Uniwersytet Ekonomiczny w Katowicach

Studia Ekonomiczne. Zeszyty Naukowe
Uniwersytetu Ekonomicznego w Katowicach
ISSN 2083-8611 Nr 234 · 2015

Rafał Marjasz

Politechnika Śląska w Gliwicach
Wydział Matematyki Stosowanej
Zakład Metod Probabilistycznych i Symulacyjnych
rafal.marjasz@polsl.pl

FINDING THE OPTIMAL STRATEGY FOR EMPLOYMENT IN CONJUNCTION TO THE MECHANISM OF PROMOTION WITHIN THE WORKFORCE – SIMULATION IN VENSIM SOFTWARE

Summary: Nowadays we can observe high dynamics within the organizations. Let us mention only few key factors like: selection, human resources development, changes in company policies and retirement age. All those issues have an influence on proper employment and mechanism of promotion. To show complexity of problems related to management of human resources author has created a System Dynamics model in Vensim. By utilizing the tools of Vensim – such as simulation, sensitivity analysis and calibration – we can comprehend the relations between employee workgroups, thus make an attempt to find proper solutions for employment and promotion management. The optimization results of this research are presented together with open questions for further investigations.

Keywords: simulation, system dynamics, calibration, Vensim.

Introduction

Nowadays we can observe high dynamics within the organizations. Modern society is more mobile, therefore cities are growing larger rapidly and big companies are expanding throughout the world. The flow of workforce is strongly connected to those occurring changes. Furthermore we must take into account the wide diversity of factors like: selection, human resources development, changes in company structures, policies, laws and retirement age. All those issues have an influence on proper employment and mechanism of promotion within every single company. To investigate this comprehensive mechanism and

show complexity of problems related to management of human resources author has created a System Dynamics model in Vensim. The extensive research on this subject requires a lot of time and many factors must be taken into account. Therefore the presented model was gradually built by author. The most simple version of the model was taken from [Ruth, Hannon, 2012] (it served as an inspiration to construct more advanced version capable to support the research). The in-company strategy for employment and the mechanism of promotion within the workforce are the main objects of this research, thus other related issues (for example economic crisis) will not be taken into account in this model.Further development of this model can address more issues, which leaves opportunity for further investigations in the future.

Presentation of the model and the object of study

As there was mentioned the simplest version of the model was taken from [Ruth, Hannon, 2012], where it was presented in STELLA software (shown in Fig. 1) as an example of disaggregation of stocks into subgroups of individuals to model the simple dynamics of a company.

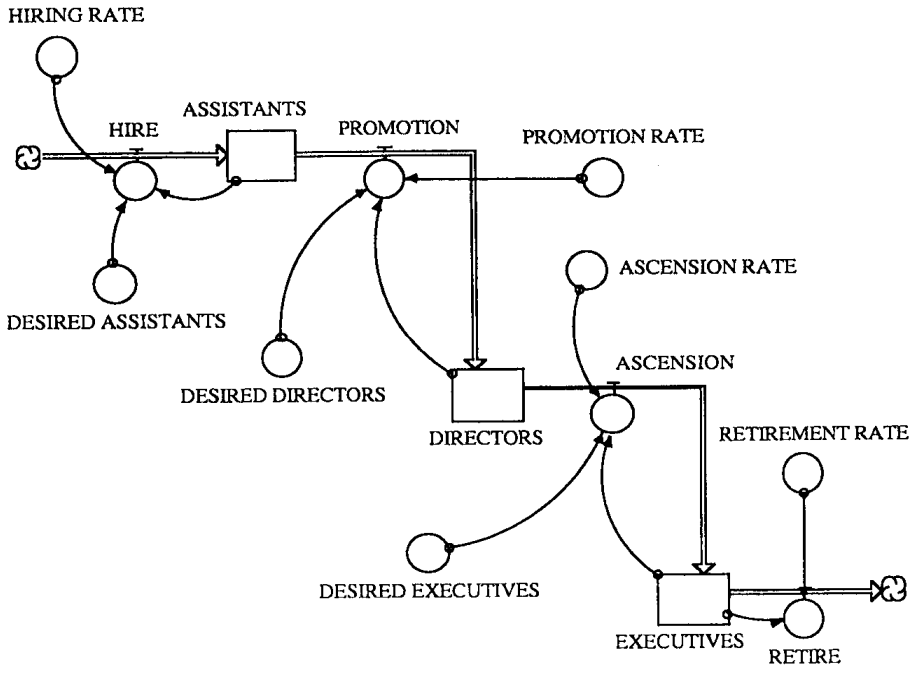

Fig. 1. STELLA model

Source: Ruth, Hannon [2012, p. 31].

