International Journal of Industrial Engineering & Production Research

ISSN: 2008-4889

March 2011, Volume 22 Number 1
pp. 21-30

http://IJIEPR.iust.ac.ir/

Using Fuzzy Cognitive Maps for Prediction of Knowledge Worker Productivity Based on Real Coded Genetic Algorithm

Asadallah Najafi & Abbas Afrazeh*

Asadallah Najafi, *Department of Engineering and Technology, Islamic Azad University, Zanjan Branch, Zanjan, Iran*

****Abbas Afrazeh,*** *Assistant professor Department of Industrial Engineering, Amirkabir University of Technology, Tehran, Iran*

KEYWORDS

Knowledge work,
Knowledge Worker Productivity;
Fuzzy Cognetive Maps;
Knowledge Management

ABSTRACT

Improving knowledge worker productivity has been one of the most important tasks of the century. However, we have few measures or management interventions to make such improvement possible, and it is difficult to identify patterns that should be followed by knowledge workers because systems and processes in an organization are often regarded as a death blow to creativity. In this paper, we seek to present a method for prediction of Knowledge worker productivity (KWP) that it must be capable of predicting the productivity of the knowledge workers in a one year period of time based on the Fuzzy cognitive maps (FCM) technique Based on Real Coded Genetic Algorithm (RCGA) , as well as presenting the best option from among different options as the knowledge workers' productivity improving strategy (suggesting solution), based on the results gained from this and the previous section and depending on the requirements. The validity of the suggested model will be tested in an Iranian Company.

1. Introduction

Nowadays, one of the principle challenges of the organizations is improving the productivity of the knowledge workers. No doubt, the productivity process of the knowledge workers is an outcome of the interaction and combination of different factors. As the productivity of the knowledge workers is not just an abstract category, and it must necessarily be applicable, the management of the organization will play an important role in providing the suitable ground for institutionalizing and promoting of it, and the knowledge workers' participation is of high importance from this viewpoint. On the other hand, the knowledge work entails many complications, paying attention to which and clarification and preparing the necessary possibilities for its implementation would be an effective step toward improving the productivity of the knowledge workers, as the organization and the knowledge worker will align for performing a knowledge work [1, 3 ,8].

The knowledge workers' productivity includes a number of organizational, individual and professional factors interacting in line with materializing as the predefined goals. Exploiting the capabilities of the personnel and providing encouragement for leading them to a common goal and supplying the necessary facilities for better implementing the knowledge work is unrelated with the productivity improvement attitude of the knowledge workers [4, 7].

Since the organizations go after the goal of improving the productivity, to improve productivity it would be

* **Corresponding author. Abbas Afrazeh**
Email: *anajafi@aut.ac.ir afrazeh@aut.ac.ir*
Paper first received May. 15. 2010, and in revised form Jan. 05. 2011.

necessary to identify the present status at first and then the causes and the solutions are described [14, 19] based on the identification results. To provide a solution, the future status of the knowledge workers' productivity must predict. The Fuzzy Cognitive Maps together with the genetic algorithm based learning mechanisms have used for analysis and prediction of the knowledge workers' productivity time series. The results gained are comparable with other fuzzy sets based modern methods of predicting.

The present research has been prepared in five main sections. Section 1 describes the knowledge management and its relationship with the knowledge worker. The research methodology introduces in the second section. The suggested method tested in the third section. The forth section has been allocated to the analysis of the research findings and presenting the results. The future suggestions made in the last section.

2. Knowledge Workers' Productivity

It presents some definitions in as follows:

2-1. Knowledge and Knowledge Management

Knowledge is a combination of experience, values, and new information. In other words, knowledge considers as property. Knowledge management, discovery, creation and development, sharing, maintenance, evaluation and suitable utilization achieves through effective utilization of human resources, information technology and communications [6].

2-2. Knowledge Work and Knowledge Worker

There are different approaches to classifying work. Some of these are presented below [2, 5]:

- Uncertainty-based work (perplexity, problem, programme, project and process)
- Structure-based work (structured, semi-structured, unstructured)
- Comprehensiveness-based work (strategic, tactical, functional and clerical)
- Maturity-based work (optimization, control and visibility)
- Knowledge-based work (knowledge work, non-knowledge work)

Of the above-mentioned classifications, the last is best suited to research since both knowledge and non-knowledge work can encompass uncertainty, structure, comprehensiveness and maturity. In other words, all other classifications can consider the sub-branches of the last classification. The definitions presented in this report are based on previous researches in this field, which formulated 31 definitions for knowledge work and 75 for knowledge workers [1, 3, 4, 7]. A comprehensive definition that summarizes the above-mentioned definitions and is applicable to this study is as follows: Knowledge work includes characteristics of complexity, input and output intangibility, nonlinearity, and non-routine. In addition, knowledge workers require mental ability, creativity, analytical ability, high educational attainment, programming capability, problem solving and decision-making skills, as well as qualities required for specific duties. There are different classifications for knowledge workers based on their duties (knowledge workers who are responsible for creating knowledge such as designers, researchers and philosophers; knowledge workers who are responsible for transferring/sharing knowledge such as teachers; knowledge workers who are responsible for knowledge utilization such as computer operators). In sum, knowledge workers are the staffs, which work with intangible resources and can be active in all sections of an organization [8, 9].

