MODELING AND ANALYSIS OF EMPLOYEE PERFORMANCE MANAGEMENT BASED ON SYSTEM DYNAMICS APPROACH

by

Samet ULUTAŞ

B. S., Industrial Engineering, Istanbul Technical University, 2010

Submitted to the Institute for Graduate Studies in

Science and Engineering in partial fulfillment of

the requirements for the degree of

Master of Science

Graduate Program in Industrial Engineering

Boğaziçi University

2013

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis supervisor, Prof. Ali Rıza Kaylan, for his guidance, support, and patience.

I gratefully thank Prof. Aslı Sencer and Assist. Prof. Gönenç Yücel for their valuable comments on this thesis and their advice that will benefit my future research.

I owe special thanks to Rasim Mahmutoğulları, Feridun Aktaş, Seval Yazıcı, Eylem Gökçay, Seniha Koçyiğit and Gizem Acarlar Bayram in XT.In addition, I appreciate TÜBİTAK for their financial support.

I am deeply grateful to my fiancée Ayşem Yorulmaz who has supported me anytime and kept my motivation at the highest point. I would like to thank to my friends Özlem, Övünç, Fatih, Kadir, Gökhan, Fatma, Şükrü, Dinç, Tolga, and Gökberk for their help to my thesis.

Finally, I would like to thank my family for supporting me in every though condition, for helping me by their experience and inspiration.

This thesis is dedicated to researchers who try to makeboth managers and employees working together happy.

ABSTRACT

MODELING AND ANALYSIS OF EMPLOYEE PERFORMANCE MANAGEMENT BASED ON SYSTEM DYNAMICS APPROACH

Since human capital is gaining importance as a key driver of competitive advantage, there is an increasing interest for the value of Human Resources (HR). Thus, decision makers in the HR field need to focus on the critical issue of how to improve employee performance. The aim of this study is to explore and compare the performance of different employee performance management policiesby using System Dynamics (SD) simulation approach. Initially, the influential factors affecting employee performance are identified by using a Structural Equation Model (SEM), based on the data obtained from an Information Technology (IT) company. These factors are used as inputs in a SD model together with other variables, such as productivity andcost. The SD model is used to analyze the effects of using different performance evaluation policies on the realized performance scores of the employees, their overall productivity, their motivation level, overtime usage, employee turnover rate and HR related costs.With this motivation, the current performance evaluation system of the IT Company –which totally ignores the productivity levels of the employees– is modeled in a SD environment and its validity is checked by using structural and behavioral validity tests. Next, two new performance evaluation policies are provided to improve the poor performance of the current system. In the first policy, performance scores are created according to solely measured productivity of the employees; and in the second policy, performance scores are created according to partial productivity of the employees. The effect of the performance evaluation policies on the realized performances of the system are analyzed and compared under four scenarios generated by considering possible external events or introducing new variable relationships to the models.

ÖZET

SİSTEM DİNAMİĞİ YAKLAŞIMIYLA ÇALIŞANLARIN PERFORMANS YÖNETİMİNİN MODELLENMESİ VE ANALİZİ

Örgütlerdeki stratejik üstünlüğü sağlayan temel kaynağın insan sermayesi olması dolayısıyla, strateji odaklı insan kaynakları sistemlerinin yaratabileceği değere olan ilgi artmıştır. Bu yüzden insan kaynakları alanındaki karar vericiler kritik bir konu olan çalışan performansının artırılması konusuna odaklanma ihtiyacı duymaktadır. Bu çalışmanın amacı birbirinden farklı performans yönetim politikalarını Sistem Dinamiği (SD) yaklaşımıyla araştırmak ve karşılaştırmaktır.Birinci aşamada bir Bilgi Teknolojileri (BT) şirketinin verileri kullanılarak, çalışan performansını etkileyen faktörler yapısal denklem modelleme tekniğiyletanımlanmıştır. Bu faktörler üretkenlik ve maliyet gibi diğer faktörlerle de birleştirilerek sistem dinamiği modeline girdi oluşturmuştur. İkinci aşamada ise, kurulan SD modeli aracılığıyla farklı performans yönetim politikalarının çalışan performansı, genel üretkenlik, motivasyon seviyesi, fazla mesai kullanımı çalışan devri ve insan kaynakları maliyeti üzerine etkisi analiz edilmiştir. Bu amaç doğrultusunda, söz konusu BT şirketinin üretkenliğini tamamen göz ardı eden mevcut performans değerlendirme sistemi süreci dinamiği ortamında modellenmiş, yapısal ve davranışsal geçerlilik yöntemleri kullanılarak modelin geçerliliği test edilmiştir. Bunun yanı sıra, performansı zayıf olan mevcut sistemi geliştirmek için iki yeni performans değerlendirme politikası önerilmiştir. İlk politikada performans skorları tamamen üretkenliğe göre yaratılmış, ikinci politikada ise performans skorları kısmi olarak üretkenliğe göre yaratılmıştır. Performans değerlendirme politikalarının sistemin performansına etkileri, olası dış etkenler düşünülerek veya yeni değişken ilişkileri tanıtılarak oluşturulan dört senaryo için analiz edilmiş ve karşılaştırılmıştır.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii
ABSTRACT iv
ÖZET v
LIST OF FIGURES viii
LIST OF TABLES xiv
LIST OF SYMBOLS xv
LIST OF ACRONYMS/ABBREVIATIONS xvi
1. INTRODUCTION 1
2. LITERATURE REVIEW 3
3. METHODOLOGY 7
3.1. Structural Equation Modeling 7
3.2. Steps in SEM 8
3.2.1. Model Specification 8
3.2.2. Model Identification 9
3.2.3. Model Estimation 9
3.2.4. Interpretation of Fit Measures 11
3.2.5. Modification of the Model 14
3.3. System Dynamics 15
3.3.1. Problem description and studying objectives 16
3.3.2. Conceptual model and data analysis 16
3.3.3. Construction of the formal model System Dynamics 17
3.3.4. Model testing and validation System Dynamics 17
3.3.5. Scenario and policy experiments 17
3.3.6. Policy recommendations and conclusions 17
3.3.7. Implementation 17
4. MODEL CONSTRUCTION AND ANALYSIS 18
4.1. Description of the Current Performance Evaluation System 18
4.2. Employee Performance Model 19
4.3. Preliminary Data Analysis 22
4.4. Model for SEM Phase 24

4.5. Model for SD Phase 28
4.5.1. Productivity part 34
4.5.2. Motivation part 34
4.5.3. Given performance scores part 34
4.5.4. Employee pool part 34
4.5.5. Employee part 35
4.5.6. Profit part 35
4.5.7. Throughput time 35
4.5.8. Project workload part 35
4.5.9. Turnover part 35
4.5.10. Capacity part 36
5. STRUCTURE AND BEHAVIOR VALIDITY OF THE SD MODEL 37
5.1. Structure validity 37
5.1.1. Extreme Condition Tests 37
5.1.2. Sensitivity Analysis 51
5.2. Behavior Validity 58
6. BASE BEHAVIOR ANALYSIS 61
7. SCENARIO AND POLICY ANALYSIS FOR SD MODEL 70
7.1. Scenario 1: Available candidates decrease 71
7.2. Scenario 2: New project amount per day suddenly decreases 73
7.3. Scenario 3: Increase workload while avoiding motivation decrease 75
7.4. Scenario 4: Gap between productivity based performance and supervisor given performance affects turnover rate directly 77
7.5. Policy 1: Managers base the performance scores according to productivity only 78
7.6. Policy 2: If gap increases, managers tend to increase given performance scores 80
7.7. Scenario & Policy Matrix 82
8. CONCLUSION & FURTHER STUDIES 87
APPENDIX A: EQUATIONS FOR SYSTEM DYNAMICS MODEL 92
APPENDIX B: STOCK-FLOW DIAGRAM OF THE SD MODEL 104
REFERENCES 105

LIST OF FIGURES

Figure 4.1. The steps of the employee performance management. 21

Figure 4.2. Age distribution of employees. 22

Figure 4.3. Performance score distribution. 23

Figure 4.4. Standardized estimates for final model. 25

Figure 4.5. Causal loop diagram of overall model. 29

Figure 4.6. Given performance scores and productivity. 30

Figure 4.7. Turnover productivity loop. 30

Figure 4.8. Productivity-overtime loop. 31

Figure 4.9. Productivity-workload loop. 31

Figure 4.10. Overtime throughput time loop. 32

Figure 4.11. Hiring project workload loop. 32

Figure 4.12. Given performance score-cost loop. 32

Figure 4.13. Performance scores gap based productivity loop. 33

Figure 4.14. Performance scores gap based turnover loop. 33

Figure 5.1. Experienced employees' productivity. 38

Figure 5.2. Total number of employee change in extreme condition 2. 39

Figure 5.3. Overtime change in extreme condition. 39

Figure 5.4. Project workload change in extreme condition. 40

Figure 5.5. Total number of employee change in extreme condition. 40

Figure 5.6. Experienced employees' productivity change in extreme condition..........41

Figure 5.7. Total number of employees change in extreme condition. 41

Figure 5.8. Performance score change in extreme condition......................................42

Figure 5.9. Productivity based score change in extreme condition. 42

Figure 5.10. Given performance score change in extreme condition. 43

Figure 5.11. Project workload change in extreme condition. 43

Figure 5.12. Total number of employee change in extreme condition. 44

Figure 5.13. Overtime change in extreme condition. 44

Figure 5.14. Motivation change in extreme condition..45

Figure 5.15. Total number of employee change in extreme condition. 45

Figure 5.16. Overtime change in extreme condition. 46

Figure 5.17. Daily hiring rate change in extreme condition. 47

Figure 5.18. Total number of employee change in extreme condition. 47

Figure 5.19. Project workload change in extreme condition. 48

Figure 5.20. Overtime change in extreme condition. 48

Figure 5.21. Average cost of per man day. 49

Figure 5.22. Project outflow. 50

Figure 5.23. Overtime. 50

Figure 5.24. Available Days. 51

Figure 5.25. Total employee sensitiveness according to training days. 53

Figure 5.26. Average cost of a project sensitivity to the training days parameter.......... 53

Figure 5.27. Experienced employees’ productivity according to training days. 54

Figure 5.28. Motivation sensitiveness. 54

Figure 5.29. Total number of employee according to target throughput time. 55

Figure 5.30. Total number of employee according to overtime adjustment time. 55

Figure 5.31. Motivation. 56

Figure 5.32. Gap of scores. 56

Figure 5.33. Total number of employees. 57

Figure 5.34. Total number of employees. 57

Figure 5.35. Simulated given performance scores vs real given performance scores. ... 59

Figure 5.36. Simulated overtime amount vs real overtime amount. 59

Figure 5.37. Total employee change for last 5 years. 60

Figure 6.1. Gap between given performance score and productivity-based score. 61

Figure 6.2. Given performance scores and productivity based scores. 62

Figure 6.3. Motivation levels. 63

Figure 6.4. Overtime change. 63

Figure 6.5. Effect of throughput time ratio on overtime. 64

Figure 6.6. Expected to desired ratio of throughput time. 64

Figure 6.7. Project workload and normal man capacity. 65

Figure 6.8. Total number of employees. 65

Figure 6.9. Experienced and inexperienced employees. 66

Figure 6.10. Hires and Resignations. 66

Figure 6.11. Effect of throughput time (with overtime) ratio on hiring. 67

Figure 6.12. Average experience of XT. 67

Figure 6.13. Productivity. 68

Figure 6.14. Average cost per man day. 69

Figure 7.1. Total number of employees. 71

Figure 7.2. Overtime change. 72

Figure 7.3. Average cost per man day. 72

Figure 7.4. Productivity. 73

Figure 7.5. Project workload. 74

Figure 7.6. Total Employee. 74

Figure 7.7. Motivation. 75

Figure 7.8. Gap of scores. 75

Figure 7.9. Motivation change. 76

Figure 7.10. Average cost of per man day. 77

Figure 7.11. Turnover rate change. 77

Figure 7.12. Motivation change. 78

Figure 7.13. Given performance score change. 79

Figure 7.14. Turnover rate change. 79

Figure 7.15. Average cost per man day. 80

Figure 7.16. Given performance score. 81

Figure 7.17. Motivation. 81

Figure 7.18. Average cost per man day. 82

Figure 7.19 Comparison of KPIs under different policies and scenarios with reference to the base run. 86

Figure B.1. Stock-flow diagram of SD model...104

LIST OF TABLES

Table 1.1. The mobility of IT employees in Turkey. 2

Table 4.1. Candidate factors for the employee performance....... 19

Table 4.2. Scale of performance scores....... 23

Table 4.3. Absolute fit of the final model. 25

Table 4.4. Relative fit of the final model. 26

Table 4.5. Comparison with final model....... 27

Table 4.6. Measure based on population discrepancy....... 27

Table 4.7. Hoelter's critical N for final model....... 28

Table 4.8. Unstandardized regression weights....... 28

Table 5.1. Equation-tested parameters under extreme conditions....... 52

Table 5.2. Sensitively analyzed parameters. 58

Table 7.1 Comparison of KPIs under different policies and scenarios with reference to the base run. 85

Table 8.1 Comparison of KPIs under different scenarios with reference to the base run....... 90

Table 8.2 Comparison of KPIs under different policies with reference to the base run. 91

LIST OF SYMBOLS

F_{ML}	Maximum likelihood function
F_0	Population discrepancy function
t	Total number of independent parameters estimated
x^2	Chi-square

LIST OF ACRONYMS/ABBREVIATIONS

AGFI	Adjusted Goodness of Fit Index
AHP	Analytical Hierarchic Process
AMOS	Analysis of Moment Structures
BT	Bilgi Teknolojileri
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CLD	Causal Loop Diagram
CMIN	Chi-square Fit Statistics
CMIN/DF	Relative Chi-Square
CN	Hoelter's critical N is the largest sample size
CR	Critical Ratio
DF	Degree of Freedom
GFI	Goodness of Fit Index
GLM	Generalized Linear Model
HI 90	Upper Boundary of the 90% Confidence Interval
HR	Human Resources
IFI	Incremental Fit Index
KPI	Key Performance Indicators

LO 90	Lower Boundary of the 90% Confidence Interval
LR	Likelihood Ratio
NFI	Normal Fit Index
NPAR	Number of Parameters
PCLOSE	P-value for test of RMSEA
PGFI	Parsimony Goodness of Fit Index
R&D	Research and Development
RFI	Relative Fit Index
RMR	Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation
SD	System Dynamics
SE	Standard Error
SEM	Structural Equation Modeling
TLI	Tucker-Lewis Index
XB	X Bank
XT	X Technology Company
VIF	Variance Inflation Factor

1. INTRODUCTION

The banking sector is becoming increasingly important in a globalizing world. Furthermore, the level of significance and impact in this sector is even higher for developing countries since the growth rates are faster. Turkeywitnessed a damaging financial crisis in 2001. This crisis caused Turkish government to take critical actions. The government immediately started to regulate the banking industry. Because of theseregulations, private banks made more investments in Information Technology (IT) in order to cope with those regulations. Due to this high IT investment, the IT related labor populations for the leading banks have now reached around 1000 employeesin 2013. With substantial investments and hiring of many key talented people in IT departments, the Turkish bank industry has gained a serious growth. On the other hand, in today's world, it is essential to keep the talented people in the organization to sustain the growth speed. Because those promising employees have high expectations and high mobility, it is difficult to keep them in the organizations.