By looking at this model, we can see the simplicity in many approaches, such as the assumption that only by obtaining the executive position someone can retire. Furthermore the mathematical equations are allowing negative promotion and ascension, which is illogical without the assumption of people dismissal. Therefore changes were made, to adapt this model to real life conditions in the company. This improvement took place in two stages. The first one included the changes in basic mathematical equations and added the possibility of retirement in every subgroup of workforce. The second stage was the addition of new parameters and corresponding mathematical equations to stabilize and optimize the operation of the model. As a result of these actionswe can see the final version of the model named Company Hierarchy (shown in Fig. 2) made in Vensim software.

List of the parameters of Company Hierarchy model:
Ascension Rate – AR
Desired Assistants – DA
Desired Directors – DD
Desired Executives – DE
Hiring Rate – HR
Initial Assistants – IA
Initial Directors – ID
Initial Executives – IE
Initial Rate – IR
Initial Stage – IS
Promotion Rate – PR
Retirement Rate – RR

List of the variables of Company Hierarchy model:
Ascension – Asc
Assistants – Asi
Assistants Change Ratio – ACR
Directors – D
Directors Change Ratio – DCR
Executives – E
Executives Change Ratio – ECR
Hire – H
Promotion – P
Retired Assistants – RA
Retired Directors – RD
Retired Executives – RE