3. Research Methodology

In this section, we will present Research methodology.

3-1. Knowledge Worker Productivity measurement Model

There are two viewpoints regarding knowledge workers' productivity, that is, the public and the specialized. According to the specialized viewpoint, several models (including those of staff long-term productivity and Fabrikant general productivity) are proposed in which the most common and applicable model is defined as the ratio of output to input [12, 14]. This model generally states the numerical value of knowledge workers' productivity. According to the public viewpoint, various models (including those of Smith, Herris &Goldsmith, Crest, Victor, Room and WCM) have been proposed that offer effective reasons and elements in productivity [2, 6, 15]. The specialized view considers specialist knowledge workers such as engineers, doctors, managers, researchers and so on, while the public view considers all knowledge workers. Since organizations today employ knowledge workers in different fields, a specialized view would be ineffective. Specialized knowledge workers interact with both within their group and outside of their group, thus rendering the public view and its existent models an effective tool for analysing the issue. The WCM Model, a public knowledge workers' productivity model, contains all the parameters in the models mentioned as well as taking into account human resources; in other words, it is a combination of models [16]. Human resource productivity bases on the three main elements of desire, ability and possibility [15]. This relationship depictes as follows:

$$P_{hr} = f\,(W,\ C,\ M) \qquad (1)$$

Where M is the required organization or facility, C is the jobholder or jobholder's capabilities, W is the job or job requirements and P_{hr} is the knowledge worker's productivity. The KWP system is shown in figure 1.

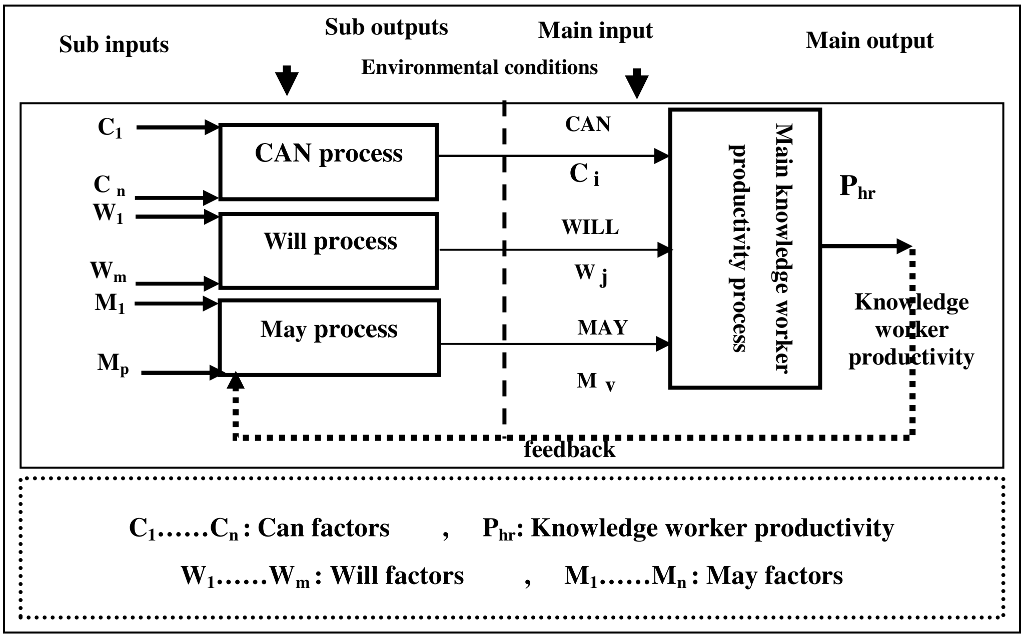

Fig. 1. Knowledge worker productivity system

Knowledge worker productivity achieves in six steps of knowledge management in Table 1.

Tab. 1. Knowledge worker productivity process

	C	W	M	KWP
Identification	C_{id}	W_{id}	M_{id}	KWP_{id}
Creation	C_{cr}	W_{cr}	M_{cr}	KWP_{cr}
Capturing	C_{ca}	W_{ca}	M_{ca}	KWP_{ca}
Application	C_{ap}	W_{ap}	M_{ap}	KWP_{ap}
Sharing	C_{sh}	W_{sh}	M_{sh}	KWP_{sh}
Saving & Storage	C_{ss}	W_{ss}	M_{ss}	KWP_{ss}

3-2. Knowledge Worker Productivity Classification

As mentioned, knowledge worker productivity factors are extracted and classified in three categories (w, c, m). In this section, we will extract the sub-factors. The KWP factors define in six steps of knowledge management in Figure 2.