The aim of this thesis is to investigate the governing factors affecting employee performance scoresgiven by supervisors and analyzing the side effects of gap between the given performance scores and the productivity based performance scores obtained by the proposed model. The scores has a direct impact on promotions and salary increase. However, there is a significant discrepancy between productivity and given performance scores in the company investigated. In this study, we will explore that difference more in depthand indicate important negative results of that gap. In order to illustrate the impact of this discrepancy, a leading bank's IT Company, referred as XT, is assessed and important strategies are proposed based on the results of a System Dynamics(SD) model.

The high mobility rate of IT employees in Turkey can be seen inTable 1.1[1]. The report was preparedby the Computer Engineering Main Division of Turkish Electrical Engineering Chamber. The commission surveyed 483 people and 85% of the participants were under the age of 35. The results clearly show that the mobility rate is extremely high for IT sector, in spite of the young age of the workforce.

Table 1.1. The mobility of IT employees in Turkey.

Question: How many times have you changed your job?

Never	18%
Once	30%
Twice	27%
Three times	12%
Four times	6%
Five time	3%
More than six times	4%

This thesis is organized intoeightchapters. The following chaptercontains thedetailed literature review.The previous studiesare not only related to the factors included in the model, but also explain HR models using SD approaches. In Chapter 3, both SD and Structural Equation Modeling (SEM) methodologies are introduced. Chapter 4 represents the main SD model and the sub-structural equation model. Three inputs obtained by SEM are integrated to the SD model. These variables are number of projects, average experience, and overtime amount. This section concentrates on issues related to productivity, motivation andturnover. Chapter 5 containsall validation tests. Equations are tested for extreme values and parameters are analyzed for sensitivity. Moreover, three variables are validated behaviorally. After validation, Chapter 6 introduces the base behavior. The model output reflecting the base behavior are in agreement with the real-life data. In Chapter 7,different scenarios and policies are analyzed in order to obtain the most beneficial results for decision makers, such as merging with a new company and creating the employee performance scores according to the real productivity. Finally, Chapter 8 summaries the study and recommends increasing the number of companies analyzed and adding new parameters to the model such as employee satisfaction, talent and ability.

2. LITERATURE REVIEW

Employee performance management is a critical issueinachieving company sustainability. Healthy performance management is realizable through accurate assessment of employee performance. In order to evaluate the employee performance, managers should be aware of the factors that affect performance. Employee performance is influenced by numerous factors such as budget limitation, profitability of last term, and overtime effort. It is provided that focusing solely on those variables and neglecting productivity issues may result indecreased productivity and increased employee turnover rates.

In this section, related literature is extensively reviewed to see the relationship of performance indicators such as trainings, motivation, job satisfaction, days-off percentage, and work experience. Afterwards, several modeling approaches in human resources management field will be cited.

Productivity is affected by training[2]. Moreover, training has an important effect on job performance[3]. These results are repeated with another study with similar results [4].

Motivation, which allows employees to deal with difficult conditions and keep working at a high level, is another important factor affecting employee productivity. It is indicated thatmotivation positively affects the productivity [5].

Knowledge about a job is gradually accumulated as the employee gathers further work experience. Work experience suggests that the cumulative knowledge about a job increases day by day while maintaining employment.The relationships between work experience and job performance is investigated.The results show that even thoughthere is a significant relationship between the aforementionedvariables, the level of significance is quite different for each of thescenarios since the task relevancy isanother important factor affecting the work experience and the job performance relation [6].

Productivity is not only affected by training, motivation and work experience. Human resourcesmanagement practices, such as the days-off policy and other reward and recognition policies are highly important for productivity. It is indicated that human resourcesmanagement practices highly affect organizational performance and productivity [7].

Another candidatevariable on productivity is overtime amount. If people work for more than their scheduled hours, the resultant fatigue leads to loss of productivity. The overtime productivity index is mentioned in the literature and it is indicated that overtime decreases the productivity [8]. Moreover, another author carries out different investigation with similar results [9]. However, recently, it is mentioned that there is no significant negative impact of overload on job satisfaction [10].

Although the available literature clearly indicates the factors affecting the productivity, the real performance evaluation in the organizations may be different. Hence, this study models the real productivity and performance scoresgiven by the managers.

Another factorconsidered in our study is motivation. It is indicated that performance appraisal satisfaction increases the motivation that decreases the turnover tendency [11]. It is stated that performance appraisal policies may decrease job satisfaction, which in turn increase the turnover intentions [12].

The above discussions in the literature specify that increasing the average performance scores is not sufficient to motivate people.Actually high motivation levels may not be attained unless the employees approve the performance management system. For instance, it is suggested in this study that, the performance management system should contain goals for each employee and they should be set at the beginning of the related term. Moreover, annual leave rights of the employees should be improved to increase the motivation and decrease the turnover rates.

Aforementioned factors will be employed in the model construction in Chapter 4. In the remaining part of the literature review, HR studies using different tools and techniques such as balanced scorecard, data envelopment analysis, and system dynamics approach are briefly summarized.

The balanced scorecard (BSC) is a performance measurement system [13]. According to creators of it, a BSC addresses shortcomings of traditional performance systems that relied solely on financial measures. To overcome this limitation, the same authors introduced three additional measurement categories that cover non-financial aspects of performance. The 'balance' of the scorecard is reflected in its mix of outcome measures and performance indicators, and of financial and non-financial measures.

A strategy map has been developed as a complementary toolin BSC evaluations [14]. A strategy map links measures of process performance, also referred as Key Performance Indicators (KPI), together in a causal chain that continues throughout all four perspectives, includingmeasures of organizational learning,and growth influence of internal business processes. Both in turn, act upon measures of the customer perspective that ultimately drive financial measures. Causal chains or causal diagrams provide a medium by which mental models and assumptions are generated. In fact, one of the hidden strengths of BSC is itsforcing the management teams to explore the beliefs and assumptions underpinning their strategy.

In spite of the several aforementioned strengths of the BSC, a number of weaknesses have been reported in the literature. It has been stated repeatedly that the BSC concept provides no mechanism for maintaining the relevance of the small set of measures devoted to a functional departmentwith the overall organizational goals and strategy [15]. The existence of such causality in most BSCs currently being used is questioned. Furthermore, the relationship is more complex than simply looking at different measures. The linkages between them must also be investigated.

The other indicated disadvantages of BSC is bridging different fields. For example, what should be done when performance indicators of different fields counteract or thwart each other? The bridging to be performed can be both horizontal and hierarchical. Regarding the former, it is stated that the BSC concept fails to identify performance measurement as a two way process, as it focuses primarily on top-down performance measurement [16]. It is indicated that BSCs have a lack of integration between the top-level, strategic scorecard, and operational-level measures [17]. Regarding the latter, it is discussed that BSCs do not consider the extended value chain in which employee and supplier contributions are also highlighted [16]. It is argued that the BSC is not able to answer one of the most fundamental questions for managers: what are the competitors doing? [18]. Thus, to summarize, the advantages of checking just a few numbers related to different fields may become a disadvantage when there are many relevant fields to search.

A system dynamics is offered approach to develop a BSC in order to overcome some of its limitations[19]. Namely, BSCs focus on unidirectional causality and are unable to distinguish delays between actions and their impact on performance. In addition, BSCs have a shortage in validation capability, integrate strategy insufficiently with operational measures, and suffer from internal biases. With this motivation, they work on a case study from the insurance sector where the BSC approach is applied. They state that developing a BSC with system dynamics is a promising approach to supplement existing BSC frameworks.

BSC can assess the overall performance of an organization, but it is not a tool to evaluate the individual's performances. A data envelopment analysis method is applied to fairly assess employee's performances [21]. They determine that there are four important factors that affect the employee performances such as job knowledge, customer relations, work habits, and interpersonal relations. In their study, years of experience of employees are operationalized as a representation of job knowledge and work habits are measured with percentage of employees' attendance. The degree the employee takes the initiative to meet internal and external customers is represented in a timely and courteous manner. Interpersonal relations refer to the effect that the employee has on others, including their ability to establish and maintain positive and productive working relationships. Employees with high levels of interpersonal skills tend to inspire goodwill, cooperation, and mutual respects, accept and acknowledge suggestions, work cooperatively and effectively with others to achieve unit goals. The conflict and misunderstanding with peers, clients, supervisors, and others are often interpreted as having low interpersonal skills.

3. METHODOLOGY

Our primary purpose in this thesis is to investigate the underlying dimensions of the employee performance construct. As employee performance is not directly observable, we modeled employee performance management with system dynamics approach. In addition, we added inputs from the structural equation model. This section aims to give a broad insight into structural equation and system dynamics methodologies respectively.

3.1. Structural Equation Modeling

Structural equation model is a general statistical procedure for multi-equation systems. This model implicates continuous latent variables, multiple indicators of concepts, errors of measurement, errors in equations, and observed variables, which are continuous, ordinal, binary, or censored [20].

While SEM operates similar to multiple regressions, it is more effective with regards to the modeling of interactions, nonlinearities, correlated input variables, measurement error, correlated error terms, latent variables each measured by multiple indicators. One or more latent dependents each possess multiple indicators. SEM could be used as a more effective alternative to multiple regression, path analysis, factor analysis, and analysis of covariance because SEM is an extension of the multiple regressions and factor analysis. SEM defines relations between variables. SEM also presents some important and supplementary benefits over these mentioned techniques including a valid way to deal with multicollinearity, and methods considering the unreliability of applied data.

Even though SEMcan be compared to multiple regression, SEM has several uniqueadvantages. For instance, SEM contains more flexible assumptions, applies confirmatory factor analysis to decrease measurement error by having multiple indicators per latent variable, the attraction of SEM's graphical modeling interface, the desirability of testing models overall rather than coefficients individually, the capability to test models with multiple dependents, the capability to model mediating variables and the error terms, the capability to test coefficients across multiple between-subject groups, and capability to deal with difficult data such as time series with auto-correlated error, non-normal data, and incomplete data [22].

The real power of SEM stems from using latent variables, whichcannot be modeled by other techniques. As it is proposed in this thesis, if we are interested in measuring a construct like employee performance we must measure its effects. The measurement of a hypothetical construct is achieved indirectly through one or more observable indicators, whichare responses to questionnaire items that are assumed to represent the construct adequately. However, in this study, we obtain the observed data from the human resources department rather than gathering through surveys. Even though carrying out a survey was a possibility, this could have created another problem to use them together with additional data set obtained for the previous year. Thus, we did not see meritin combining data from two different periods that could potentially lead to an inaccurate analysis.

3.2. Steps in SEM

An analysis that uses SEM has several components which are specified as follows and examined in the next subsections [24].

(i) Model specification,
(ii) Identification,
(iii) Estimation,
(iv) Model-data fit assessment,
(v) Respecification

3.2.1. Model Specification

Describing the hypothesized relations between all latent and observed variables is the first step. Through the model specification process, the researcher asserts which effects are null, which are fixed to a constant (usually 1.0), and which vary. Variable effects are presented as arrows in the model, while null effects presented as an absence of error. Fixed effects usually reflect either effects whose parameter has been established in the literature or more commonly, effects set to 1.0 to establish the metric for a latent variable. In SEM, each unobserved latent variable must be explicitly identified as a metric, which is a measurement range. This is normally used by constraining one of the paths the latent variable to one of its indicators variables, as by assigning the value of 1.0 to this path. When dealing with confirmatory factor analysis, for each latent factor, we can estimate the loadings given a fixed variance for the latent factor, which standardizes the scale of the factor to a z-score, or we can estimate the factor variance given at least one fixed loading. Loadings are a function of the variance of the latent factor. Hence, one solution here is to fix the variance of all factors, to one, and estimate all factors loadings. In SEM, it is more customary to use the factor variances.

3.2.2. Model Identification

SEM programs need a critical number of known correlations or covariances as inputs in order to compose a sensible set of results. Each equation should also be properly identified. Identification represents the concept that there is at least one unique solution for each parameter estimate in a structural equation model.

Degrees of freedom is equal to sample moments minus free parameters. The number of sample moments equals the number of variances plus covariances of indicator variables, for n indicator variables, this equals n[n+1]/2. The number of free parameters equals the sum of the number of error variances plus the number of factor variances plus the number of regression coefficients, not counting those constrained to be 1's.

3.2.3. Model Estimation

When the model is built, estimates of the free parameters have to be gathered from a set of observed data. The easiest way to gather these estimates is to use simple regression techniques to calculate the values of relations between variables in the model. However, computer software packages use iterative formulas. Normally, the process requires creating a series of estimates of the free parameters that indicate a covariance matrix like the spotted one. The indicated covariance matrix is the covariance matrix that would result if the values of the anchored parameters and current estimates of the free parameters were substitutive into the structural equations that make up the defined model. Thus, the program starts with a set of start values that are in some cases estimated from the data or can be a set of revert values; the indicated covariance matrix is estimated and compared to the actual covariance matrix. The differences between these matrices are stored in a residual matrix.

This matrix symbolizes the error between the model and the real data. Estimates are changed to attempt to minimize the values in the residual matrix. When the residuals cannot be reduced any further, the iterationsis completed. The residuals are indicated as a single value that represents the degree of correspondence between the implied covariance matrix and the actual covariance matrix. This value is sometimes called the value of the fitting function. The discrepancy function's role is to quantify the discrepancy.

The reason statisticians favor to minimize F_{ML} rather than some other criterion is because F_{ML} has useful statistical properties. Specifically, it is possible to compute estimated standard errors for each path coefficients and to perform traditional tests of statistical significance for the path coefficients using these standard errors. In addition, F_{ML} can be used to define a variety of goodness-of-fit indices for evaluating overall model fit.

If the researcher does not have a good reason, this default should be taken even if other methods are provided by modeling software. MLE makes estimates based on maximizing the probability or likelihood that the monitored covariances are drawn from a population assumed to be the same as that reflected in the coefficient estimates. That is, MLE selects estimates, which have the greatest chance of reproducing the observed data.

It should be noted that MLE is an iterative procedure in which either the researcher or the computer must assign initial starting values for the estimates. In most cases, SEM software programs produce good starting values automatically and users need not to define starting values for any free parameter. With two stage least squares, generalized least squares, instrumental variables, and diagonally weighted least squares, it is possible to obtain other types of estimators. These are often used to obtain starting values needed by algorithms that compute ML solutions, or when the assumptions of multivariate normality areinappropriate.

The statistical power, or the capability to detect and reject a poor model, is specifically critical in SEM analysis. Opposed to the traditional hypothesis testing, the goal in SEM analysis is to yield a non-significant result. The reason is that the researcher is trying to develop a theoretical model that accounts for all the covariances among the measured items. Thus, a non-significant difference between the implied covariances derived from the parameter estimates for the model and those of the sample data is argued to be suggestive of support for the model.

The concept of power in statistical theory is defined as the probability of rejecting the null hypothesis given that the null hypothesis is not correct. In context of structural equation modeling, the null hypothesis is explained by the specification of the fixed and free elements in pertinent parameter matrices of the model equations. The specification of fixed and free elements symbolizes the researchers' initial hypothesis concerning the direct and indirectputativeeffectsamong hidden variables if they exist. The null hypothesis is analyzed by forming a discrepancy function between the model-implied set of moments and the sample moments with the aim to derive a test statistics that has a known distribution. Later, the obtained value of the test statistic is compared against tabled values in order to make a decision with regard to the null hypothesis.