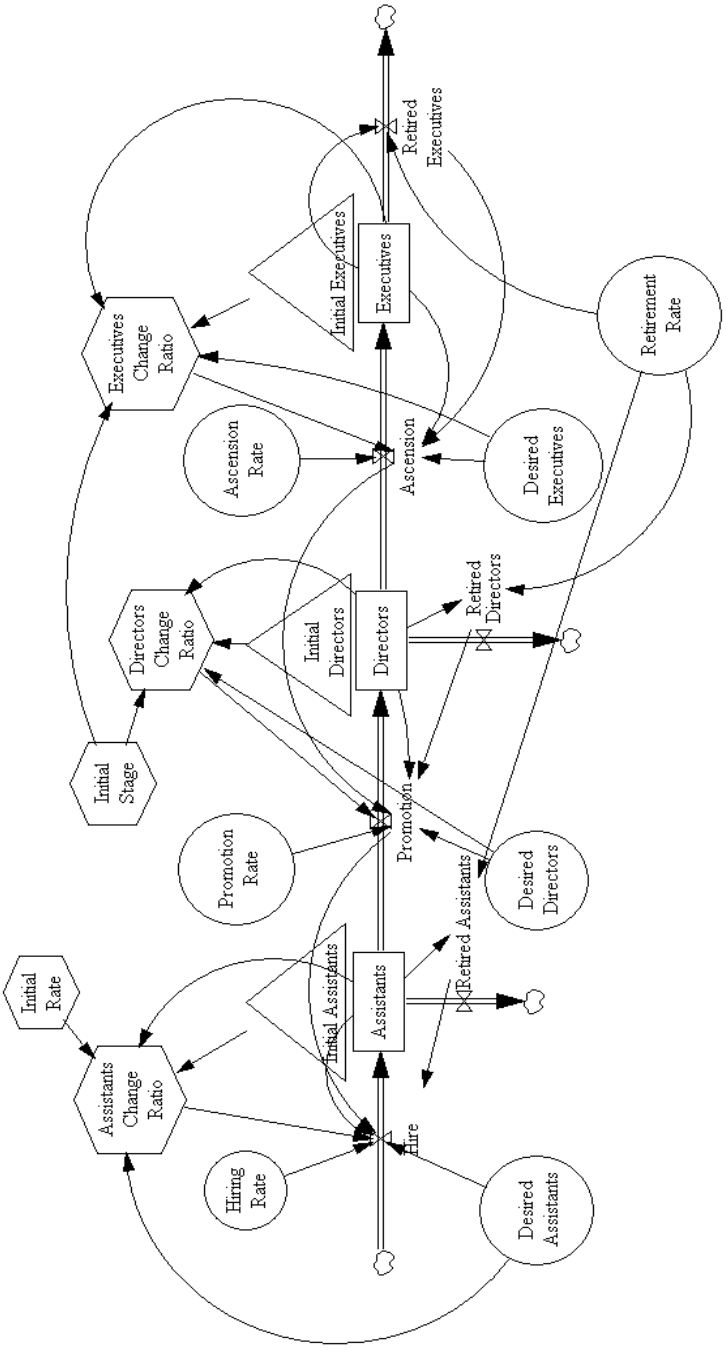

Fig. 2. Vensim model of Company Hierarchy

Source: Own research.

The mathematical model of Company Hierarchy:

$$Asc(t) = \_\begin{cases} (DE - E(t) + RE(t)) * AR, & DE - E(t) \geq 0 \\ ABS(ECR(t)) * (ABS(DE - E(t)) + RE(t)), & DE - E(t) < 0 \end{cases}$$

$$Asi(t + dt) = Asi(t) + dt * (H(t) - P(t) - RA(t))$$

$$ACR(t) = IR * (DA - Asi(t))/IA$$

$$D(t + dt) = D(t) + dt * (P(t) - Asc(t) - RD(t))$$

$$DCR(t) = IS * (DD - D(t))/ID$$

$$E(t + dt) = E(t) + dt * (A(t) - RE(t))$$

$$ECR(t) = IS * (DE - E(t))/IE$$

$$H(t) = = \begin{cases} (DA - Asi(t) + RA(t) + P(t)) * HR, & DA - Asi(t) \geq 0 \\ ABS(ACR(t)) * (ABS(DA - Asi(t)) + RA(t) + P(t)), & DA - Asi(t) < 0 \end{cases}$$

$$P(t) = = \begin{cases} (DD - D(t) + RD(t) + Asc(t)) * PR, & DD - D(t) \geq 0 \\ ABS(DCR(t)) * (ABS(DD - D(t)) + RD(t) + Asc(t)), & DD - D(t) < 0 \end{cases}$$

$$RA(t) = Asi(t) * RR$$

$$RD(t) = D(t) * RR$$

$$RE(t) = E(t) * RR$$

The scope of this research is to optimize Company Hierarchy employment and the mechanism of promotion within the workforce. It can be achieved by appropriate selection of certain parameter values. The way of finding those values will be described in next section.

Operating of Company Hierarchy model and optimization experiments using simulation by Vensim

In order to monitor the functioning of the mechanism of recruitment and promotion within the company we have to choose and consider particular scenarios. The Company Hierarchy model is built in such a way that it encompasses a particular group of scenarios. In these scenarios we will be dealing with the following aspects:

- the reduction of workforce to the desired value (excluding the possibility of instantaneous people dismissal),
- the employment of staff to the desired value,
- maintenance of desired number of employees during periodic changes in workforce demands.

To address each scenario author has provided an appropriate set of parameters (shown in Table 1). Before we examine those scenarios let us focus on some key variables and their impact on model behavior – namely the Assistants Change Ratio, the DirectorsChange Ratio, and the ExecutivesChange Ratio. Those three variables determine the respective level of hiring, promotion and ascension during periods with negative demand for employment. Initial Rate and Initial Stage parameters determine the level of impact of those variables, so by changing them to zero we can see the primary behavior of employment and promotion mechanism (shown in Fig. 3). The values of other parameters are taken from first scenario (see Table 1).

