{qn}, c_{qm} show the rate of possessing different characteristics needed to occupy a vacancy; u_{qp} is the indicator value, describing the requirements of IT-specialist to the vacancy.

The rate of specific IT specialist S_g competence possession is determined by a separate membership function

$$\mu_{l_{gj}}(S_g): S \times L \to [0,1], \ \mu_{c_{gf}}(S_g): S \times C \to [0,1]. \quad (2)$$

IT specialist's requirements for a vacancy are expressed by matrix $S_U = \|u_{g\gamma}\|_{ip}$, and $\mu_{u_{i\gamma}}(S_g): S \times U \to [0,1]$ determines fuzzy intensity measures of IT specialist's requirements.

In fact, there are two sets of fuzzy conditions, describing the state of supply $\tilde{V}_i$ and demand $\tilde{S}_g$ in the IT specialists' labor market:

$$\tilde{V}_i = \{<\mu_{l_{ij}}(V_i)>, <\mu_{c_{if}}(V_i)>, <\mu_{u_{i\gamma}}(V_i)>\} = \{\mu_{V_i}(y)/y\}. \quad (3)$$

$$\tilde{S}_g = \{<\mu_{l_{gj}}(S_g)>, <\mu_{c_{gf}}(S_g)>, <\mu_{u_{g\gamma}}(S_g)>\} = \{\mu_{S_g}(y)/y\}, \quad (4)$$

Here the set $\tilde{V}_i = \{\mu_{V_i}(y)/y\}$ $i=\overline{1,k}$ is a description of fuzzy reference conditions, and the set $\tilde{S}_g = \{\mu_{S_g}(y)/y\}$ $g=\overline{1,q}$ is the description of fuzzy real situations.

The goal of the management of supply chain and demand on the IT-specialist labor market is to recognize and detect, among multiple real search images of IT specialists and model search images, the one pair, the proximity of the elements whereof is the highest.

3. Results

To determine the supply chain and demand in IT specialists' labor market on a micro level, it is reasonable to reduce the identification problem of supply chain and demand correspondence to the problem of fuzzy pattern recognition and evaluation criteria, and to the rate of their possession. Search and decision-making, in this case, are reduced to the comparison of each fuzzy IT specialists' search image (applicants for a particular position) with each reference fuzzy search image of employers' requirements, and to the pairs' identification with the highest proximity rate. In this formulation, decision-making on the accordance of supply chain and demand is based on the situational management using the measures of proximity definition of two fuzzy situations. As the assessment methods of the similarity of any real situation with each of the reference ones, single or multiple-step procedures of determining the degree of fuzzy shift of $\tilde{S}_g$ fuzzy situation into $\tilde{V}_i$ fuzzy situation, the rate of fuzzy equality $\tilde{V}_i$ and $\tilde{S}_g$, the rate of fuzzy commonness $\tilde{V}_i$ and $\tilde{S}_g$, and etc. can be used [18, 31, 32].

According to [32], the degree of fuzzy inclusion of situation $\tilde{S}_g$ into situation $\tilde{V}_i$ is determined as follows:

$$\theta(\tilde{S}_g, \tilde{V}_i) = \& \theta(\mu_{S_g}(y), \mu_{V_i}(y)) = \underset{y \in Y}{\&} (\max(1-\mu_{S_g}(y), \mu_{V_i}(y))) = \min(\max(1-\mu_{S_g}(y), \mu_{V_i}(y))) \quad (5)$$

Situation $\tilde{S}_g$ is considered fuzzily included into situation $\tilde{V}_i$ ($\tilde{S}_g \subsetneqq \tilde{V}_i$) if the degree of inclusion of $\tilde{S}_g$ into $\tilde{V}_i$ does not exceed a certain inclusion threshold $\psi \in [0.6; 1]$, which is determined by the management conditions, i.e. $\theta(\tilde{S}_g, \tilde{V}_i) \ge \psi$.