In the body of structural equation modeling, the assessment of power is complicated. Unlike basic procedures such as the t-test or ANOVA wherein alternative hypotheses apply to only a few parameters, structural equation modeling has substantially more parameters. Each fixed parameter in the model is likely false and each can take on, in principle, an unlimited number of alternative values. Therefore, each fixed parameter needs to be conceptually evaluated one at a time.

3.2.4. Interpretation of Fit Measures

The assessment of the overall fit of model to the data is concerned by part of model evaluation. The goodness of fit of the whole model may be formed by means of four measures of overall fit includingthe chi-square (x^2), the Root Mean Square Residuals (RMR), the Goodness-of-Fit Index (GFI) and the Adjusted Goodness-of-Fit Index (AGFI). Goodness of fit test determines if the model being tested should be accepted or rejected. These overall fit tests do not establish that particular paths within the model are significant. This set of goodness-of-fit measures is based on fitting the model to sample moments, which means to compare the observed covariance matrix to the one estimated on the assumption that the model being tested is true. These measures, therefore, apply the conventional discrepancy function.

The x^2 measure is (N-1) times the minimum value of the fit function for the specified model. If the model is correct and the sample size is sufficiently large, the x^2 measure may be applied as a test statistic for testing the model against the alternative that it is unconstrained. The degrees of freedom for x^2 are equal to [1/2](n)(n+1)-t, where n is the number of observed variables analyzed and t is the total number of independent parameters estimated. The p-value reported by the program is the probability level of x^2, that is, the probability of obtaining a x^2 value larger than the value actually obtained, given that the model is correct.

The chi-square value should not be significant if there is a good model fit, while significant chi-square indicates lack of satisfactory model fit. The researcher's model is rejected if model's chi-square is smaller than.05.

The x^2 measure is sensitive to sample size and highlysensitive to departures from multivariate normality of the observed variables. In large samples, departures from normality tend to increasex^2. One reasonable way to use x^2 measures in comparative model fitting is to use x^2-differences in the following way. If a value of x^2 is obtained that is large compared to the number of degrees of freedom, the fit may be examined and assessed by an inspection of the fitted residuals, the standardized residuals, and the modification indices. Often these quantities will suggest ways to relax the model by introducing more parameters. The new model usually yields a smallerx^2. The changes made in the model that represent areal improvement are signaled by a large drop in x^2, compared the difference in degrees of freedom. Since x^2 is influenced by the sample size, model evaluations with extremely large sample sizes will almost lead to model rejection. Chi-square should be used to make the fit dependent on sample size relative.

The chi-square fit index divided by degrees of freedom is relative to chi-square, also known asnormal chi-square. Different researchers considers that relative chi-squares high as 5 means a model adequate fit. The relative chi-square is listed as CMIN/DF in AMOS software.

If the RMR is close to zero for a model being tested, then the model is a better fit. A RMR of zero indicates a perfect fit. RMR residuals are the coefficients, which result from taking the square root of the mean of the squared residuals. Fitted residuals result from subtracting the sample covariance matrix from the fitted or estimated covariance matrix. In the sample covariance matrix, RMR is a measure of the average of the fitted residuals and can only be inferred in relation to the sizes of the observed variances and covariances in the sample covariance matrix.

GFI varies from 0 to 1, but theoretically can yield meaningless negative values. A large sample size pushes GFI up. When GFI cannot be interpreted as percent of error explained by the model, analogies are made to R^2. That is, R^2 in multiple regression deals with error variances, whereas GFI deals with error in reproducing the variance-covariance matrix. GFI should be equal to or greater than .90 to accept the model by convention.

AGFI which considers mean squares instead of total sums of squares in the numerator and denominator of 1-GFI is a variant of GFI. It, too, varies from 0 to 1, but theoretically can yield meaningless negative values. AGFI>1.0 is associated models with perfect fit. AGFI<0 is associated with models with extremely poor fit, or based on small sample size. AGFI should also be at least .90.

Alternative class of fit indices measure howthe model fits better as compared to a baseline modelthat is usually the independence model. The first indices of this are TLI and NFI. Other variations of these have been proposed as RFI, IFI and CFI. These indices are supposed to lie between 0 and 1, but values outside this interval can occur, since the independence model almost always has a huge chi-square, one often obtains values very close to 1.

NFI, also known as Delta1, is the normed fit index. It is an alternative to CFI, but it does not require making chi-square assumptions. It varies from 0 to 1, with 1 equaling perfect fit. NFI reflects the proportion by which the researcher's model improves fit compared to the null model. It is indicated that the model should be re-specified if the NFI values below .90.

RFI, also known as Rho1, is the relative fit index. It is not guaranteed vary from 0 to 1. It is indicated that a good fit if RFI is close to 1.

IFI, also known as Delta2, is the incremental fit index, and should be equal to or greater than .90 to accept the model.

TLI is the Tucker-Lewis index. It is similar to NFI, but penalizes for model complexity. TLI is not guaranteed to vary from 0 to 1. TLI close to 1 indicates a good fit, but if it is indicated below .90, the model needs to be re-specified.

There is a good model fit if RMSEA is less than or equal to .05. RMSEA is a popular measure of fit since it does not require comparison with a null model. RMSEA is also called discrepancy per degree of freedom. PCLOSE tests the null hypothesis that RMSEA is no greater than .05. If PCLOSE is less than .05, we reject the null hypothesis and conclude that the computed RMSEA is greater than .05, indicating lack of a close fit.

AMOS reports a critical N for significance levels of .05 and .01. Hoelter's critical N is the largest sample size for which the researcher would accept the hypothesis that a model is correct. This throws light on the chi-square fit index's sample size problem.

Standard structural coefficient estimates are based on standardized data, including correlation matrices. Standardized estimates are used when comparing direct effects on a given endogenous variable in single-group study. Unstandardized estimates are based on raw data or covariance matrices. When comparing across groups, indicators may have different variances, as may latent variables, measurement error terms, and disturbance terms. Unstandardized comparisons are preferred when groups have different variances.

3.2.5. Modification of the Model

The models generally do not fit at first. Occasionally model modification is required to obtain a better-fitting model. AMOS allows for the use of modification is required to obtain a better-fitting model. AMOS allows for the use of Modification Indices (MI) to generate the expected reduction in the overall model fit chi-square for each path that can be added to the model.

MI, or the modification index, allows specifying what of chi-square change is required for a path to be included in the modification index output. It is important to understand that when modifying a model based upon the modification index output, we are re-specifying our model on sample-dependent results.

When we re-specify or modify our model, we are implicitly changing its meaning in some fundamental way. In many instances, a change in model specification results in a trivial or unimportant corresponding alteration of the model's substantive meaning. However, in other cases model modification can foreshadow a strong shift in the model's meaning from a theoretical standpoint. Hence, thinking through each proposed model modification and asking if making the modification is theoretically consistent with our research goals is crucially important.

Relying on the empirical data rather than theory to help us to specify the model is a second consideration to take into account when modifying a model. The more empirically based modifications we incorporate into our final model, the model is less likely to replicate in new samples of data. The more model modifications done based on sample data as reflected in MI, the more chance the changed model will not replicate for future samples, therefore, modifications not only should be done based on the MI but also should be done based on theory.

3.3. System Dynamics

System dynamics (SD) methodology is employed in modeling the dynamics of performance management of XT. System dynamics discipline deals with dynamic policy problems such as problems arise from the interactions between system variables and from the feedbacks between managerial actions and the system's reactions. The purpose of a system dynamics study is to understand the causes of a dynamic problem, and then search for policies that alleviate them [8].

Feedback loops show the circular causal relations between the variables. As long as the variables interact with each other, they are prone to change over time. Therefore, the problem is dynamic. However, the changes are not easy to predict. Between the causes and effects are time delays. Internal structure of the system is the main cause of dynamic behavior. Managerial control and improvement is possible since the dynamics are formed by internal structure, which is the main purpose of this study.

The SD methodology consists of 7 major steps:

(i) Problem description and studying objectives
(ii) Conceptual model and data analysis
(iii) Construction of the formal model
(iv) Model testing and validation
(v) Scenario and policy experiments
(vi) Policy recommendations and conclusions
(vii) Implementation

3.3.1. Problem description and studying objectives

A system dynamics study is applied for studying a dynamic problem. The critical step for the success of the project is the selection of a meaningful dynamic problem. Some of the sub-steps of problem identification:

(i) Plotting and examining the dynamic behaviors
(ii) Determining the time horizon
(iii) Determining the reference dynamic behavior
(iv) Determining the precise statement of the dynamic behavior

3.3.2. Conceptual model and data analysis

The main objective of this step is to develop a theory that explains the causes of problematic dynamics. This step includes the following sub-steps:

(i) Examining the relevant information in literature
(ii) Documenting all potential variables causing the dynamics concern
(iii) Specifying the major causal effects and feedback loops
(iv) Creating an initial causal loop diagram
(v) Identifying the main stock-flow diagrams

3.3.3. Construction of the formal model System Dynamics

This step covers the following sub-steps:

(i) Specifying the mathematical formulations for all relations
(ii) Estimating the numerical values of parameters
(iii) Testing consistency of the model

3.3.4. Model testing and validation System Dynamics

Model validity's two components are structural and behavioral. The structural validity of the model covers meaningful description of the real relations existing in the problem of interest. The behavioral aspect compares the real patterns with the patterns created by the model.

3.3.5. Scenario and policy experiments

Scenario analysis in a system dynamics model covers the changing situations in the environment. The researcher should investigate the realistic different scenarios that may affect the simulation with creating a set of equations. However, the policy experiments include changing the values of some parameters and construction of some relations, which may be changed by decision maker in the real world. Both scenarios and policy experiments are required to make useful recommendations at the end of a study.

3.3.6. Policy recommendations and conclusions

At the end of a system dynamics study, recommendations made by researcher should be realistic, and policy must be robust. In the sense that, it should work under different environmental conditions and scenarios.

3.3.7. Implementation

This step is only applicable if the system dynamics study is an applied one.

4. MODEL CONSTRUCTION AND ANALYSIS

This chapter introduces the description of the current performance evaluation system in XT. Then, it details the overall model, whichis composed of the SEM and SD modules. Model validation and various scenario analysis will follow in subsequent chapters.

4.1. Description of the Current Performance Evaluation System

There are numerous problems with the employee evaluation system of XT. Although salary increase and promotion are directly dependent on the employee performance score, the performance evaluation process is not transparent.

Each year is split intotwo evaluation periods withsix months. The first period is from January to June followed by the second period from July to December. The evaluation process starts at the end of the period. Managers are expected to evaluate their teams individually, and get an approval from the directors.There are only two key performance indicators provided for managers to base their evaluation process. These are number of projects and overtime duration. Projects are listed for each employee with respect to its size, which is categorized as small or large. Managers are expected to know each employees’ effort and contribution for specified projects. Overtime work is also provided in monthly man hours for each employee. Accordingly, managers can give their scores for each employee.

Because of aforementioned reasons, managers may assess the employees according to theirown personal relationship and perception, which may cause a serious problem in the long term for the company sincesuccessful but unsatisfied employees may leave the company because of the poor employee-manager relationships. In fact, turnover rate is quite high for the last few years. Most of the employees left the company complaining about the unfair performance assessment system, and unfairness was ranked as the first reason to leave the company.

There may be many ways to alleviate the increasing turnover ratio of the company. Recently, the company works on a HR project to predict the employee’s performance incorporating new Key Performance Indicators (KPI). Line of codes, number of test scenarios recorded, number of bugs detected, number of failures encountered, and number of problems faced after project deployment, the success degree of analysis report assessed are some of the suggested indicators. If that project is put in the action, the problems we mentioned above can be eliminated in the long term. However, for the time being, they need to refine their approach for increasing the fairness of performance assessment system. Thus, this study takes into account the key human resources data of the underlying company. The candidate variables are analyzed using SEM methodologyto identify the significant factors affecting the employee performance. After finding the influentialvariables, these are fed into the SD model and different scenarios and policies are investigated in order to obtain a useful strategy to increase employee performance and to improve the fairness of the employee performance system.

4.2. Employee Performance Model

As it is mentioned in the previous section, a two-phased system model is employed in this thesis. In the first phase, influential variables for employee performance are identified using SEM methodology. Those variables are also used as input for the SD model in the second phase. SD model is constructed based on the causal relationships as illustrated in the literature review.The first and second phasesare portrayed in Figure 4.1.

Investigating the factors that may be affecting the given employee performance scores, we came up with the parameters inTable 4.1.

Table 4.1. Candidate factors for the employee performance.

Factors
Projects
Days Off
Overtime
Current Experience
Training Days

(i) Projects: Each employee is assigned to certain number of projects for the related term. These projects are actually classified as major and minor. Major projects are those which require more than 40 man-days. We will not distinguish these two project classes in our model construction.
(ii) Days Off: Total number of days employee is out of work in the related term.
(iii) Overtime: It is the additionalman hours for each employee beyond the regular work hours.
(iv) Current Experience: It is the number of years spent in the XT Company by each employee.
(v) Training days: Training programs are planned annually. Accordingly, each employee spends certain number of days in training annually.

SEM is constructed based on the aforementioned five variables as inputs affecting employee performance scores. There are no latent variables included in this model. Only three variables are observed as significant. These are projects, overtime and current experience. Those three parameters are linked to the system dynamics model as input for given performance score parameter.

In the second phase, system dynamics model is constructed as explained in Section 4.5. New scenarios and policies are generated which help to find strategies to alleviate the high mobility and increase the employee motivation in the company.

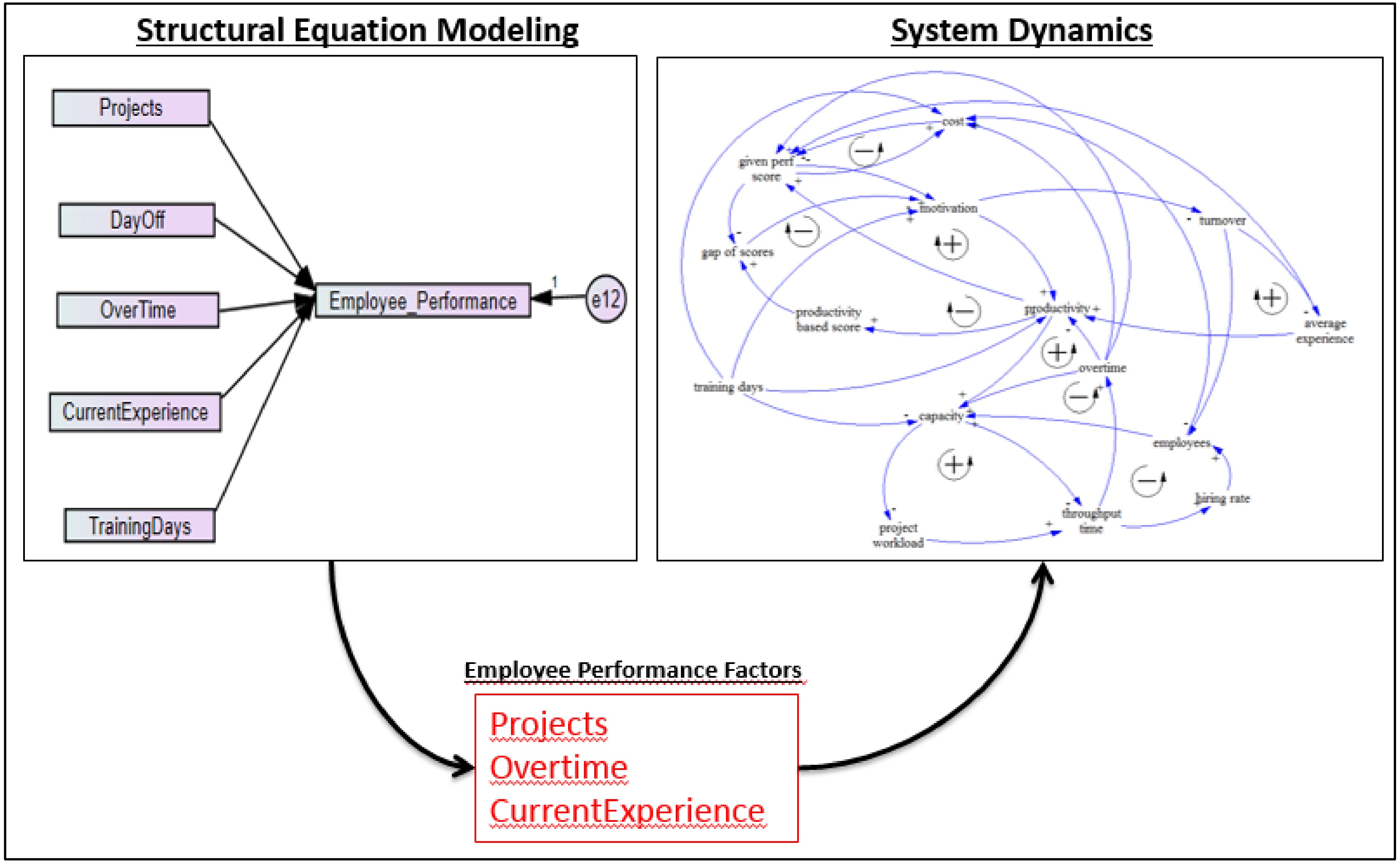

Figure 4.1. The steps of the employee performance management.