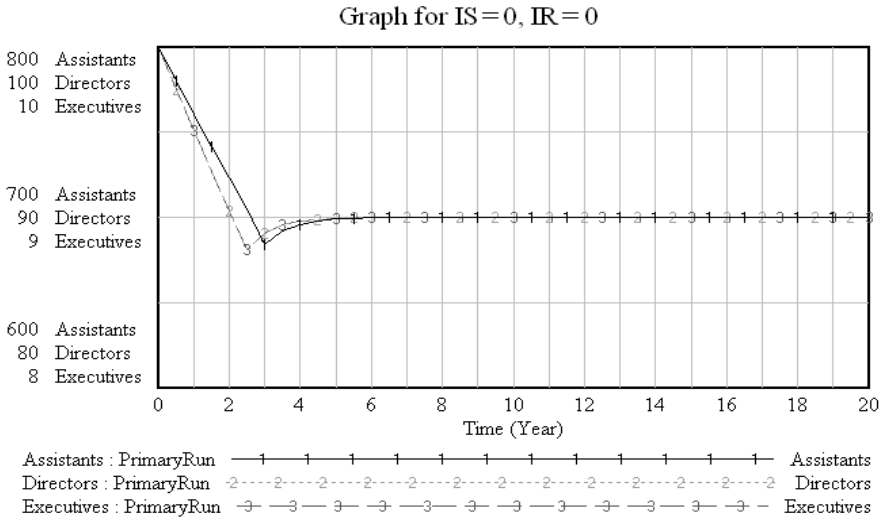

Fig. 3. Graph of Asi,D,E variables with IS and IR set to zero

Source: Own research.

This primary model run is focused on reducing the workforce to the desired level. As we can see all three variables (Assistants, Directors and Executives) achieve the desired level afterapproximatelyfive years with a two to three years period of staff deficiency. Further research will concentrate on finding optimum values for Initial Stage and Initial Rate, thus reducing period of staff deficiency to minimum.

Table 1. Scenarios for conducted research

Parameters	Scenario 1 'FirstRun'	Scenario 2 'SecondRun'	Scenario 3 'ThirdRun'	Scenario 4 'OptimumRun'	Scenario 5 'OptimRun2'
Ascension Rate	1	1	1	1	1
Desired Assistants	700	1000	{950,1050}	700	{950,1050}
Desired Directors	90	110	110	90	110
Desired Executives	9	12	12	9	12
Hiring Rate	1	1	1	1	1
Initial Assistants	800	800	1050	800	1050
Initial Directors	100	100	100	100	100
Initial Executives	10	10	10	10	10
Initial Rate	1	1	1	1.99294	2.15124
Initial Stage	1	1	1	1	1
Promotion Rate	1	1	1	1	1
Retirement Rate	0.05	0.05	0.05	0.05	0.05

Source: Own research.

The first scenario is focused on reducing the workforce to the desired level. Second scenario presents the employment of staff to the desired level. Third scenario shows the maintenance of desired number of employees during periodic changes in workforce demands. The fourth and fifth scenarios are the results of proper optimization process described later in the article. Let us proceed to thorough examination of each scenario.

Scenario 1 (see Table 1 and Fig. 4) represents the mechanism of staff reduction. Comparing Fig. 3 and Fig. 4 we can see the difference in model behavior with variables Assistants Change Ratio, Directors Change Ratio and Executives Change Ratiotaken into account. We can also notice that the change in number of Directors and Executives seems optimum, but the change in number of Assistants can be further improved. This leads to the conclusion that the appropriate value of Initial Rate and Initial Stage parameters can alone improve the way of reducing the workforce, which leads to the process of optimization expressed by Scenario 4.

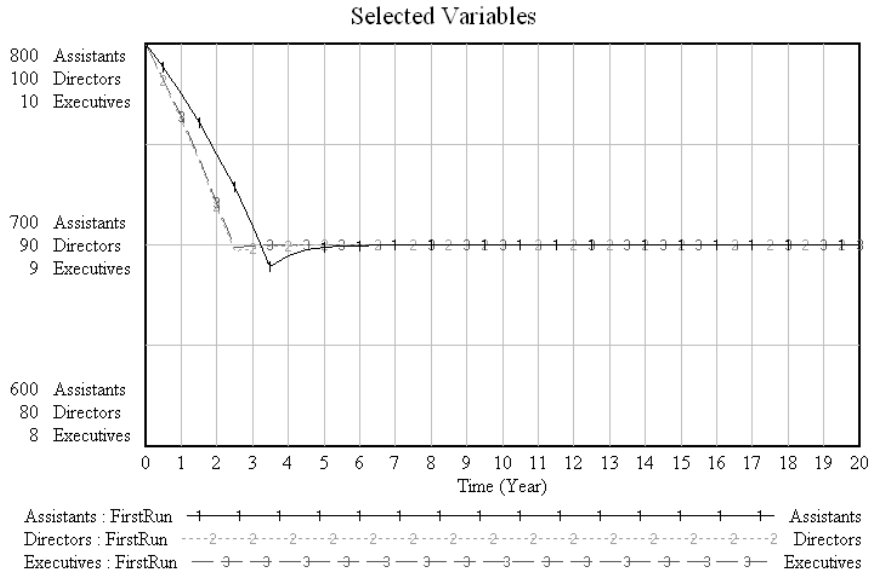

Fig. 4. Graph for Scenario 1

Source: Own research.