3-3. Knowledge Workers' Productivity Prediction

Predicting the time series for recognizing the numerical or explanatory levels is a new approach. This approach has presented using the Fuzzy Cognitive Maps together with a learning method enjoying the advantage of the real-coded genetic algorithm. In **Fuzzy Cognetive Maps** s framework, the systems describe through their reciprocal concepts and relationships. The suggested prediction method combines the **Fuzzy Cognetive Maps** with the fuzzy set grain model, one of the advantages of which being the modeling and predicting in two numerical and explanatory levels. Comprehensive activities have performed in mind considering two main goals. First, estimating the quality of the suggested structure and second, testing the effects of the prediction technique parameters on the prediction quality. The gained results in comparison with other fuzzy based prediction techniques show that the suggested structure produces higher accuracy in numerical and explanatory levels. The main aims, and in other words, the motive of selecting the **Fuzzy Cognetive Maps** are as follows:

- Application of the **Fuzzy Cognetive Maps** for predicting the time series: The motive for using this specific technique is a result of its simple and comprehensive structure, consisting of the reciprocal relationship concepts, conforming to a given range. The **Fuzzy Cognetive Maps** are capable of acquiring the behavior of a given dynamic system. Recently, they introduced genetic optimization based learning algorithm (genetic algorithm) allows for automatic expanding of the **Fuzzy Cognetive Maps** from the genetic data. This learning approach is flexible considering the input data. For example, both observations in successful time points of t and t+1 can be used for learning the map, and if some observations are removed from the historical data, all the remained couples still can be successfully used for learning.

The possibility of design and expanding the absolute predicting systems based on the **Fuzzy Cognetive Maps, which** are capable of predicting in two numerical and explanatory levels. The desired steps for implementing are according to the description given in fig. 3.