4.3. Preliminary Data Analysis

XT Company is a typical example of leading IT companies. HR profile supports the fact that employees are young, mostly coming from engineering background, mostly male with limited past experience. In fact, it is the first job in their career for a good percentage of employees.

This study excludes service support personnel. The remaining core group including network, system and software development has 639 employees.The HR database of these people contains demographic data such as age, gender, education, and previous experience as well as most recent performance scores.

Age distribution of employees is reflected in Figure 4.2. The distribution looks highly skewed. The average ageis computed as 33, its median is 31, and mode is 27. Their ages vary between 22 and 53 with a standard deviation of 6.8. Considering the gender distribution, it is seen that 64% are male. Undergraduate degrees are mostly in computer engineering followed by electrical and electronics, and industrial engineering. The related statistics are 282, 70, and 48 respectively.

176 employees have started their career in XT Company whereas the remaining 463 have past experience from their previous companies. The pertinent statistics on past experiences are also computed. They range between 1 and 23 years. The average experience is 5.27, its median is 4, and the standard deviation is 3.83.

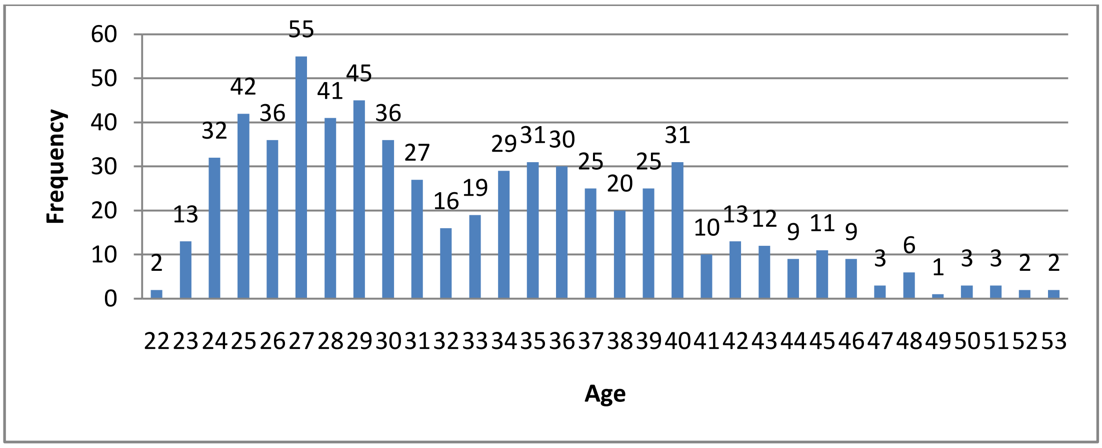

Figure 4.2. Age distribution of employees.

Employee performance scores obtained from the 2012 July employee performance database. Performance score frequencies are portrayed in Figure 4.3. The scores are given on a scale of 1 to 6 in Table 4.2. The corresponding letter grades and their explanations are as follows:

Table 4.2. Scale of performance scores.

Grade	Value	Explanation
BCU	6.0	Much higher than expected
BU+	5.5	Higher than expected plus
BU	5.0	Higher than expected
BK+	4.5	Expected plus
BK	4.0	Meet expectancy
GG	3.0	Needs improvement
BA	2.0	Lower than expected
Y	1.0	Unsatisfactory

It is observed that low grades including GG are rarely given. The key reason is the fact that those employees with low scores perceive the feedback as a message to leave the company rather than improvement signal. In practice, BK looks like the lowest grade. Furthermore, the grade distribution is manipulated in such a way so that average would be BK+. Thus, the current performance scoring system is not an effective instrument for HR management.

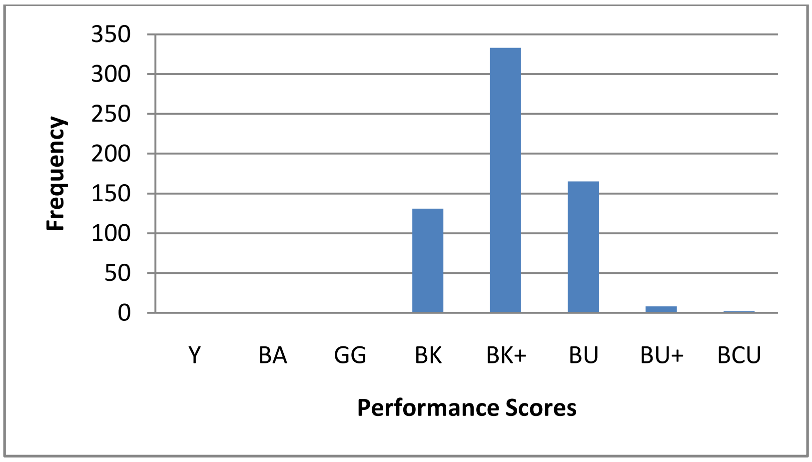

Figure 4.3. Performance score distribution.

4.4. Model for SEM Phase

The amount of change in the dependent variable, employee performance,caused by a unit change in the explanatory variable is represented by standard regression coefficients as shown in Figure 4.4. The highest contribution is coming from the input variable entitled as projects with the coefficient 0.16. It is also observed that current experience and day off variables have a negative effect on the output.

The arrows linking the explanatory variables indicate the correlation coefficients between the corresponding explanatory variables. The highest value is 0.27 in magnitude. It is between current experience and training days. The negative linear relationship between these variables seems to be reasonable because there is a policy that the new employees are encouraged to participate more frequently in training programs. In this way, candidate employees are more attracted to the company. It is also observed that the most intensive employees with the highest overtime figures participate less in training programs.

It sounds counterintuitive to see a negative correlation between projects and overtime. However, this is due to the current practice related to overtime and count of the projects. Even though project supervisors and managers do not actively work on the projects, they are accounted for all those projects of their employees. Furthermore, they are not allowed to have overtime compensation. Thus, their project number increases with no overtime allowance. Nevertheless, none of the correlation coefficients are significantly high to indicate multicollinearity.

The AMOS program computes the Chi-Square Statistic (CMIN) as the model goodness of fit index. It is too sensitive to the size of the sample as a significance test. Different researchers have recommended using CMIN/DF ratio to be lower than 5 to indicate a reasonable fit [26]. However, Byrne takes the threshold value as 2 and considers it as inadequate fit if the ratio is larger than 2 [27]. The chi-square statistic and the degrees of freedom for the final model in this study are 1.290 and 2 respectively. They are referred as CMIN and DF in Table 4.3. NPAR is the number of parameters for the model. Assuming that the default model is correct, the probability of getting a discrepancy as large as 1.290 is 0.525.

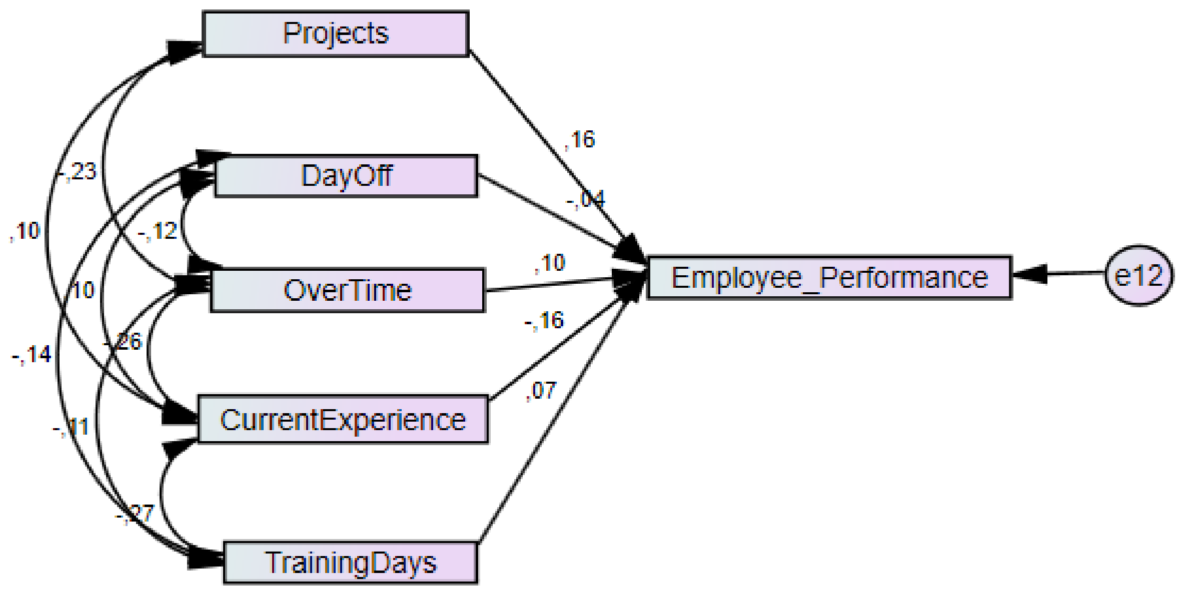

Figure 4.4. Standardized estimates for final model.

The independence model referred in Table 4.3 assumes all linear relationships among measured variables do not exist. In other words, it is the uncorrelated variables model. On the other hand, default model is the final structural model, almost always fitting better than the independence model.This result is based on the comparison using goodness of fit measures.

Due to the drawbacks of the chi-square statistic, many researchers have turned to other fit indices that are less sensitive to sample size than chi-square statistic. These are also known as indices of relative fit and are presented in Table 4.4under the summary of models.

Table 4.3. Absolute fit of the final model.

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	19	1.290	2	.525	.645
Saturated model	21	.000	0		
Independence model	6	226.207	15	.000	15.080

Root Mean Square Residual (RMR) is the square root of the average squared amount by which the sample variances and covariances differ from their estimates obtained under the assumption that the model is correct. Our model's RMR value is 2.057and is considered as relatively small.The Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index(AGFI) are supposed to take values in the range of 0 to 1. Zero indicates poor fit whereas one indicates perfect fit [25]. The GFI is analogous to a squared correlation as far as it indicates that the proportion of the observed covariances explained by the model. The AGFI, which is calculated from the GFI, includes an adjustment for model complexity [24]. The AGFI takes into account the degrees of freedom available for testing the model. The GFI is a measure how well the data fit the model. Recommended values should be greater than 0.90. The values for GFI and AGFI in the default model in this study are 0.999 and 0.993 respectively indicating that there is a model-data correspondence.

Table 4.4. Relative fit of the final model.

Model	RMR	GFI	AGFI	PGFI
Default model	2.057	.999	.993	.095
Saturated model	.000	1.000		
Independence model	18.713	.897	.856	.641

The next step for the goodness-of-fit measure, compare our model to the fit of the independence model. The Normed Fit Index (NFI) varies from 0 to 1, with 1 equaling perfect fit. By convention, NFI values below 0.90 indicate a need to re-specify the model. RFI is the relative fit index, which is not guaranteed to vary from 0 to 1.

The RFI close the 1 indicates a good fit. IFI is the incremental fit index, which is not guaranteed to vary from 0 to 1. IFI close to 1 indicates a good fit and values above 0.90 an acceptable fit. TLI is the Tucker-Lewis coefficient, also called the Bentler-Bonett non-normed fit index (NNFI). TLI is not guaranteed to vary from 0 to 1. TLI close to 1 indicates a good fit. The Comparative Fit Index (CFI) is an incremental fit index, which indicates the proportion of the improvement of the overall fit of the model relative to the independence model. CFI close to 1 indicates a very good fit, and values above 0.90 are an acceptable fit. From the values these measures take, seen at Table 4.5we can say that all the aforementioned criteria are met.

Table 4.5. Comparison with final model.

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.994	.957	1.003	1.025	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

The Root Mean Square Error of Approximation (RMSEA), with its lower and upper confidence interval boundaries is another highlyvaluable fit index that is commonly reported. The recommended values for this fit statistics are those below 0.05 [24]. The value for the final model is 0.000 as shown in Table 4.6, which indicates model fit. Since the PCLOSE is a "*p* value" for testing the null hypothesis that the population RMSEA is no greater than .05. This p value is 0.851 for the default model and not smaller than 0.05. Thus, we do not reject the null hypotheses and conclude that the computed RMSEA is smaller than 0.05 indicating no lack of fit.

Table 4.6. Measure based on population discrepancy.

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.069	.851
Independence model	.149	.132	.166	.000

Hoelter’s critical N is the largest sample size to accept the model at the 0.05 or 0.01 levels of significance. Our model would give an acceptable chi-square up to thesample size 2965 at 0.05probability level and 4557 for the 0.01 level, respectively. Thisis shown in Table 4.7.

Table 4.7. Hoelter's critical N for final model.

Model	HOELTER .05	HOELTER .01
Default model	2965	4557
Independence model	71	87

The Standard Errors (S.E.) are estimates of the errors of unstandardized coefficients to be expected because of the sampling error. Table 4.8displays the unstandardized estimates, S.E., and the estimates divided by the standard errors referred to as the Critical Ratio (C.R.).

Table 4.8. Unstandardized regression weights.

			Estimate	**S.E.**	**C.R. (t-value)**	**P**
Employee Performance	<---	Projects	.0020	.0005	4.000	***
Employee Performance	<---	OverTime	.0030	.0013	2.2909	.0220
Employee Performance	<---	DayOff	-.0016	.0017	-.9788	.3277
Employee Performance	<---	CurrentExperience	-.0119	.0031	-3.8586	***
Employee Performance	<---	TrainingDays	.0052	.0031	1.6748	.0940

If we are dealing with random variables with standard normal distributions, estimates with C.R. more than 1.96 are significant at the 0.05 level. Thus, by examining the obtained results, the significant parameters at the 0.05 level areprojects, overtime and currentexperience.