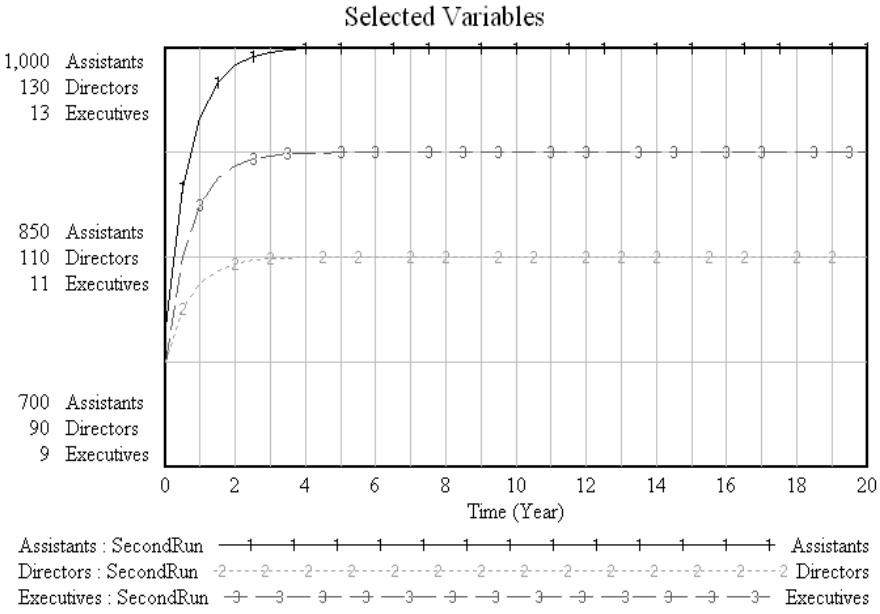

Fig. 5. Graph for Scenario 2

Source: Own research.

Scenario 2 (see Table 1 and Fig. 5) represents the employment of staff to the desired value. The rate of change between three chosen variables is very similar, furthermore it is an optimal rate due to Ascension Rate, Promotion Rate and Hiring Rate being set to 1 (this is an equivalent to 100%).

Scenario 3 (see Table 1 and Fig. 6) express the maintenance of desired number of employees during periodic changes in workforce demands. For better understanding we will focus only on Assistants workgroup(similar result could be achieved by performing periodic changes in the number of Directors and Executives). Periodic changes in the workforce will be expressed by switching the value of Desired Assistants between 950 and 1050 person every 6 months (equivalent of twoTime units on the scale of the graph in Fig. 6).As we can see the oscillations are very high, and in the end of each low period the number of Assistants is falling under the value of 950 people. The process of optimization expressed by Scenario 5 is an attempt of reducing the oscillation to an acceptable level.

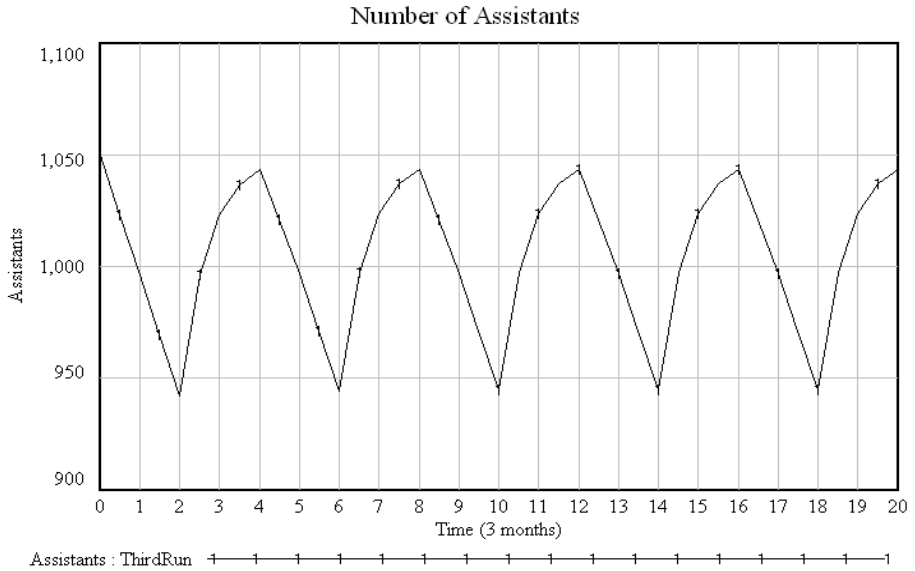

Fig. 6. Graph for Scenario 3

Source: Own research.