In other words, the situation $\tilde{S}_g$ is fuzzily included into situation $\tilde{V}_i$ if the fuzzy values of indices (actual values of competencies of a job application) $\widetilde{S}_g$ are fuzzily included into the values of the indices of situation $\widetilde{V}_i$ (model values of indices that describe the requirements to the characteristics of the job applicant). In order to make a decision, each alternative situation out of the multitude of applicants for a certain job (vacancies) is compared in terms of the degree of inclusion to the model image of the vacancy (situations out a multitude of vacancies). The sought an alternative situation (candidate) is the one that affords the maximum to the following expression:

$$\max\left[\min(\max(1-\mu_{S_g}(y),\ \mu_{V_i}(y)))\right],\ g=\overline{1,q},\ i=\overline{1,k}. \quad (6)$$

The degree of fuzzy equality (equivalence) as a means of determining the proximity of any two fuzzy situations is based on the following reasoning. Assume an equality threshold is set for two situations (for instance, $\psi\in[0.7;\ 1]$) and there are situations that are mutually inclusive, i.e. $\widetilde{S}_g \subsetneqq \widetilde{V}_i$ and $\widetilde{V}_i \subsetneqq \widetilde{S}_g$, $g=\overline{1,q},\ i=\overline{1,k},\ g\neq k$, ($\subsetneqq$ is the fuzzy inclusion sign), then situations $\widetilde{S}_g$ and $\widetilde{V}_i$ are considered approximately identical. Such similarity of situations, called fuzzy equality, is found from the following expression:

$$\mu(\widetilde{S}_g,\widetilde{V}_i)=\vee(\widetilde{S}_g,\widetilde{V}_i)\,\&\,\vee(\widetilde{V}_i,\ \widetilde{S}_g)=\&\,\mu(\mu_{S_g}(y),\ \mu_{V_i}(y)=$$
$$=\min_{y\in Y}\left[\min\left(\max\left(1-\mu_{S_g}(y),\mu_{V_i}(y)\right),\ \max\left(1-\mu_{V_i}(y),\mu_{S_g}(y)\right)\right)\right] \quad (7)$$

Situations $\widetilde{S}_g$ and $\widetilde{V}_i$ are considered fuzzily equal $\widetilde{S}_g \approx \widetilde{V}_i$ if $\mu(\widetilde{S}_g,\widetilde{V}_i)\geq\psi,\ \psi\in[0{,}7;1]$, where ψ is a certain threshold of fuzzy equality of situations.

A fuzzy *(p -λ)* generality of situations is a similarity of situations, when the fuzzy values of all attributes in situations are fuzzily equal, with the exception of fuzzy values that do not exceed *λ* attributes. If situations $\widetilde{S}_g$ and $\widetilde{V}_i$ are described by *p*-attributes, then a sufficiently fuzzy equality of *p - λ* attributes out of a multitude is sufficient for their *(p - λ)*-generalities. If the attribute that were used to describe the object of management do not depend on each other, then it is possible to transition from a certain situation $\widetilde{S}_g$ to any situation $\widetilde{V}_i$ that has a *(p - λ)*-generality with situation $\widetilde{S}_g$ by applying not more than *λ* local (affecting the value of a single attribute) equations.

The degree of the *(p – λ)*-generality $k_{p-\lambda}(\widetilde{S}_g,\widetilde{V}_i)$ of situations $\widetilde{S}_g$ and $\widetilde{V}_i$ is determined by the following expression:

$$k_{p-\lambda}(\widetilde{S}_g,\widetilde{V}_i)=\underset{y\in Y\backslash Y_\lambda}{\&}\mu(\mu_{S_g}(y),\mu_{V_i}(y)),$$

(8)

where $|Y_\lambda|\leq\lambda$, attribute y_z belongs to Y_λ if $\mu(\mu_{Sg}(y_z),\mu_{V_i}(y_z))<t$.

If $Y_\lambda = \varnothing$, situations $\widetilde{S}_g$ and $\widetilde{V}_i$ are fuzzily equal.

Similar to the determination of fuzzy equality, the assumption is that situations $\widetilde{S}_g$ and $\widetilde{V}_i$ have a *(p – λ)*-generality if $k_{p-\lambda}(\widetilde{S}_g,\widetilde{V}_i)$ > *t*.

Formally, the problem of identifying the state of supply chain and demand can be described as follows:

D = V, S, R, where: V – number of vacancies; S – number of IT specialists; R – number of rules determining the relationship between the elements of sets V and S (that is to say, allowing to compare the descriptions of the real states of IT professionals with all reference demand states).

Thus, the State Statistical Committee of the Republic recorded 1,680 enterprises and organizations of the IT sector by early 2013. This amounts to 2.1% of the total number of all legal entities in the country. Already in 2016 the number of employees in IT-sphere by of statistical Classification of Economic Activities was estimated at almost 20,172 persons [33].

Revenues of the IT industry in real prices achieved US$231,6 million or AZN180,7 million,10 accounting for 11,2% of total ICT sector income – 12,5 times less than telecom services' input to the sector – and only 0,32% of GDP. IT industry employees earn very competitive salaries: a junior specialist's monthly wage was US$1,206,00 or AZN940,00, a senior manager's US$6,200,00 or AZN 4,836,00 in 2013.