4.5. Model for SDPhase

This section models employee performance assessment process. All the variables included in the model are selected as recommended by numerous investigators in the literature survey. Furthermore, the given performance scores together with its influential variables which are identified using the SEM modelare input to the SD model in the second phase. Real productivity and given performance scores are compared at the end of each term and researched the side effects of the gap on employee motivation, turnover rates and sustainability.

All the system dynamics model constructs are created utilizing a Causal Loop Diagram (CLD). In this study, as seen from Figure 4.5, CLD is composed of 9 loops. 4 of these are positive and the remaining ones are negative. The positive loops are as follows: performance scores - productivity loop,employee turnover - productivityloop, productivity - overtime loop and productivity - workload loop. The negative loops includeovertime-throughput time loop,hiring rate-project workload loop, performance score-cost loop,performance gap - productivity loop and performance gap - turnover loop. Moreover, the equations and stock-flow diagram of the SD model are displayed in Appendix A and Appendix B respectively.

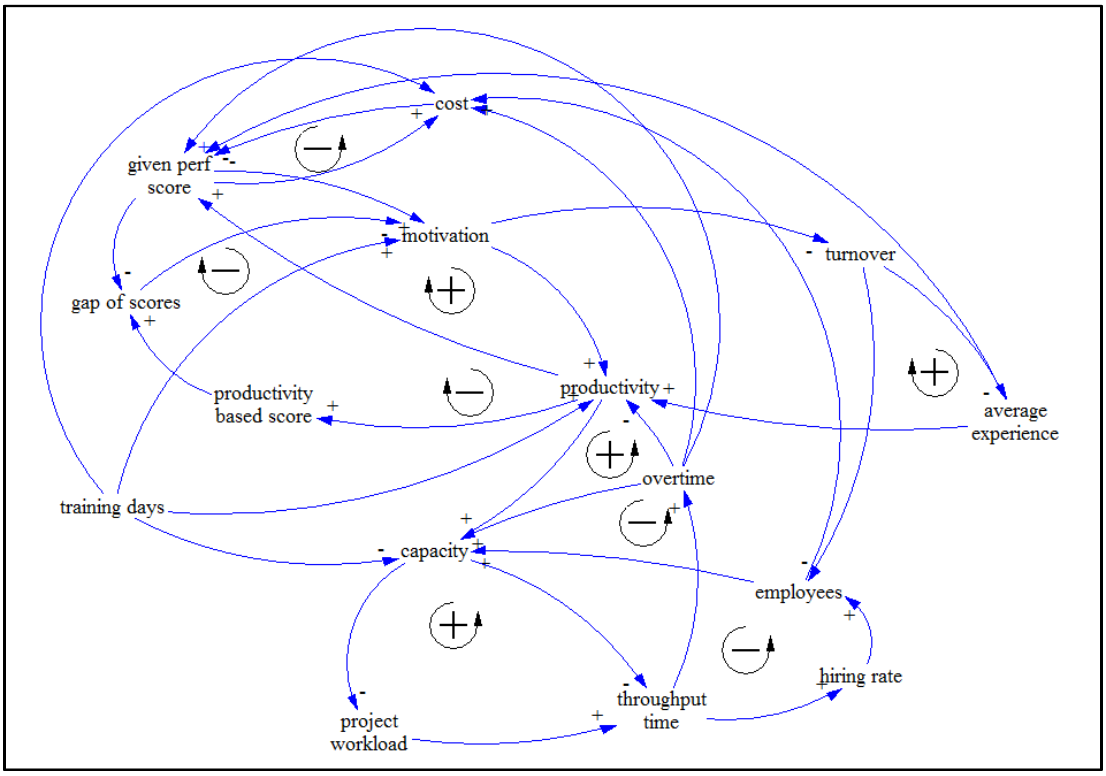

Figure 4.5. Causal loop diagram of overall model.

P1: Performance scores - productivity: Given performance scores positively affect motivation as seen in Figure 4.6. Motivation also affects productivity positively, which in turn affects given performance scores positively.

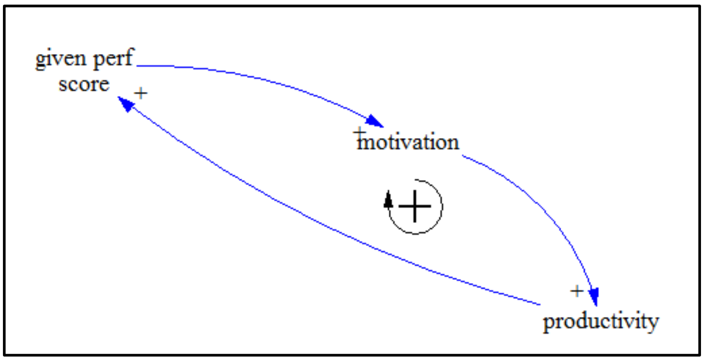

Figure 4.6. Given performance scores and productivity.

P2: Turnover- productivity loop: Increasing turnover negatively affects average experience of the company, which in turn decreases the productivity as seen in Figure 4.7. Decreased productivity results in decreased given performance scores, which in turn causes turnover increase.

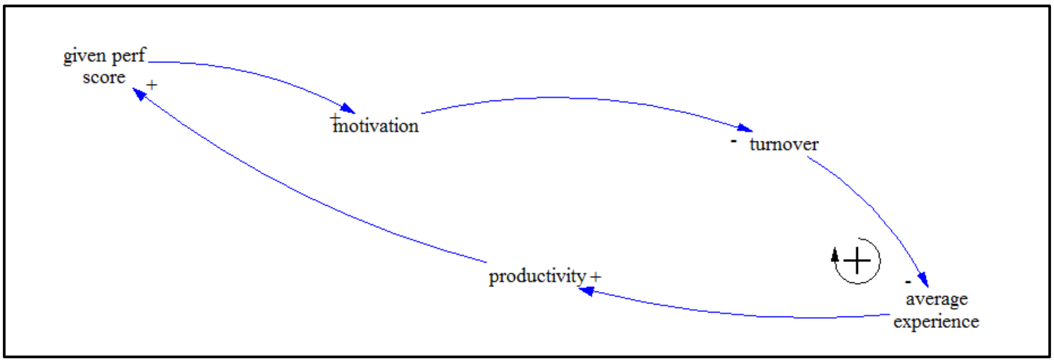

Figure 4.7. Turnover productivity loop.

P3: Productivity-overtime loop: If productivity increases, the need for overtime decreases. Again, decreased overtime increases the productivity as seen in Figure 4.8.

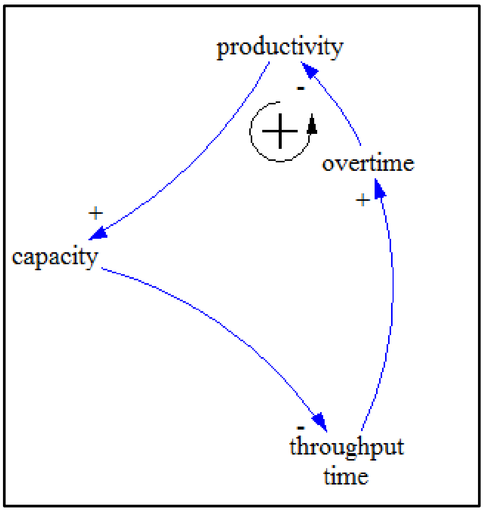

Figure 4.8. Productivity-overtime loop.

P4: Productivity-workload loop: If productivity increases, the project workload decreases. Decreased workload means decreased overtime amount, which cause productivity increase as seen in Figure 4.9.

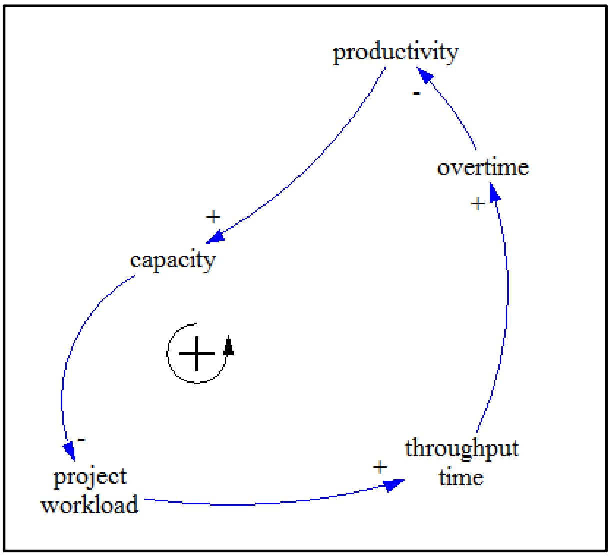

Figure 4.9. Productivity-workload loop.

N1: Overtime -throughput time loop: If overtime increases, capacity increases, too as seen in Figure 4.10. However, increased capacity decreases throughput time, which helps decrease in the long-term overtime.

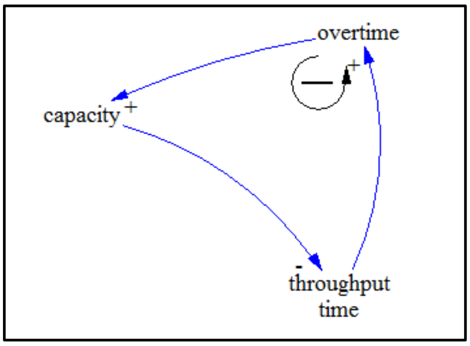

Figure 4.10. Overtime throughput time loop.

N2: Hiring - project workload loop: If project workload increases, the throughput time increases. Increased throughput time causes overtime and hiring rate increase. Increased hiring rate increases capacity, which in turn decreases the project workload as seen in Figure 4.11.

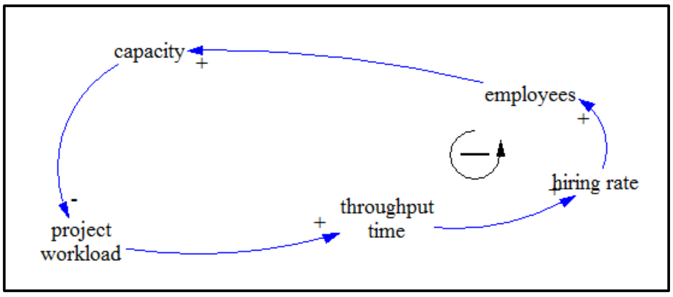

Figure 4.11. Hiring project workload loop.

N3: Performance score-cost loop: If given performance scores average increases then, the average cost of company increases, too which in turn decreases the given performance scores average as seen in Figure 4.12.

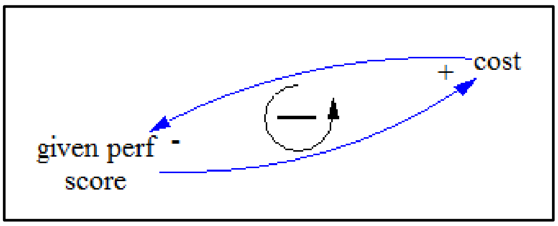

Figure 4.12. Given performance score-cost loop.

N4: Performance gap - productivity loop: If the gap between given performance score and productivity based score increases, motivation and productivity decrease as seen in Figure 4.13.

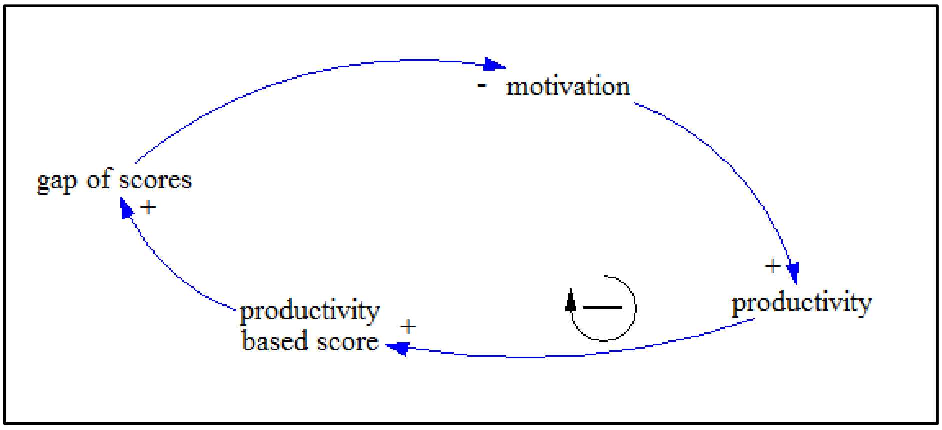

Figure 4.13. Performance scores gap based productivity loop.

N5: Performance gap -turnover loop: If the gap between given performance score and productivity based score increases, motivation decreases, which in turn causes turnover increase as seen in Figure 4.14. Increase in turnover impact productivity negatively. In conclusion, the productivity based score alsodecreases and the gap decreases.

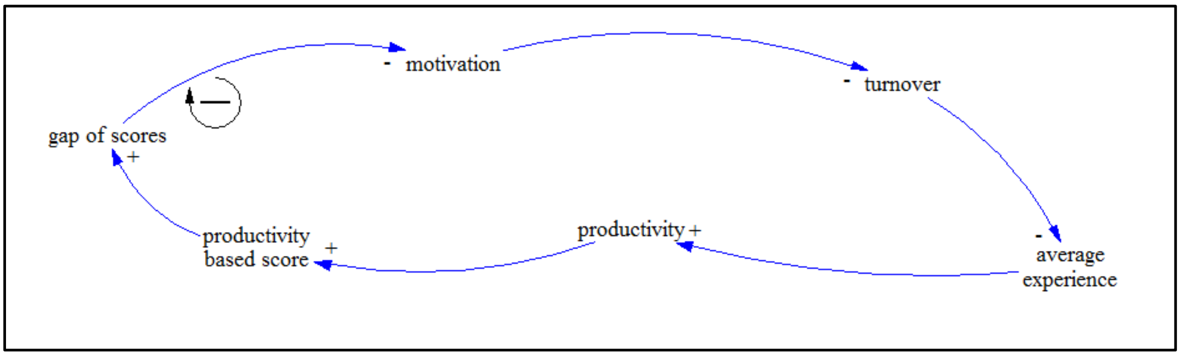

Figure 4.14. Performance scores gap based turnover loop.

Model variables and parameters were explained in detail in the following sections.

4.5.1. Productivity part

According to the literature, the productivity of an employee is influenced positively by motivation and training. However, overload affects productivity negatively. Inexperienced employee's productivity level is assumed to be 0.5 on a scale of0 to 1. It is obvious that a new employee would need some time to gain some experience in this high technology company, so that, the true performance level can be revealed. Besides, the productivity level of experienced employees is not fixed and it varies continuously according to the factors mentioned above within the range of 0-1.

4.5.2. Motivation part

Performance scores, days off, and training amountall affect motivation level positively. However, overtime amount and especially the gap between productivity level and given performance scores affect employee's motivation negatively.

4.5.3. Given performance scores part

This constructis created from the observations of the organization and the result of SEM phase. According to the results, given performance scores is affected by overtime amount and project amount positively. Interestingly, average experience of employees affect this variable negatively. The average experience affects productivity positively as reported in the literature; however, the results of SEM indicates that its effect on given scores is just the opposite.

4.5.4. Employee pool part

To create a simulation model to represent the HR system more realistically, we added an employee pool variable to show the potential employee candidates in the outside world.This pool contains 5000 people initially. Inflow to this reservoiris 264 new graduates every year, and the hired people by XT lessen the pool population. According to the XT policies, it is not possible to rehire the people who have resigned from XT Company in the past. Thus, the pool may not be adequate in the long term for the company.