Scenario 4 presents the outcome of optimization process focused on finding optimal values of Initial Stage and Initial Rate. This results in discovery of optimal strategy for employment and mechanism of promotion within the workforce. By utilizing the sensitivity analysis and calibration tools of Vensimauthor had found and verified optimality of IS and IR values (see Table 1; Fig. 7 and Fig. 8).

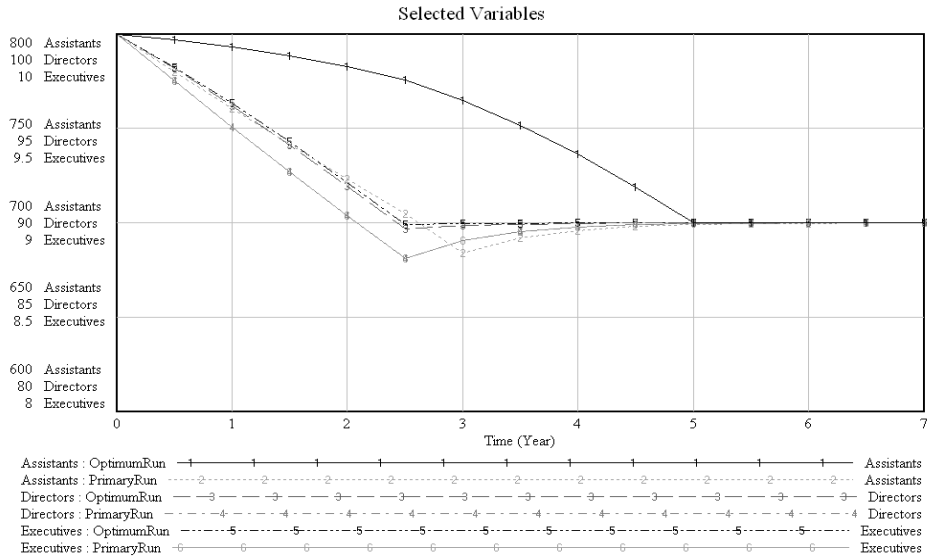

Fig. 7. Graph for Scenario 4

Source: Own research.

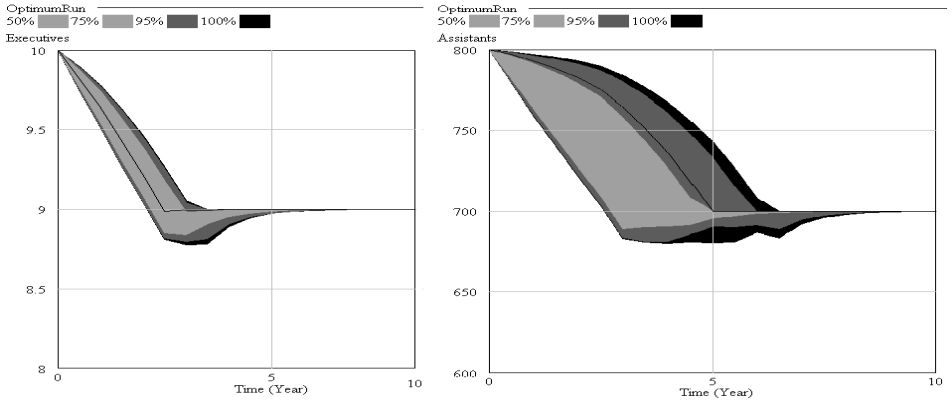

Fig. 8. "Confidence bounds" for variables Executives and Assistants

Source: Own research.