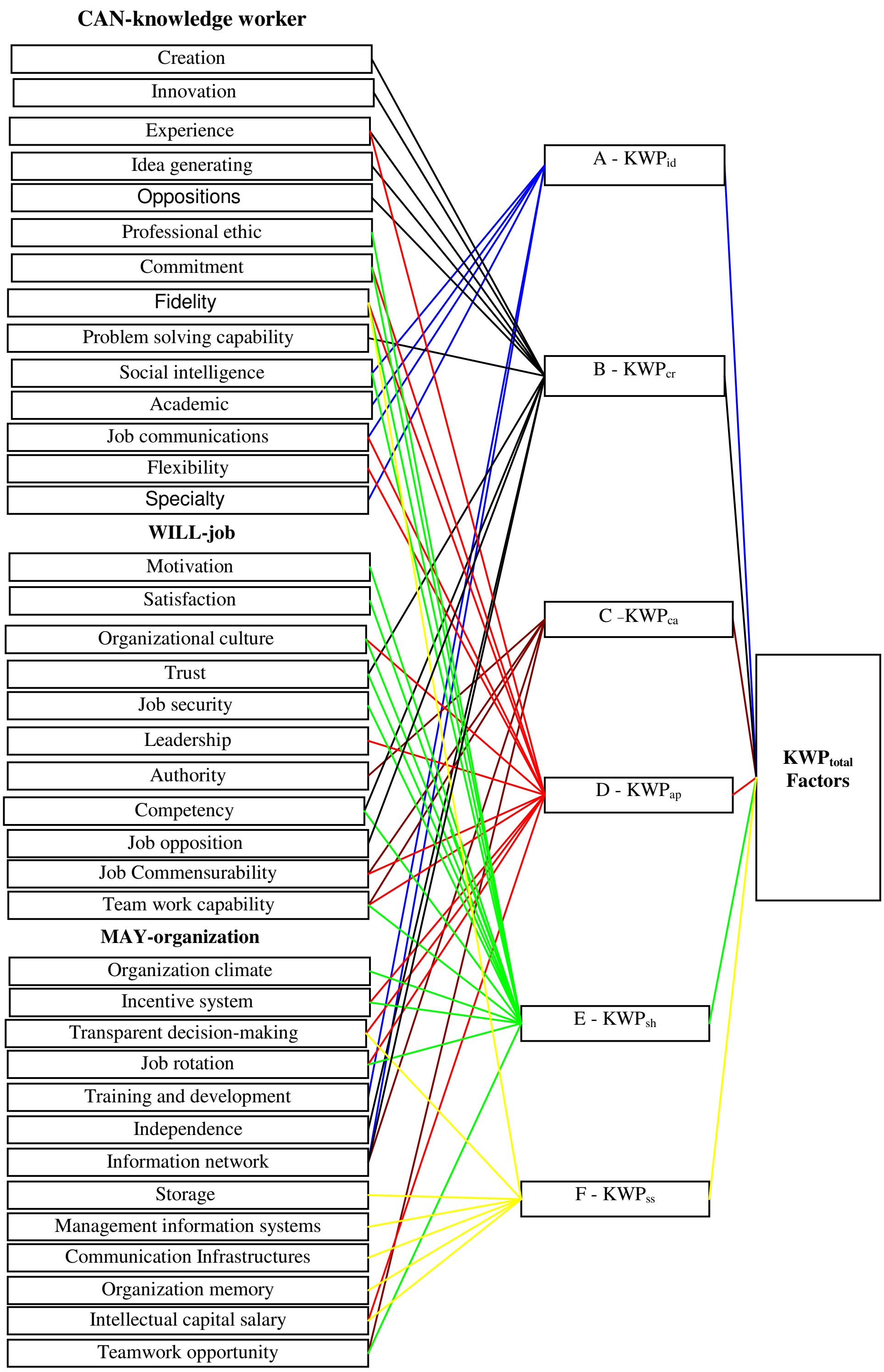

Fig. 2. Knowledge worker productivity factors

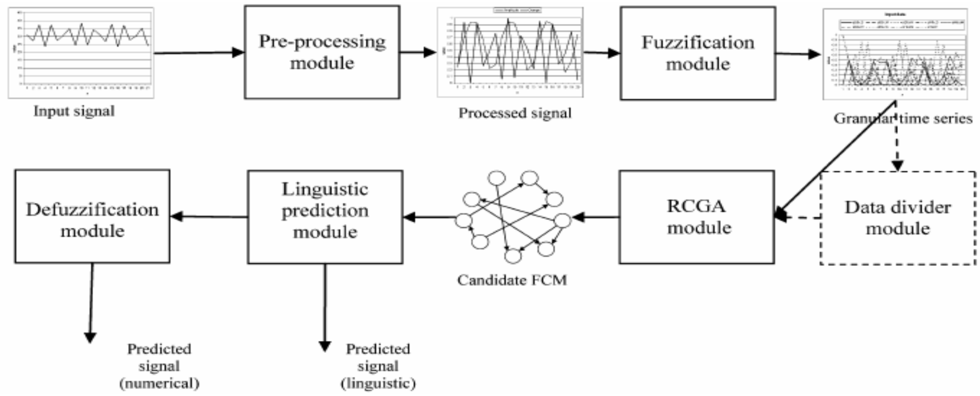

Fig. 3. Diagram of the suggested prediction method

4. Case study: Mobarakeh Steel Co. of Isfahan

This descriptive-survey type research has carried out using the questionnaire as the research tool for gathering the required data. Data's gathering involved both reference material and a questionnaire survey. Sampling was simple random sampling and the data gathering instrument was the questionnaire. Statistical population of the research has been the project managers working for the Mobarakeh Steel Co. of Isfahan subsidiary companies.

About 100 employees from the said group have selected as the statistical sample from whom the required data was gathered. The validity of the supplied questionnaire comprising of the above-mentioned issues tested using several interviews with the experts and project managers of Mobarakeh Steel Co. of Isfahan, Iran.

4-1. The Knowledge Workers' Productivity Prediction

In this section attempt has made to predict the productivity for the future, based on the defined productivity value and using the Fuzzy Cognitive Maps. In addition, we tried to suggest different solutions and scenarios in accordance with the causes and their effects on the knowledge workers' productivity as well as the predicted status. ***In the first stage***, an optimized signal exploited for prediction from among the knowledge workers' productivity signals in four sections of the Executive department, Engineering department, Programming department, and the whole Organization. The signal with minimum change standard deviation and max range standard deviation would be select. Table No. 2 shows the change value and knowledge workers' productivity range in different departments of the company in question.

Conform to the above table, the productivity signal of the whole organization has the minimum change Standard deviation and the max range standard deviation, and therefore, it selected as the input signal of the prediction.

In the second stage, the graphs relating to each stage is to be exploited from the six stages of the knowledge workers' productivity in network form and based on their relationship level and their influence on others. This action has performed in the analysis step of the knowledge workers' productivity.

In the third stage, the weight matrix of the Wij=Ci/Cj is exploited in which the same influence of the factors has been included. In continuation, the Xi(t) level which is the actual value of the factors in each stage is calculated (in analysis section). The Wij*Xi(t) can now be calculated based on the calculated data.

In the forth stage, the change rate of factors or Ui(t) is gained and by multiplying the Wi=Ci in Ui(t), the change rate value of factors Wi*Ui(t) is calculated.

In the fifth stage, the values of Xi(t+1)=Wij*Xi(t)+Wi*Ui(t), Yi(t+1)=C*Xi(t+1) and Y=Sum(Wi*Yi) is calculated for each department respectively.

In the sixth stage, the Y value of all the six stages of the knowledge workers' productivity divided on the weight of the related stage to acquire its normalized value. The gained value is the same as the knowledge workers' productivity prediction for the next period.