4.5.5. Employee part

The XT Company employees are considered as inexperienced or experienced according to their residence time in the company. The threshold value is taken as one-year experience.

4.5.6. Profit part

There are several cost items such as salaries, overtime, salary raises, and training. On the other hand, the number of projects completed is the only source of revenue generation.

4.5.7. Throughput time

Target throughput time is the planned project completion time. It is expected to be 3 months on the average for the X Bank. If the actual throughput time for a specific project is higher than the target value, this is a clear indication of project delay. Consequently, employees are expected to work overtime. If overtime is not adequate to decrease the expected throughput time to thetarget levels, the model triggers the hiring channel for the new employees.

4.5.8. Project workload part

Project workload is defined as man workday amount waiting to be done. Each workday,X Bank requests 18 new projects and each of them requires 50 man workdays to be completed.

4.5.9. Turnover part

Quit rate is only affected by motivation in this model. Higher turnover rate is the worst side effect of the management since the productivity level is directly affected by turnover rate.

4.5.10. Capacity part

Capacity is the amount of available man workdays. It is obtained by multiplying the available days by the productivity level. Available days arewhen employees are not on holidays or trainings.

5. STRUCTURE AND BEHAVIOR VALIDITY OF THE SD MODEL

The aim of the model validation is to ensure that the model is an acceptable description of the real system with respect to the dynamic problem [8]. In this context, model validation is carried out in two steps.

5.1. Structure validity

A structure test is applied in order to check whetherthe structure of a model is a meaningful and acceptable description of the real relations that exist in the problem. There are two types of structure tests, which include direct structure tests and structure-oriented behavior tests [8].

Making a comparison between the model structure and knowledge about the real system structure assesses the validity of the model structure. Parameter confirmation, variable confirmation, dimensional consistency, and extreme condition tests are included in direct structure testing. In the proposed model, all parameters and variables have real life counterparts. The equations and relationships are compatible with our knowledge about the real system and there is no dimensional inconsistency in the equations. Dimensions of the variables and parameters are presented in the appendices. Lastly, all the model equations are valid under extreme conditions.

Extreme conditions tested via simulation are one of the tests in indirect structure testing. Extreme values are assigned to selected parameters and model-generated behavior is compared with the expected behavior of the real system under the same extreme conditions.

5.1.1. Extreme Condition Tests

Extreme Condition 1: Productivity of inexperienced employee is set to 0 instead of 0.5. Assuming that inexperienced employees have 0 productivity, we can expect that total capacity decreases. Because of the decrease in the capacity, employees will have to do overtime in order to decrease workload. However, increased overtime will also decrease the productivity of the experienced employees. HR will immediately react to this situation, and it will hire more people to decrease overtime rate. After some point, the overtime will decrease owing to the increased workforce. The result of the run indicates that decreased overtime will provide an increase in productivity of the experienced employees as expected, which can be seen inFigure 5.1.

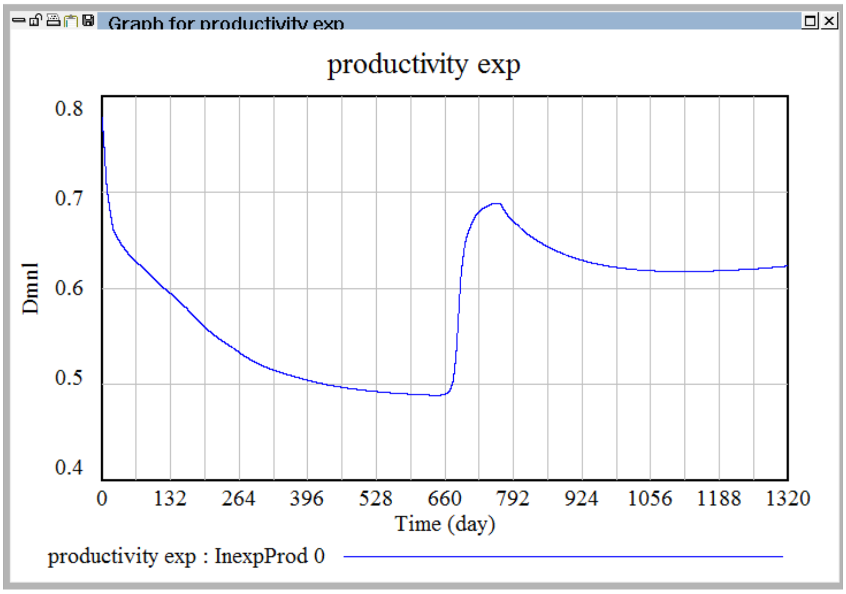

Figure 5.1. Experienced employees' productivity.

Extreme Condition 2: Initial project workload is set to zero. While the total number of employees decrease at first then, subsequently the total number of employee catch the level of base behavior as shown in Figure 5.2 as expected since the coming new work amounts are the same for the different runs.

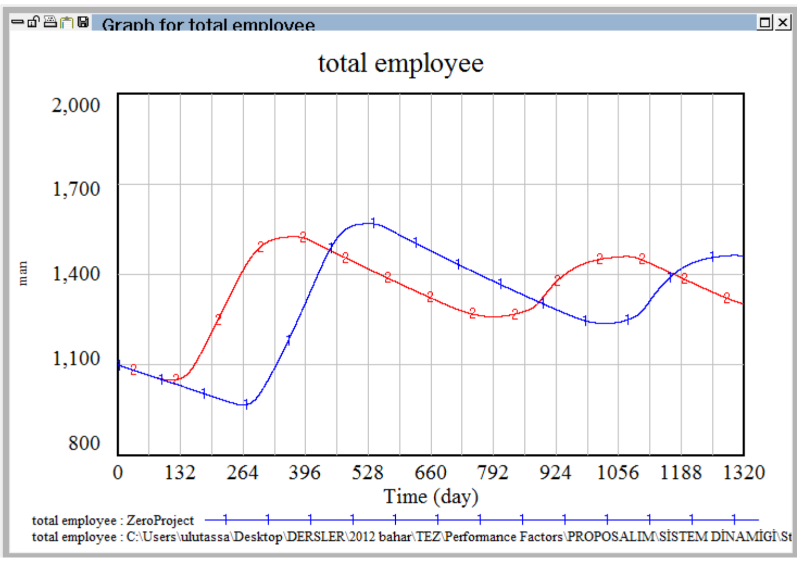

Figure 5.2. Total number of employee change in extreme condition 2.

Besides there is no need to do overtime in the beginning of the simulation as there is no work to do. However, after one year, the overtime level begins to increase and follow the pattern of base behavior with a delay as seen in Figure 5.3 as expected.

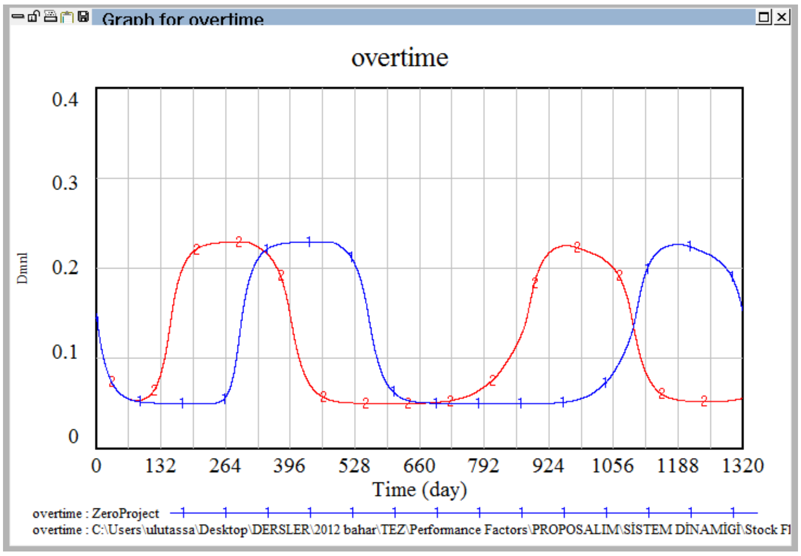

Figure 5.3. Overtime change in extreme condition.

Moreover, the change of the project workload can be seen in Figure 5.4. The graph indicates that there is no work at the beginning, and it takes longer for project workload to reach its highest level compared to base run since the employees could respond to work easier.

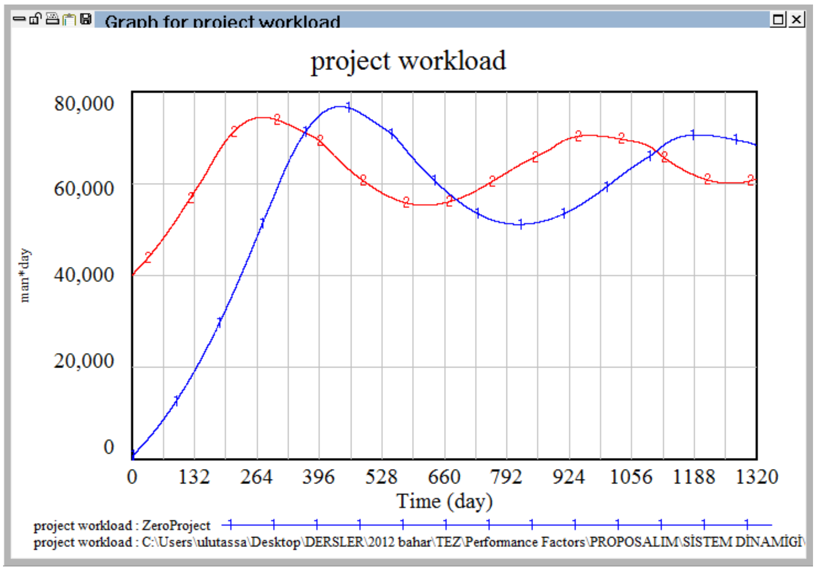

Figure 5.4. Project workload change in extreme condition.

Extreme Condition 3: Total number of employees increases to the double the level of the base behavior as expected since employees are busy to attend trainings as shown in Figure 5.5. The total number of employees decreases immediately after time 450 because the employee pool is empty.

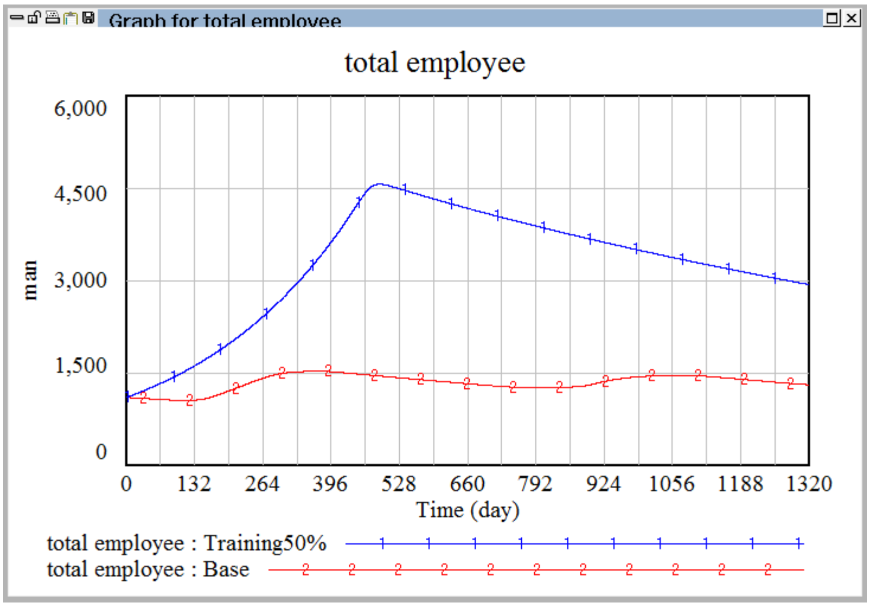

Figure 5.5. Total number of employee change in extreme condition.

Average productivity is also higher than the base behavior in the long term as expected since employees have experienced extensive training as shown in Figure 5.6.

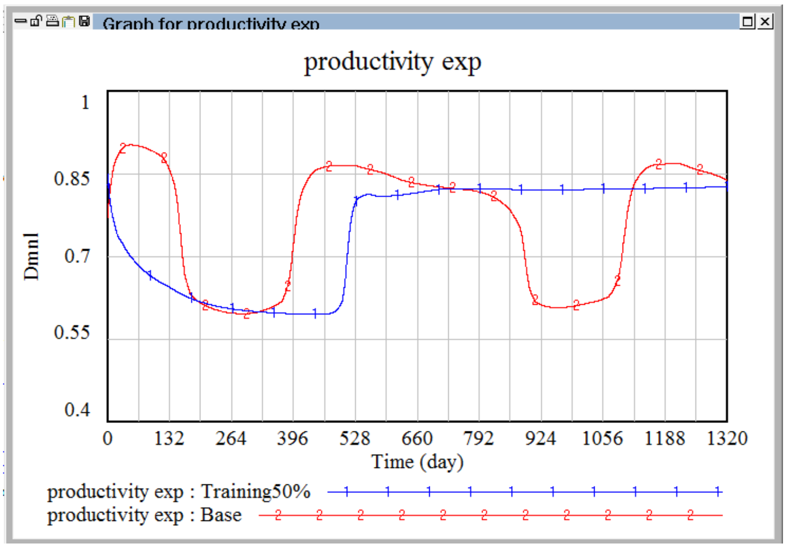

Figure 5.6. Experienced employees' productivity change in extreme condition.

Extreme Condition 4: Initial number of project workload is very high: Initial number of project workload is set to 1000000. The model tries to stabilize the project workload level. Firstly, it tries to deal by increasing the amount of overtime; however, this is not adequate to decrease the workload. Thus, the company hires thousands of employees in coming years as expected as shown in Figure 5.7.

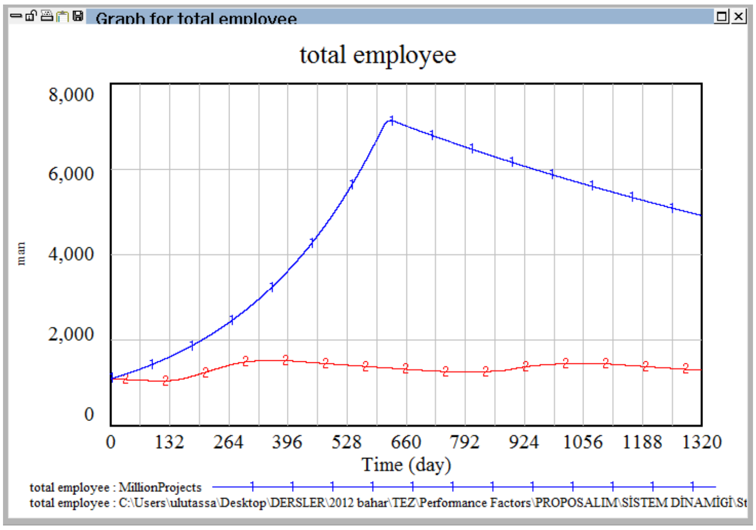

Figure 5.7. Total number of employees change in extreme condition.

After stabilizing the project workload, completion of just one project becomes very costly as shown in Figure 5.8. Thus, the model decreases the given performance scores and waits for employees to leave the company.