Scenario 5 express the outcome of optimization process focused on reducing the oscillation observed in Scenario 3 (see Fig. 6). By utilizing the calibration tool of Vensim author had found an optimal Initial Rate value (see Table 1 and Fig. 9). In general the fluctuations in the number of employeesare kept within reasonable limits (the number of Assistants never exceeds the boundaries of 950 and 1050 person). Furthermore the seasonal job character has been preserved. In times of lower demand for workforce the number of Assistants falls, but to a sensible level.

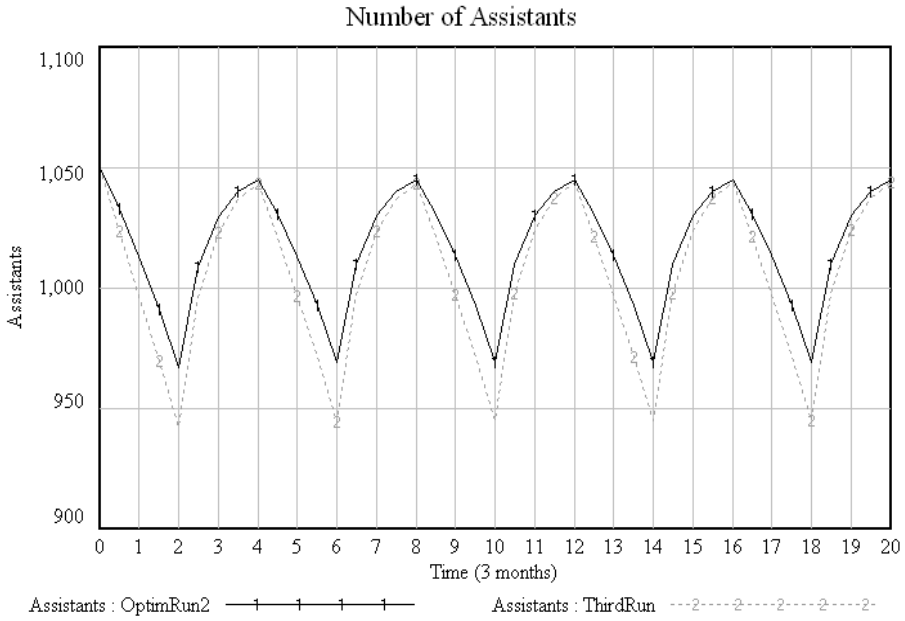

Fig. 9. Graph for Scenario 5

Source: Own research.

Conclusions, ideas and open questions for further investigations

The aim of this paper was the presentation of some new results of author investigation in the area of employment and the mechanism of promotion within the workforce. Each of the first three presented scenarios describes a different aspect of staff management and related problems. The applied simulation language of Vensim software helped in finding some optimum values of related initial parameters. More detailed investigation undertaken by author led to the following conclusions:

- the size of difference between the desired values and current values of Assistant, Directors and Executives parameters has a direct impact on Initial Rate and Initial Stage optimum parameter values;
- minimization of time, when number of employees is under the desired level, can prolong the period of workforce reduction (especially when the difference from previous point is high);
- the proper Initial Rate and Initial Stage parameters selection illustrated as optimum values indicates the possibility of automatic adjustment in Company Hierarchy model − that leaves the field for further research to be done.

Further development of Company Hierarchy model can address more issues, which leaves opportunity for further investigations in the future. For example taking into account the possibility of people dismissal or adding new parameters like cost of maintaining a single employee for a single time unit. Such modifications can completely change the way of perception in the model, which leads to the following open questions that need further research to be done:

- What is the golden mean between the costs incurred by keeping the number of employees within reasonable limits and the profits achieved by fast job reduction?
- How to provide an automatic adjustment in Company Hierarchy model for Assistants, Directors, and Executives Change Ratio in such a way, that the rate of changes in hiring, promotion and ascension will be optimal?
- What other features of employment and mechanism of promotion can be incorporated into the model?

References

Kasperska E., Kasperski A., Bajon T., Marjasz R. (2014), *Visualization for Learning in Organization Based On the Possibilities of Vensim*, Proceedings of Knowledge Management Conference 2014, International Institute for Applied Knowledge Management, Bulgaria, pp. 21-34.