In the seventh stage, by adding up the knowledge workers' productivity values of all the previous stages, the knowledge workers' productivity prediction for the next stage can calculated.

In the eighth stage, the knowledge workers' productivity simulated using the genetics algorithm up to 10000 next generations and the result, which is the result of the optimized predicted value of any stage, allocated to the related period as the optimized predicted knowledge workers' productivity.

In the ninth stage, this cycle repeated for the next periods. The gained results are optimized once more using the remained analysis method and filtering.

The knowledge workers' productivity prediction results for one period have presented in table 3, and the results for 36 predicted periods have been given in table 4.

Tab. 2. Knowledge worker productivity Domain

KWP (total)			KWP (Executive)			KWP (Engineering)			KWP (Planning)		
change	Domain	quantity	Change	Domain	Quantity	change	Domain	quantity	change	Domain	quantity
0.806	0.636	5.8	0.656	0.521	5.2	0.771	0.731	6.6	0.821	0.487	**5.5**
0.781	0.611	5.62	0.648	0.513	5.14	0.75	0.71	6.42	1.106	0.772	**7.41**
0.616	0.446	4.43	0.414	0.279	3.28	1.04	1	8.90	0.503	0.169	**3.37**
0.828	0.659	5.96	0.471	0.336	3.73	0.48	0.44	4.10	0.573	0.239	**3.84**
0.677	0.508	4.88	0.656	0.522	5.21	0.342	0.301	2.92	1.124	0.79	**7.53**
0.709	0.539	5.10	0.903	0.768	7.16	0.515	0.475	4.41	0.546	0.212	**3.66**
0.447	0.278	3.22	1.135	1	9.00	0.925	0.885	7.91	0.813	0.479	**5.45**
0.57	0.401	4.10	0.718	0.583	5.69	0.811	0.77	6.94	0.863	0.529	**5.78**
0.407	0.238	2.93	0.249	0.114	1.97	0.767	0.727	6.56	0.505	0.172	**3.39**
0.456	0.286	3.28	0.306	0.171	2.42	0.539	0.499	4.61	1.18	0.847	**7.91**
0.315	0.145	2.27	0.135	0	1.07	0.977	0.937	8.36	1.314	0.98	**8.80**
0.461	0.291	3.32	1.127	0.993	8.94	0.493	0.453	4.22	1.252	0.918	**8.39**
0.798	0.628	5.74	0.463	0.328	3.67	0.697	0.657	5.97	0.745	0.411	**4.99**
0.513	0.344	3.69	0.265	0.13	2.10	0.551	0.51	4.71	0.378	0.044	**2.53**
0.402	0.232	2.89	1.052	0.917	8.34	0.82	0.779	7.01	0.854	0.52	**5.72**
0.432	0.262	3.11	0.179	0.045	1.42	0.794	0.754	6.79	1.251	0.917	**8.38**
0.875	0.705	6.30	0.186	0.051	1.47	0.331	0.291	2.83	1.132	0.798	**7.58**
0.588	0.419	4.24	0.997	0.862	7.90	0.228	0.188	1.95	0.834	0.5	**5.59**
0.505	0.335	3.63	0.334	0.199	2.65	0.144	0.104	1.23	0.696	0.362	**4.67**
0.944	0.775	6.80	0.292	0.158	2.32	0.342	0.302	2.92	1.334	1	**8.94**
0.914	0.744	6.58	0.969	0.834	7.68	0.638	0.598	5.46	1.326	0.992	**8.88**
1.169	1	8.42	1.08	0.945	8.56	0.947	0.907	8.10	0.8	0.466	**5.36**
0.649	0.48	4.67	0.549	0.415	4.36	0.86	0.82	7.36	1.032	0.698	**6.91**
0.316	0.147	2.28	0.749	0.614	5.94	0.56	0.52	4.79	0.838	0.504	**5.61**
0.783	0.614	5.64	0.464	0.329	3.68	0.793	0.753	6.79	0.439	0.105	**2.94**
0.383	0.214	2.76	0.527	0.392	4.18	0.865	0.825	7.40	1.037	0.703	**6.95**
0.169	0	1.22	1.125	0.99	8.92	0.293	0.253	2.51	0.71	0.376	**4.76**
1.052	0.883	7.57	1.092	0.958	8.66	0.04	0	0.34	0.91	0.576	**6.09**
0.228	0.059	1.64	0.761	0.627	6.04	0.913	0.873	7.81	1.297	0.964	**8.69**
0.998	0.829	7.18	0.819	0.685	6.50	0.26	0.22	2.23	0.901	0.567	**6.04**
0.384	0.214	2.76	0.402	0.267	3.19	0.165	0.125	1.41	1.106	0.772	**7.41**
0.235	0.066	1.69	0.285	0.151	2.26	0.871	0.831	7.45	0.334	0	**2.24**
0.727	0.558	5.23	1.116	0.982	8.85	0.634	0.594	5.42	0.979	0.645	**6.56**
0.521	0.352	3.75	0.711	0.576	5.64	0.297	0.256	2.54	1.054	0.72	**7.06**
0.723	0.553	5.20	0.484	0.349	3.84	0.931	0.891	7.96	0.86	0.526	**5.76**
1.115	0.946	8.03	1.069	0.934	8.48	0.715	0.675	6.12	1.111	0.777	**7.45**
0.625	**0.455**		**0.650**	**0.515**		**0.614**	**0.574**		**0.904**	**0.570**	**average**
0.068	**0.068**		**0.107**	**0.107**		**0.076**	**0.076**		**0.080**	**0.080**	**var**
Totally Section							**min std. of change & max std. of domain**				