With that, IT education programs in state universities and colleges do not produce an adequate supply of skilled workers to meet the growing demand of the industry. The shortages of qualified candidates and, as a consequence, the high cost of skilled labor are key constraints to the IT industry's development in Azerbaijan. Methods for managing the scenarios of coordination of the supply chain and demand of IT specialists Studies offer possible scenarios of coordination of the supply chain and demand of IT specialists [32]. The recognition of the most acceptable (in terms of proximity) "employer – IT specialist" pair out of the multitude of search images of IT specialists (supply) and model search images can be followed by several possible scenarios:

Scenario 1. One vacancy (employer's order) – one applicant (IT specialist). In this case, of the degree of fuzzy similarity of the two situations (model search image of the vacancy and the search image of the applicant) exceeds the threshold set by the employer, a decision is made to recruit the applicant.

Scenario 2. Several applicants (IT specialists) meet the requirements of the employer in accordance with the accepted measure of similarity of two fuzzy situations. These applicants form a subset of fuzzy situations (alternatives), among which the employer has to pick one that corresponds to the best candidate. In this case, the employer that acts as an expert (decision-maker) can be offered the following methods of decision-making:

Scenario 2.1. The decision-making task comes down to comparing the degree of proximity of the model and real situations in terms of the significance of criteria that characterize the job applicants and the choice of the best decision based on the greatest matching of the most significant criteria. In this case, the formulas (5) or (6) are used to estimate the degree of proximity of the model situation $\widetilde{V}_i$ and the real situation $\widetilde{S}_g$. Then, the set equality threshold (for instance, $\psi \in [0.7; 1]$) is used to determine the situations that are mutually inclusive or fuzzily equal. The sought situation is the one that affords the maximum to the proximity to the model situation.

Scenario 2.2. The decision-making task comes down to a multi-objective choice of the optimal decision (alternative) with regard to the relative significance of the criteria that characterize IT specialists [33]. In this case, the decision-making task is realized in accordance with the following stages:

Stage 1. Similar to scenario 2.1, this stage involves a determination of mutually inclusive or fuzzily equal situations, after which it is possible to "narrow down" the real situations, for which the degree of proximity to the model situation does not exceed the threshold set by the employer.

Stage 2. This stage involves the determination of relative significance factors [34, 35]:

w_L, w_C, w_U (based on fuzzy ratios $L \times C \times U$);

$w_{l1}, w_{l2}, \ldots, w_{ln}$ (based on fuzzy ratios of indices $l_1 \times l_2 \times \ldots \times l_n$);

$w_{c1}, w_{s2}, \ldots, w_{cm}$ (based on fuzzy ratios of indices $c_1 \times c_2 \times \ldots \times c_m$);

$w_{u1}, w_{u2}, \ldots, w_{up}$ (based on fuzzy ratios of indices $u_1 \times u_2 \times \ldots \times u_p$);

Stage 3. Based on the aggregation of the degrees of possession of certain indices (i.e).

$$\mu_{l_{gj}}(S_g),\ j=\overline{1,n},\quad \mu_{c_{gf}}(S_g),\ f=\overline{1,m},\quad \mu_{u_{g\gamma}}(S_g),\ \gamma=\overline{1,p} \tag{9}$$

by specific IT specialists S_g, $g=\overline{1,q}$, the degrees of similarity between fuzzy real situations and the model situation are determined based on the following steps [15], [33]:

3.1. Based on the "convolution" of the degrees of possession of indices l_1, $l_2, \ldots, l_n$ (i.e. $\mu_{l_{gj}}(S_g)$, $j=\overline{1,n}$) by each specific IT specialist S_g, $g=\overline{1,q}$, the degree of proximity to the model search image for the job is determined based on personal characteristics; based on the "convolution" of $\mu_{c_{gf}}\left(S_g\right),\ f=\overline{1,m}$ – the degree of similarity based on *C* – competencies; based on the "convolution" of $\mu_{u_{g\gamma}}(S_g),\ \gamma=\overline{1,\ p}$ – the degree of similarity based on *U* – job requirements:

$$\varphi_L\left(\tilde{S}_g\right)=\sum_{j=1}^{n} w_j\,\varphi_{l_j}\left(S_g\right),\quad \varphi_C\left(\tilde{S}_g\right)=\sum_{f=1}^{m} w_f\varphi_{c_f}\left(S_g\right),\quad \varphi_U\left(\tilde{S}_g\right)=\sum_{\gamma=1}^{p} w_\gamma\varphi_{u_\gamma}\left(S_g\right). \tag{10}$$