Kasperska E., Kasperski A., Mateja-Losa E. (2013), *Sensitivity Analysis and Optimization On Some Models of Archetypes Using Vensim – Experimental Issue* [in:] M. Pańkowska, H. Sroka, S. Stanek (eds.), *Cognition and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Kasperska E., Kasperski A., Mateja-Losa E. (2013), *Sensitivity Analysis and Optimization On Some Models of Archetypes Using Vensim – Theoretical Issue*, [in:] M. Pańkowska, H. Sroka, S. Stanek (eds.), *Cognition and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Kasperska E., Kasperski A., Mateja-Losa E. (2014), *Simulation and Optimization Experiments On some Model of SD Type – Aspect of Stability and Chaos* [in:] M. Pańkowska, J. Palonka, H. Sroka (eds.), *Ambient Technologies and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Kasperska E., Mateja-Losa E., Bajon T., Marjasz R. (2014), *„Did Napoleon Have to Lose the Waterloo Battle?" – Some Sensitivity Analysis and Optimization Experiments Using Simulation by Vensim* [in:] M. Pańkowska, J. Palonka, H. Sroka (eds.), *Ambient Technologies and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Kasperska E., Mateja-Losa E., Marjasz R. (2013), *Sensitivity Analysis and Optimization for Selected Supply Chain Management Issues in the Company – Using System Dynamics and Vensim* [in:] M. Baran, K. Śliwa (eds.), *System Theories and Practice*, "Journal of Entrepreneurship Management and Innovation", Vol. 9, Issue 2, pp. 29-44.

Lamza-Maronić M., Glavas J., Uroda I. (2014), *The Role of Management in Career Development*, Proceedings of the 37th International Convention on Information and Communication Technology, Electronics and Microelectronics, Opatija; Croatia, May 2014, MIPRO, pp. 669-673.

Marjasz R. (2014), *Wspomaganie logistyki produkcji w firmie z użyciem narzędzi symulacyjnych* [w:] T. Porębska-Miąc, H. Sroka (red.), *Systemy wspomagania organizacji*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Pańkowska M. (2013), *Creativity as the Foundation of Contextual Approach for Enterprise Architecture Design* [in:] M. Pańkowska, H. Sroka, S. Stanek (eds.), *Cognition and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

Ruth M., Hannon B. (2012), *Modelling Dynamic Economic Systems*, from book series: *Modelling Dynamic Systems*, Springer Science+Business Media, LLC.

Stanek S., Sroka H., Kostrubala S., Twardowski Z. (2008), *A Ubiquitous DSS in Training Corporate Executive Staff* [in:] P. Zaraté, J. P. Belaud, G. Camilleri, F. Ravat (eds.), *Collaborative Decision Making: Perspectives and Challenges 2008*, IOS Press Netherlands, pp. 449-458.

Trąbka J. (2013), *Specific Analytical Perspectives in the Modelling of Workflow Systems* [in:] M. Pańkowska, H. Sroka, S. Stanek (eds.), *Cognition and Creativity Support Systems*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice.

[www1] Vensim User's Guide Version 6, Ventana Systems, Inc. 2014, http://www.vensim.com/documentation /index.html (accessed: 17.05.2015).

PRÓBA ZNALEZIENIA OPTYMALNEJ STRATEGII ZATRUDNIANIA WRAZ Z MECHANIZMEM AWANSU PRACOWNIKÓW – SYMULACJA Z WYKORZYSTANIEM APLIKACJI VENSIM

Streszczenie: Obecnie obserwujemy wysoką dynamikę w organizacjach. Wymieńmy tylko kilka kluczowych czynników, takich jak: selekcja, rozwój zasobów ludzkich, zmiany w polityce firmy i wieku emerytalnego. Wszystkie te kwestie mają wpływ na proces zatrudniania i mechanizm awansu w firmie. Aby pokazać złożoność problemów związanych z zarządzaniem zasobami ludzkimi, autor artykułu stworzył model dynamiki systemowej w programie Vensim. Dzięki wykorzystaniu narzędzi aplikacji Vensim – takich jak: symulacja, analiza wrażliwości i kalibracja – możemy poznać i zrozumieć relacje pomiędzy grupami pracowników, a tym samym podjąć próbę znalezienia odpowiednich rozwiązań dla właściwego zatrudniania i zarządzania zasobami ludzkimi. Rezultaty badań i podjętej optymalizacji prezentowane są wraz z pytaniami otwartymi dla dalszej pracy badawczej.

Słowa kluczowe: symulacja, dynamika systemowa, kalibracja, Vensim.