Tab. 3. Steps of Knowledge worker productivity prediction in case stud

Y	Yi(t+1)	Xi(t+1)	Wi*Ui(t)	Ui(t)=0.01	kwp	final score	quantity	factor	weight	kwp
	2.95	2.95	0.01	0.10		0.6	5.2	Social intelligence		
	1.91	1.91	0.01	0.10		0.3	4.2	Academic level		
	1.40	1.40	0.01	0.20		0.3	6.3	Job communications		
	1.17	1.17	0.00	0.10		0.4	7.3	Specialty		
	1.04	1.04	0.01	0.20		0.2	5.2	Training and development		
	1.12	1.12	0.01	0.20		0.1	3.1	Information network		
0.69	0.32	0.32	0.00	0.20	5.2	0.1	6.3	Transparent decision-making	0.37	**KWPid**
	0.28	0.28	0.00	0.20		0.0	5.2	Storage		
	0.16	0.16	0.00	0.20		0.0	6.4	Management information systems		
	0.12	0.12	0.00	0.20		0.0	6.4	Communication Infrastructures		
	0.08	0.08	0.00	0.20		0.0	6.4	Organizational memory		
	0.05	0.05	0.00	0.20		0.0	5.1	Intellectual capital salary		

Tab. 4. Steps of Knowledge worker productivity quantities in case study

Total KWP

Prediction					**month**
				34.84	**1**
			40.10	39.32	**2**
		41.51		46.15	**3**
				41.32	**4**
	44.70		42.91	38.65	**5**
46.81				48.75	**6**
				49.7	**7**
			51.08	51.2	**8**
		52.12		52.34	**9**
				52.6	**10**
			53.16	53.21	**11**
				53.66	**12**
				53.78	**13**
	53.09		53.36	54.1	**14**
		53.06		52.2	**15**
				54.6	**16**
			52.77	53.6	**17**
56.53				50.1	**18**
				53.66	**19**
			56.72	56.7	**20**
		60.00		59.8	**21**
				65.4	**22**
	57.48		63.28	63.23	**23**
				61.2	**24**
				56.4	**25**
			52.43	51.1	**26**
		50.00		49.8	**27**
				47.7	**28**
			47.57	49.4	**29**
49.64				45.6	**30**
				48.7	**31**
	48.71		48.33	47.7	**32**
		49.28		48.6	**33**
				45.5	**34**
			50.23	52.2	**35**
				53	**36**

Figure 4 presents the Knowledge worker productivity prediction quantitie in 36 month in f future.

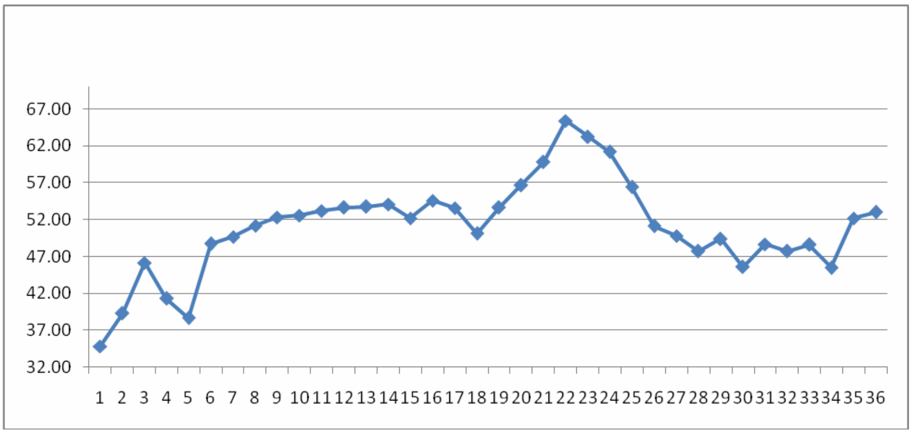

Fig. 4. Knowledge worker productivity quantities in case study

Figure 5 presents the Knowledge worker productivity prediction quantities(3th month) in f future.