3.2. The degrees of similarity between the real situations and the model situation are determined based on the obtained results and relative significance factors *L*, *C* and *U* – w_L, w_C, w_U, i.e.:

$$\varphi_{\tilde{V}_i}\left(\tilde{S}_g\right)=\omega_L\cdot\varphi_L(\tilde{S}_g)+\omega_C\cdot\varphi_C(\tilde{S}_g)+\omega_U\cdot\varphi_U(\tilde{S}_g) \tag{11}$$

3.3. A fuzzy real situation with the maximum value is chosen:

$$\varphi_{\tilde{V}_i}\left(\tilde{S}*\right)=\max\left\{\varphi_{\tilde{V}_i}\left(\tilde{S}_g\right),\ g=\overline{1,n}\right\}. \tag{12}$$

The fuzzy real situation of choice corresponds to the search image of the applicant that has the highest degree of similarity with the model image of the vacancy. This situation is accepted as the optimal decision.

4. Conclusion

The study investigated the micro-level of modeling of the interaction between supply chain and demand on the IT-specialist labor market, at which the supply to demand ratio is considered from the perspective of individual subjects (IT specialists and employers) on the labor market and their behavioral strategies. The problem of figuring out the degree of correspondence between the supply chain and demand at the micro-level comes down to the development of mechanisms for the effective selection and recruitment of IT specialists. A fuzzy situational model of supply chain and demand on the IT-specialist labor market was developed. A method of fuzzy recognition of images that is based on the determination of the degree of proximity between two fuzzy situations was offered for decision making in the selection and recruitment of IT specialists. Scenarios of coordination of supply chain and demand of IT specialists were offered. A decision-making method was offered for each scenario, which allows choosing the candidate that best corresponds with the requirements of the demand (employer). The proposed methodological approach to intelligent management of the IT-specialist labor market at the micro-level takes into account the specificity of the information technology sector, the needs, preferences, and claims of the main subjects of the IT labor market and the qualitative nature of the unbalance therein, and allows making managerial decisions aimed at reducing the competency-based (skill-based) inconsistency between supply chain and demand. This, in turn, allows providing various sectors of the national economy with IT personnel that meet the requirements of the labor market.

References

[1] Gholami, R., Higón, D.A., Hanafizadeh, P., and Emrouznejad, A. *"Is ICT the key to development?"*, Journal of Global Information Management, Vol 18, pp. 66–83, 2010.

[2] Abbasi, M., Tabatabaei, S.A.N., and Labbaf, H. *"Identify Future Changes of ICT in Human Resources Management: A Delphi Study*", Human Resourse Management, Vol 3, pp. 36–44, 2016.

[3] Ehrenberg, R.G., and Smith, R.S. *Modern labor economics: Theory and public policy*, Routledge, 2016.

[4] Niederman, F., Ferratt, T.W., and Trauth. E.M. *"On the co-evolution of information technology and information systems personnel". ACM SIGMIS Database*, Vol 47, pp. 29–50, 2016.

[5] Gareis, K., Husing, T., Birov, S., Bludova, I., Schulz, C., and Werner, B.K. *"E-skills for jobs in Europe: Measuring progress and moving ahead"*, 2014, http://www.voced.edu.au/content/ngv:62508.

[6] Wennergren, D.M. *"Forecast of Future IT Labor Supply chain and demand",* 2007, http://dodcio. defense. gov/Home/Initiatives/NetGenerationGuide/ForecastofFutureLaborSupplyandDemand.aspx.

[7] Balcerzak, A.P. *"Europe 2020 strategy and structural diversity between old and new member states. application of zero unitarization method for dynamic analysis in the years 2004-2013"*, 2015, *Econ Sociol*, 8:190–210. DOI: 10.14254/2071-789X.2015/8-2/14.

[8] Kuenzi, J.J. *"Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and*

legislative action", 2008.

[9] Bartlett, W. *"Skills anticipation and matching systems in transition and developing countries: conditions and challenges"* 2012, http://www.voced.edu.au/content/ngv%3A53976.

[10] Kelly, A.E., Lesh, R.A., and Baek, J. Y. *Handbook of design research methods in education: Innovations in science, technology, engineering, and mathematics learning and teaching*, Routledge, [2014].

[11] Drew, D.E. *STEM the tide: Reforming science, technology, engineering, and math education in America*, JHU Press, [2015].