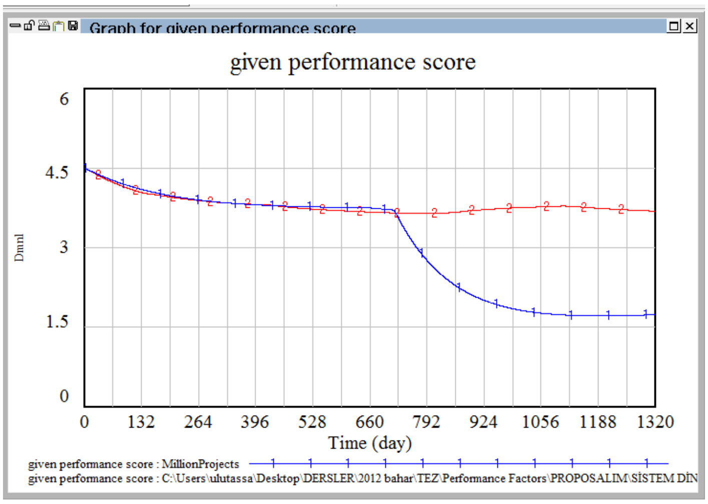

Figure 5.8. Performance score change in extreme condition.

It should be noted that productivity level decreases faster if the motivation level is low. Also, the reason behind the motivation level low is higher level of overtime. Since the productivity level is low, the productivity based score created by the proposed model will lower than the base run as seen in Figure 5.9.

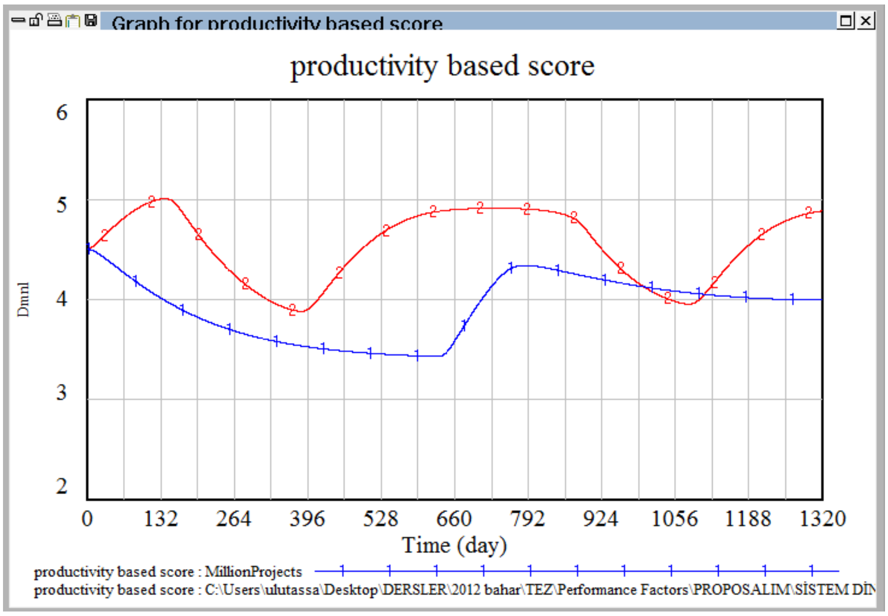

Figure 5.9. Productivity based score change in extreme condition.

Extreme Condition 5: Initial number of employees is set to 2000 instead of 1100. In this condition, the total number of employees decrease immediately due to the poor given performance scores as expected as seen in Figure 5.10. Moreover, the hiring rate is low in this situation since the there is no backlog.Decreasing workload and total number of employee can be seen in Figure 5.11 and Figure 5.12 respectively.

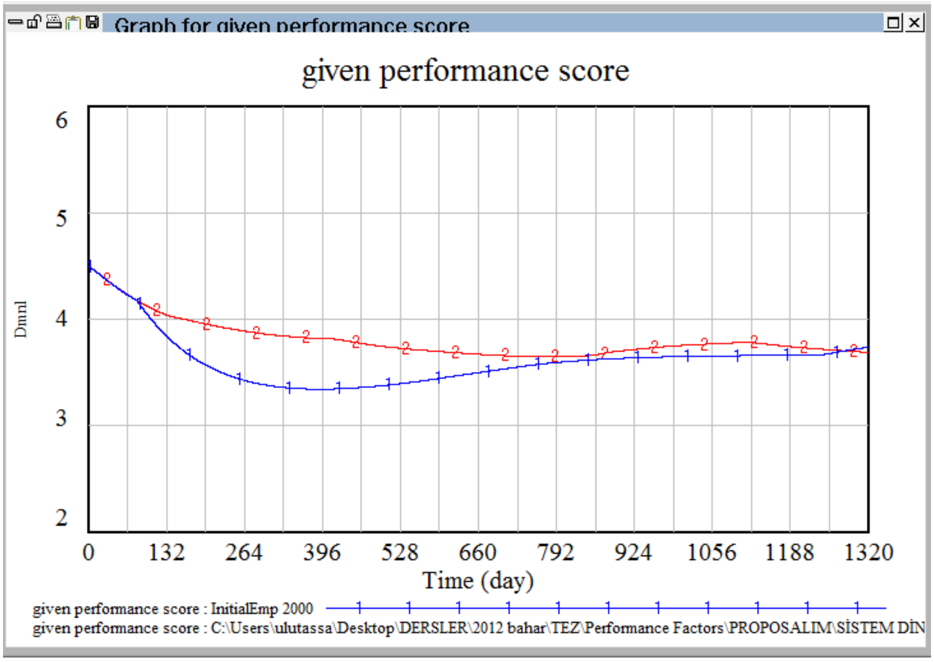

Figure 5.10. Given performance score change in extreme condition.

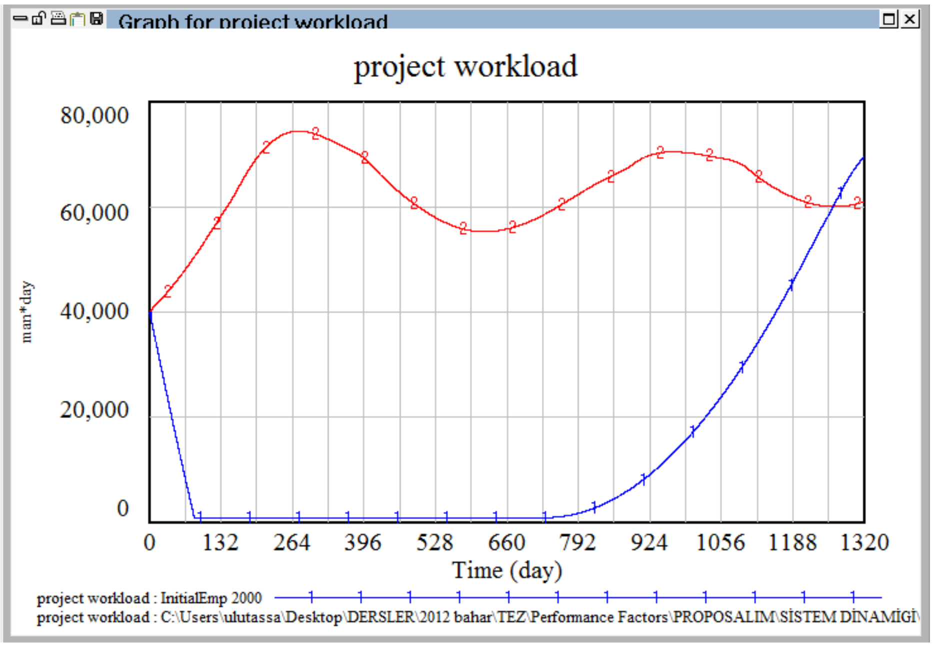

Figure 5.11. Project workload change in extreme condition.

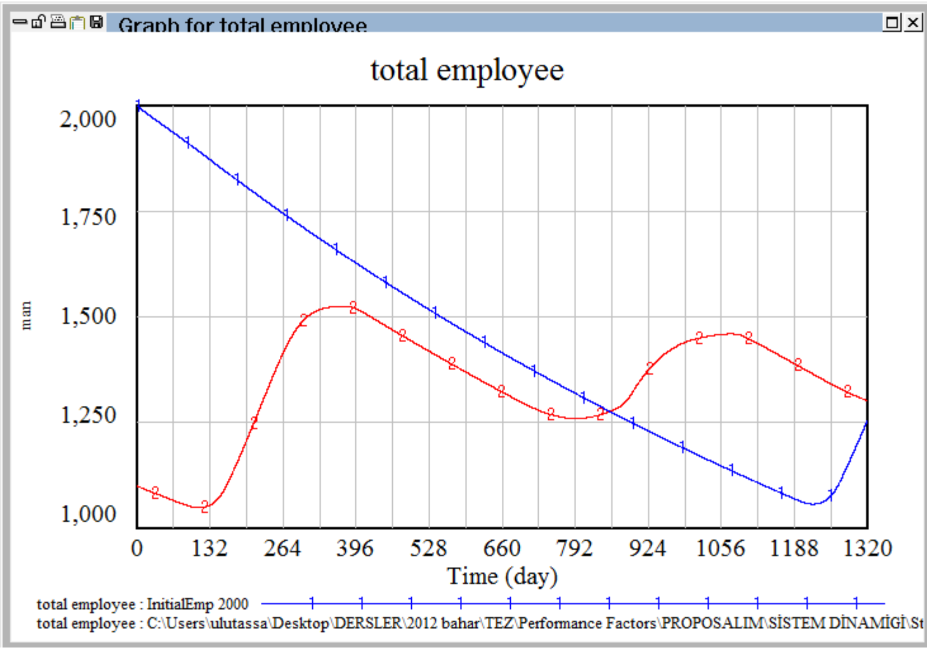

Figure 5.12. Total number of employee change in extreme condition.

Extreme Condition 6: Target throughput time is set to 660 instead of 66. As expected, overtime will decrease to the lowest level of 5% as seen inFigure 5.13.The motivation level will decrease since the lower level of overtime will decrease the given performance scores as seen in Figure 5.14.

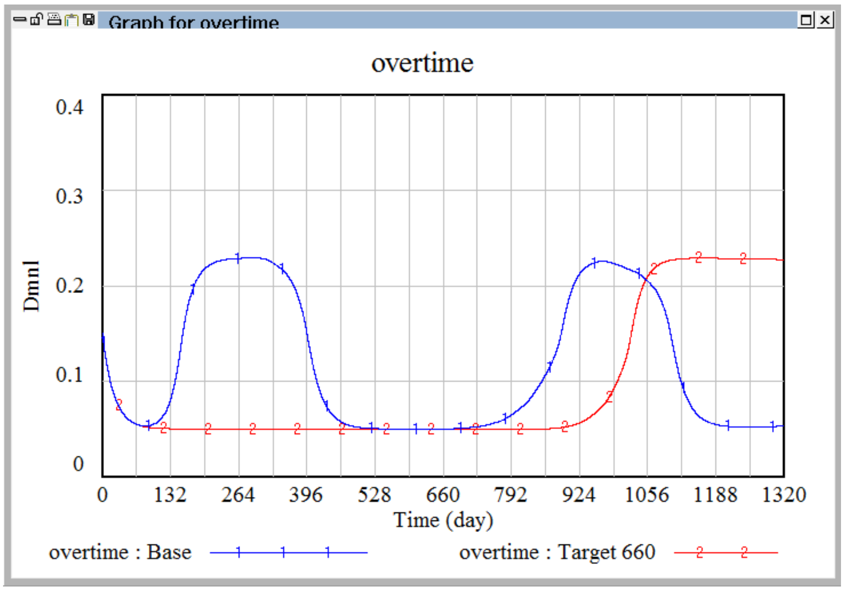

Figure 5.13. Overtime change in extreme condition.

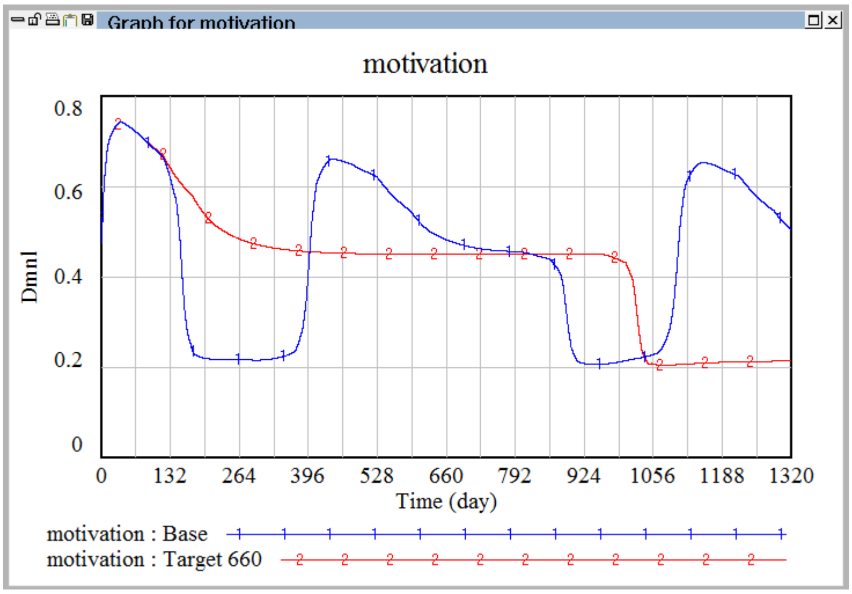

Figure 5.14. Motivation change in extreme condition.

Extreme condition 7: The assimilation period is set to 22 days instead of 264 days. In this case, we expect that total number employees will be less than the base case since the productivity level of experienced employees is higher. The result of the test indicates that our expectation are met as seen in Figure 5.15. Because the productivity level is high, the need for overtime will be lower for a long term. After a period, the overtime level for new condition will be stabilized like the base scenario as seen in Figure 5.16.

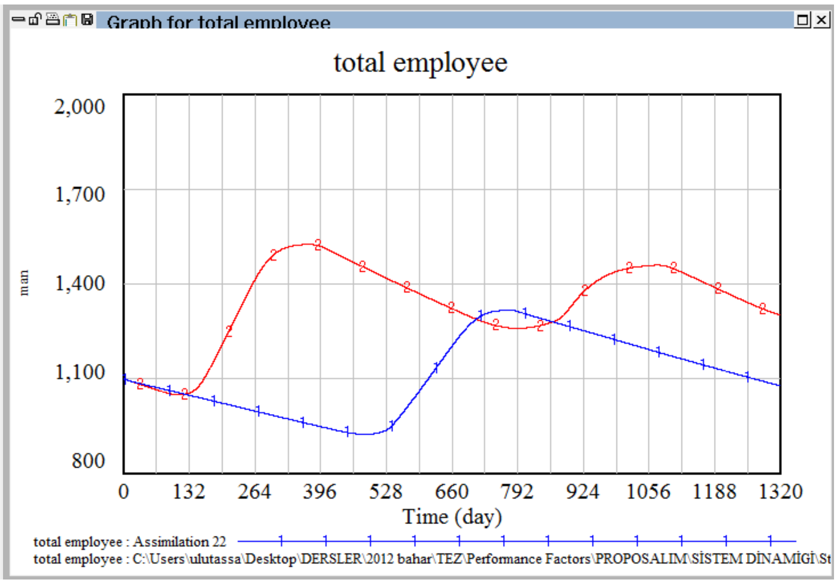

Figure 5.15. Total number of employee change in extreme condition.