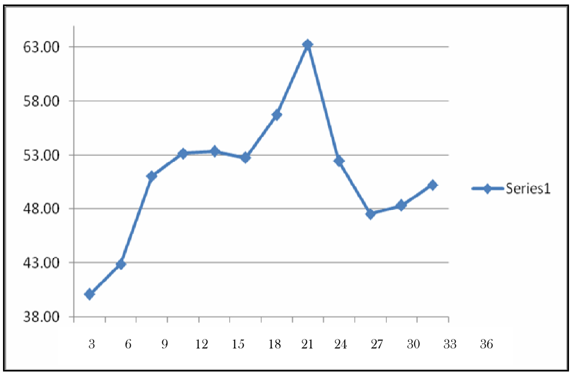

Fig. 5. Knowledge worker productivity in case study

We can infer from the gained results that by increasing the number of the periods. This can observe in 3-month, 6-month and 9-month periods. The best period for investigating the knowledge workers activities are three month periods because of this period has minimum errors rather than other periods (0.076), for the most changes with the less failure occurs in it. So the 3-month period has used as the base for the research. This result by itself considered as a finding of the research because the tasks performed by the knowledge workers are often from intangible, complicated and mental type with long-term results. Therefore, the researchers suggested choosing 3-month periods as their time base.

According to the prediction data, we have:

- The average value of the knowledge workers' productivity in the past and future 36 month is equal to 46.3% and 50.99% respectively. To compensate this decrease and to increase the productivity during the next 36 month, the optimized scenario was executed and now six months past the implementation of the optimized scenario, the average value of the knowledge workers' productivity has grown to the level of 56%. This indicates that through timely predicting the knowledge workers' productivity and identifying the key factors influential on it, not only overcoming the effects of the decrease in the productivity would be possible, but also considerable increasing the knowledge workers' productivity will not be out of the reach. This result is confirmable.
- The mean square error reached to its minimum value using the above function: 0.076
- The R^2 value reached to 99%, which indicates the model validity.
- The Cronbach alfa value is 98%, confirming the validity of the model.

In addition, interviews with the experts based on the Delphi method confirmed the above values in 97% of the cases.

The important solutions using the prediction method in **Mobarakeh Steel Co. of Isfahan** is as follows;

- Creating financial and spiritual motivation based on the output work.
- Vesting authority in the knowledge workers and removing the hindering rules

Optimized solutions: Vesting authority in the knowledge workers has been the best exploited scenario.

5. Comparison with other Methods

The results gained from the suggested method in comparison with the results of the other methods showed that the prediction methods based on the existing fuzzy sets have been tested only on one or two data sets. On the contrary, our paper includes comprehensive tests and comparing the results with all the rival methods, as shown in table 5. Table 5 makes a comparison between the results of the predicting data relating to 36 months of the knowledge workers' productivity based on the error level. As it can be seen from the results, the Fuzzy Cognitive Maps method incurs the minimum error possible. The second better method, that is the Fuzzy time method gained the score 0.09. The other methods, including the Sung-Chissom, Chen, Markove and Hwang methods achieved the next ranks.

Tab. 5. Comparison of methods based on error

Approach	Error %
Song - Chissom method	**0.129**
Chen's method	**0.34**
Markov method	**0.578**
Hwang method	**0.245**
Fuzzy time series method	**0.09**
proposed method	**0.076**

6. Conclusion

In this paper attempt was made to suggest a method for prediction of **Knowledge worker productivity** that it must be capable of predicting the productivity of the knowledge workers in a one year period of time, based on the time series' techniques and suggests the best option as the solution for improving the knowledge workers' productivity from among different options and according to requirements.

The suggested method was tested in **Mobarakeh Steel Co. of Isfahan, Iran**. The validity of the model was tested based on the Face Validity approach and other statistical analysis methods. Furthermore, the suggested prediction method was compared with other predictive methods like Sung-Chissom, Chen, Markove and Hwang methods. The results of this comparison showed that our method is the most suitable method for prediction; in other words, it entails the least errors possible. The above mentioned research has been carried out for the first time using the introduced tool of the knowledge management and the Knowledge workers' productivity which is important by itself.

7. Future Research

One possible follow-up is the comparison of the proposed method with other models, such as the Hidden - Markov models and Bayesian network.

8. Acknowledgement

This work was supported by Islamic Azad University, Zanjan Branch.

References

[1] Abooie, M.H., Aminnayeri M., *An Analytic Variable Limit np Control Chart*, Scientia Iranica; in press.2010.

[2] Afrazeh, A., Zarinozv, I.,. *A conceptual Framework for Presenting and Promoting Human Resource Knowledge Sharing in the Supply Chain as a Social Network*, International Journal of Services, Economics and Management , (Special Issue on: Modeling and Analysis of Supply Chain Networks), Vol. 2, Nos. 3/4, 2010, pp 227-245.