[12] Lau, S.K., Winley, G.K., Leung, N.K., Tsang, N, and Lau, S. Y. *"An exploratory study of expectation in IT skills in a developing nation: Vietnam"*,2016,http://ro.uow.edu.au/cgi/viewcontent.cgi?article=6963&context=eispapers.

[13] Szewczyk, R., Kaštelan, I., Temerinac, M., et al. *Embedded Engineering Education*, Advances in intelligent systems and computing, 2016, p. 421.

[14] Daigger, G.T., Murthy, S., Love, N.G., and Sandino, J. "*Transforming environmental engineering and science education, research, and practice"*, Environmental Engineering Science, Vol 34, pp. 42–50, 2017.

[15] Sánchez-Rodríguez, C., Dewhurst, F.W., and Martínez-Lorente, A. R. *"IT use in supporting TQM initiatives: an empirical investigation"*, An initial Journal of Operations and Production Management, Vol 26, pp. 486–504, 2006.

[16] Qi, C., and Chau, P.Y. *"Investigating the roles of interpersonal and interorganizational trust in IT outsourcing success*", Information Technology and People, Vol 26, pp. 120–145, 2013.

[17] Lawson, R.A., and Bierhanzl, E. *"Labor market flexibility: An index approach to cross-country comparisons"*, Journal of Labor Research, Vol 25, pp. 117–126, 2004.

[18] Vincent, N. *"Unbalances between Labor Demand and Supply"*, 2011, www/URL: http://www23. hrsdc. gc. ca/l. 3bd. 2t. 1ilshtml@-eng. jsp.

[19] Koplyay, T., Lloyd, D., and Mako, C. *"HR issues evolution along the market lifecycle and the value chain: Case of the hi-tech industry"*, Human Resourse Management, Vol 2, pp. 7–33, 2014.

[20] Roberts, G.G. *SET for success: the supply of people with science, technology, engineering and mathematics skills: the report of Sir Gareth Roberts' review*,2002, http://dera.ioe.ac.uk/4511/3/ACF614.pdf.

[21] Caballero, R.J., Cowan, K.N., Engel, E.M., and Micco, A, *"Effective labor regulation and microeconomic flexibility",* Journal of Development Economics, Vol 101, pp. 92–104, 2013.

[22] Keller, M. *"New Employment Relationships and the Labor Market"*, Journal Labor Research, Vol 18, pp. 551–559, 2002.

[23] Tüzemen, D. "*Labor market dynamics with endogenous labor force participation and on-the-job search"*, Journal of Economics Dynamics Control, Vol 75, pp. 28–51, 2017.

[24] Popescu, G.H. *"Labor market regulation and the shadow economy*", Economics Management and Financial Markets, Vol 9, pp. 110–115, 2014.

[25] Liang, H., Wang, J.J., Xue, Y., and X. Cui. IT *"Outsourcing research from 1992 to 2013: A literature review based on main path analysis"*. Information Managment,Vol 53, pp. 227–251, 2016.

[26] Handel, M.J. *"Skills mismatch in the labor market"*, Annual Review of Sociology, Vol 29, pp. 825–867, 2003.

[27] Mýtna Kureková, L., Beblavý, M., Haita, C, and Thum, A.E. *"Employers' skill preferences across Europe: between cognitive and non-cognitive skills"*, Journal of Education and Work, Vol 29, pp. 662–687, 2016.

[28] Stenard, B.S., and Sauermann, H. *"Educational Mismatch, Work Outcomes, and Entry into Entrepreneurship"*, Organization Science, Vol 27, pp. 801–824, 2016.

[29] McMullen, S. *"How do Students Respond to Labor Market and Education Incentives? An Analysis of Homework Time*", Journal Labor Research, Vol 32, pp. 199–209, 2011.

[30] Roztocki, N., and Weistroffer, H.R. *"Information and communication technology in transition economies: an assessment of research trends"*, Information Technology for Development, Vol 21, pp. 330–364, 2015.

[31] Feiler, L., Fetsi, A., Kuusela, T., and Platon, G. *"Forecast and anticipation for skills demand and supply in ETF partner countries", Eur. Train. Found,* 2013, www.etf.europa.eu.

[32] Mammadova, M.H., and Mammadzadeh, F.R. *"Conceptual bases development of supply chain and demand intelligent management in the labor market for specialists in information technology",* Eastern-European Journal of Enterprise Technologies, Vol 4, pp. 53–67, 2015.

[33] The State Statistics Committee of Azerbaijan. https://www.stat.gov.az/menu/13/?lang=en (accessed 28 April 2017).