[3] Afrazeh, A., Bartsch, H., *Integration of Information Quality Management and Process Quality Management in Supply Chain, a Hybrid Model*, in Book: Innovative Logistics Management Competitive Advantages through new Processes and Services, Edited by: Wolfgang Kersten, Thorsten Blecker, Cornelius Herstatt, Erich Schmidt Verlag GmbH & Co., 2007, pp 3-14, Berlin.

[4] Arthur, M.B., Defillippi, R.J., Lindsay, V.J., *On Being a Knowledge Worker*, Organizational Dynamics, Volume 37, Issue 4, 2008, pp. 365-377.

[5] Buch, R., Kuvaas, B., Dysvik, A., *Dual Support in Contract Workers' Triangular Employment Relationships, Journal of Vocational Behavior*, In Press, Corrected Proof, Available online, 2010.

[6] Darchen, S., Tremblay, D., *What Attracts and Retains Knowledge Workers/students: The Quality of Place or Career Opportunities*? The cases of Montreal and Ottawa, Cities, In Press, Corrected Proof, Available online. 2010.

[7] Eshghi, K., Nematian, J., *Special Classes of Fuzzy Integer Programming Models with All-Different Constraints*, Scientia Iranica , Transaction E, Vol. 16, No 1, 2009, pp. 1-10.

[8] Faraj, S., Yan, A., *Boundary Work in Knowledge Teams*, Journal of Applied Psychology, Volume 94, Issue 3, 2009, pp. 604-617.

[9] Fazel Zarandi, M.H., Moattar Hoseini, S.M., Bastani, S., Mohebi, A., *A Fuzzy Intelligent Information Agent Architecture for Supply Chains*, Scientia Iranica, Vol. 15, No 5, 2008, pp 623-636.

[10] Frost, J., Osterloh, M., Weibel, A., *Governing Knowledge Work:: Transactional and Transformational Solutions*, Organizational Dynamics, Volume 39, Issue 2, 2010, pp. 126-136.

[11] Hahn, J., WangV, T., *Knowledge Management Systems and Organizational Knowledge Processing Challenges: A Field Experiment,* Decision Support Systems, Volume 47, Issue 4, 2009, pp. 332-342.

[12] Harmon, P., Davenport, T., *Task Analysis, Knowledge Workers and Business Rules*, Business Process Change, 2007, pp. 255-293.

[13] Hsieh, P.J., Lin, B., Lin, C., *The Construction and Application of Knowledge Navigator model (KNM™): An Evaluation of Knowledge Management Maturity*, Expert Systems with Applications, Volume 36, Issue 2, Part 2, 2009, pp. 4087-4100.

[14] Huang, J., *The Evolutionary Perspective of Knowledge Creation – A Mathematical Representation*, Knowledge-Based Systems, Volume 22, Issue 6, 2009, pp. 430-438.

[15] Karr-Wisniewski, P., Lu, Y., *When More is too Much: Operationalizing Technology Overload and Exploring its Impact on Knowledge Worker Productivity*, Computers in Human Behavior, Vol. 26, Available online. Sep. 2010.

[16] Kerr, A., Riain, S.Ó., *Knowledge Economy*, International Encyclopedia of Human Geography, 2009, pp. 31-36.

[17] Lai, J., Wang, C., Chou, C., *How Knowledge Map fit and Personalization Affect Success of KMS in High-Tech Firms*, Technovation, Volume 29, Issue 4, 2009, pp. 313-324.

[18] McAusland, C., Kuhn, P., *Bidding for Brains: Intellectual Property Rights and the International Migration of Knowledge Workers*, Journal of Development Economics, In Press, Corrected Proof, Available online, 2010.

[19] Najafi, A., *Developing Knowledge Management in Strategic Framework of Mabena Model*, World Applied Sciences Journal 9 (8): 2010, pp. 879-888.

[20] Najafi, A., Afrazeh, A., *Using Analytical Network Process for Ranking Educational Factors Influencing on Knowledge Worker Productivity*, World Applied Sciences Journal 9 (6): 2010, pp.605-618.

[21] Paton, R., McLaughlin, S., *Services Innovation:: Knowledge Transfer and the Supply Chain*, European Management Journal, Volume 26, Issue 2, 2008, pp. 77-83.

[22] Song, H., Miao, C., Roel, W., Shen, Z., Catthoor, F., *Implementation of Fuzzy Cognitive Maps Based on Fuzzy Neural Network and Application in Prediction of Time Series*, Volume 18, Issue 2, 2010, pp. 233-250.

[23] Tseng, S., *The effects of Information Technology on Knowledge Management Systems*, Expert Systems with Applications, Volume 35, Issues 1-2, 2008, pp.150-160.

[24] Vandaie, R., *The Role of Organizational Knowledge Management in Successful ERP Implementation projects,* Knowledge-Based Systems, Volume 21, Issue 8, 2008, pp. 920-926