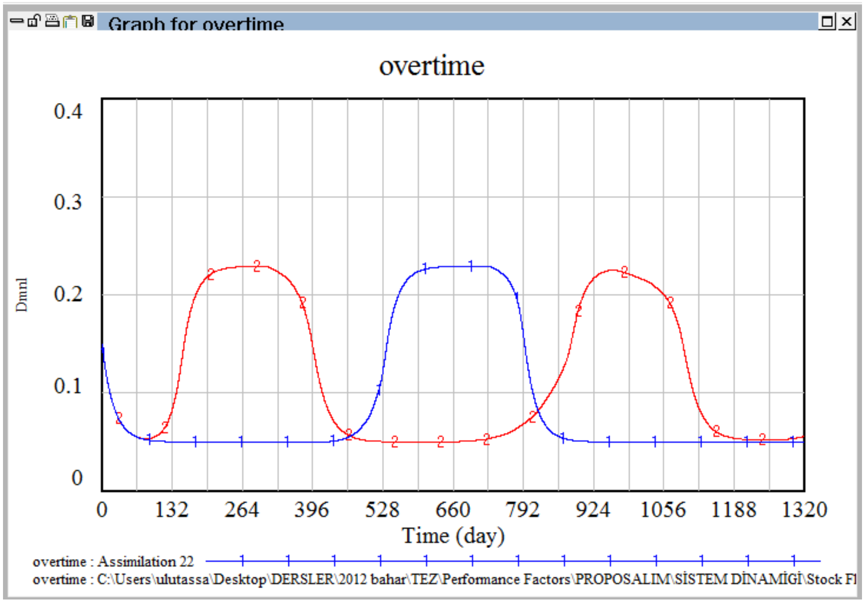

Figure 5.16. Overtime change in extreme condition.

Extreme Condition 8: Initial number of employee pool is empty. It means that there is only one way to fill the pool, i.e. the new graduates inflow. Our assumption for number of graduations per day is one. In this condition, HR department cannot hire more than 1 person as seen in Equation 4.1. Since the employee pool has only 1 employee at a time, the company cannot handle this condition as seen in Figure 5.17. The result of low hiring will decrease the total number of employees as seen inFigure 5.18. A decreased number of employees will increase the overtime ratio, and finally average cost of per man day will increase compared to the base behavior. Project workload, overtime, and average cost per man day can be seen in Figure 5.19, Figure 5.20, and Figure 5.21 respectively.

$$\text{hiring rate} = \text{MIN (employee pool / workday, IF THEN ELSE (total employee} * \text{turnover rate} = 0, 10, \text{MIN (total employee} * 0.01 \text{ / workday, effect of total ratio on hiring} * \text{turnover rate} * \text{total employee)))} \quad (4.1)$$

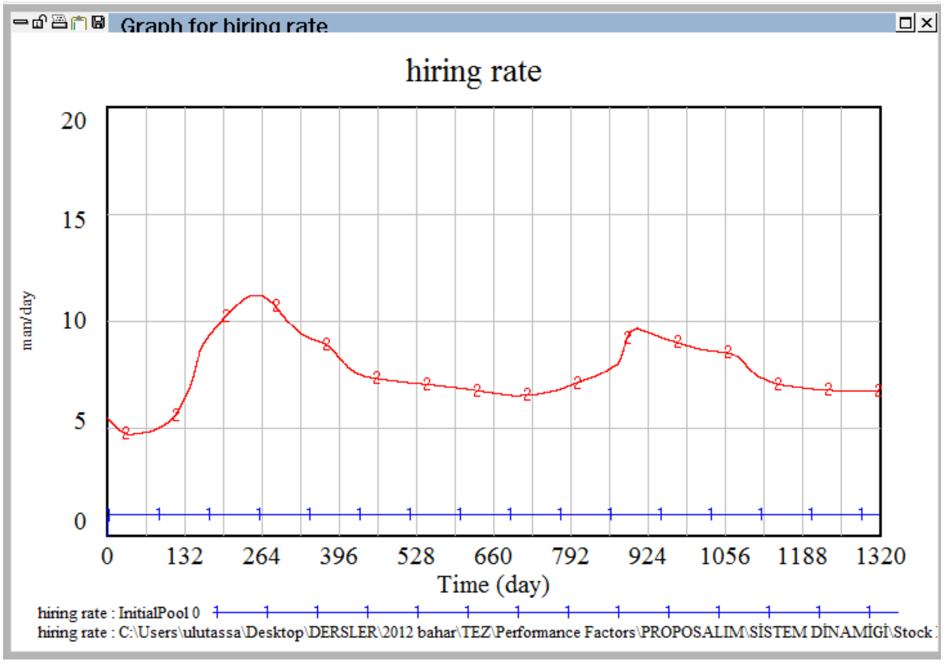

Figure 5.17. Daily hiring rate change in extreme condition.

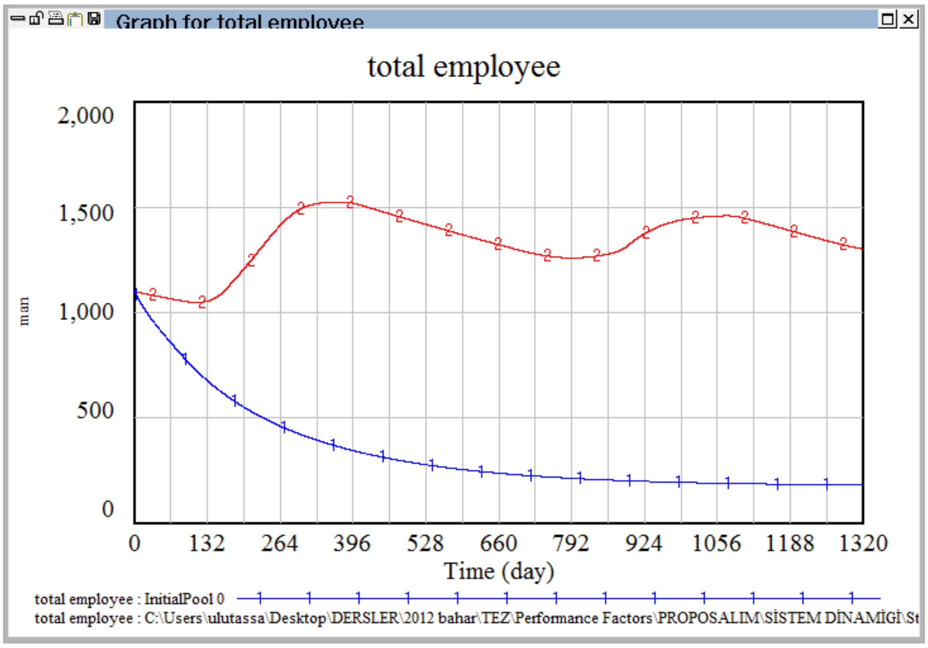

Figure 5.18. Total number of employee change in extreme condition.

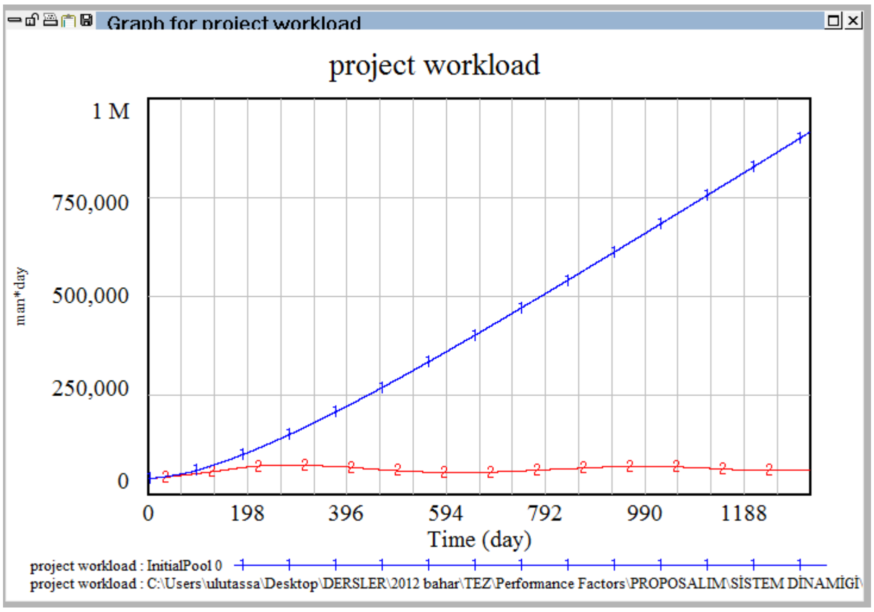

Figure 5.19. Project workload change in extreme condition.

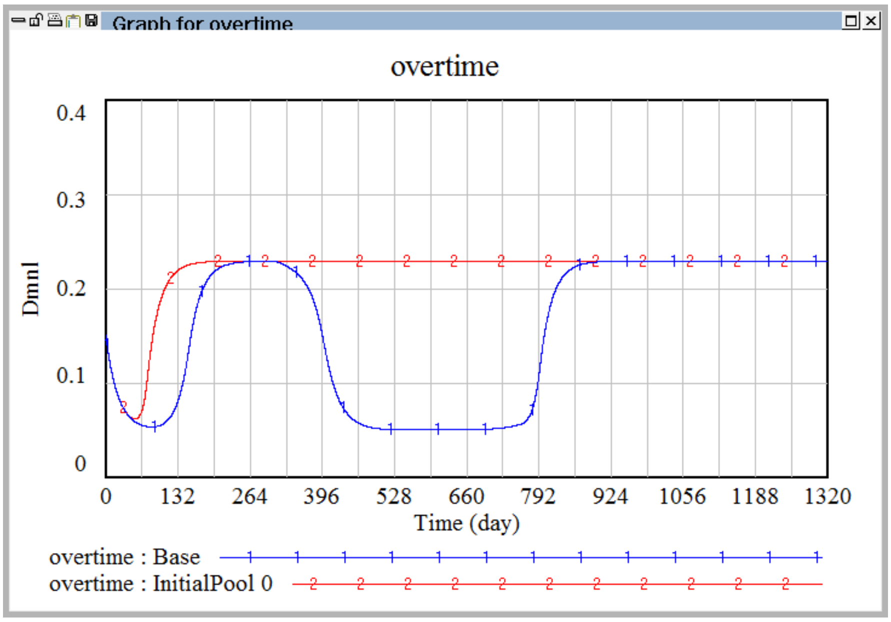

Figure 5.20. Overtime change in extreme condition.

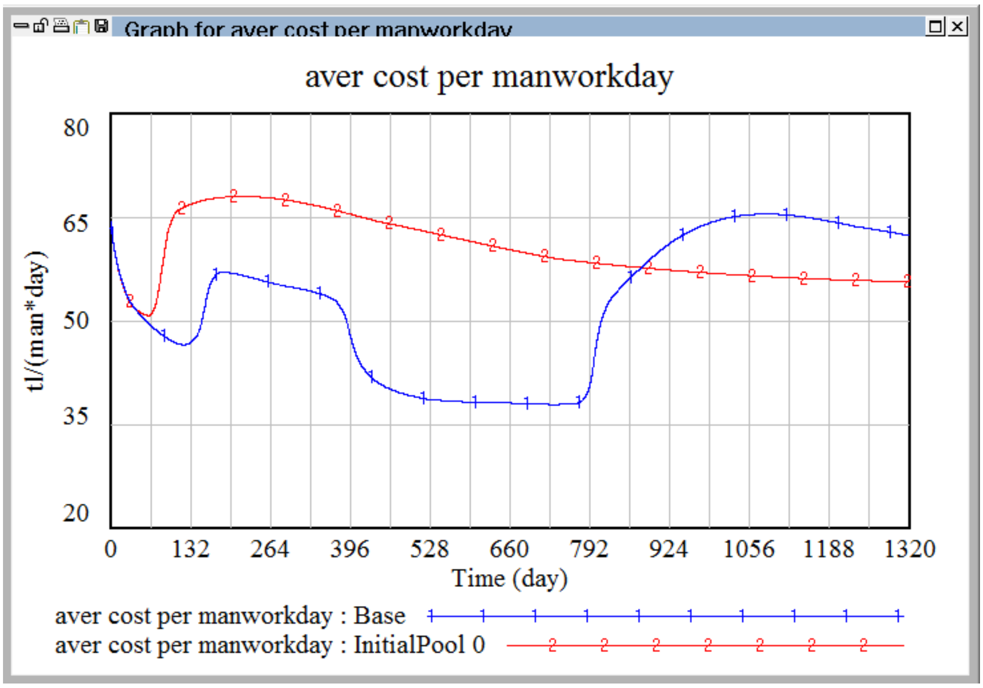

Figure 5.21. Average cost of per man day.

Extreme Condition 9: If the model has no employee, the project outflow should be zero at the beginning according to Equation 4.2.

$$\text{project outflow} = \text{MIN(project workload/workday, IF THEN ELSE} \quad (4.2)$$
$$\text{(normal capacity man days/workday} < 1{,}0\ , \mathit{total\ capacity/workday}))$$

The results for project outflow of the extreme condition test can be seen in Figure 5.22 and it is validated since the result is 0-project outflow as expected.

Extreme Condition 10: If there is no work to do, the overtime amount should decrease to the demanded lowest level immediately, which is 5% of normal time. The equation for the overtime change is in Equation 4.3.

$$\text{overtime change} = \text{(effect of ratio on overtime} - \text{overtime)/overtime adj} \quad (4.3)$$

The result indicate that overtime amount decreased to the 5% level in just 6 month as seen in Figure 5.23.

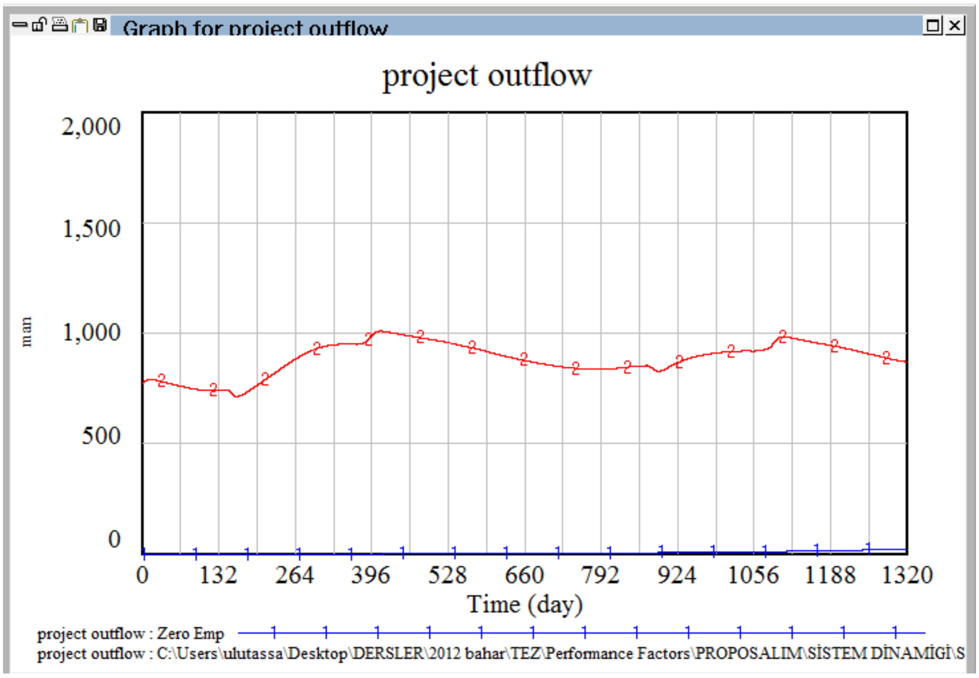

Figure 5.22. Project outflow.

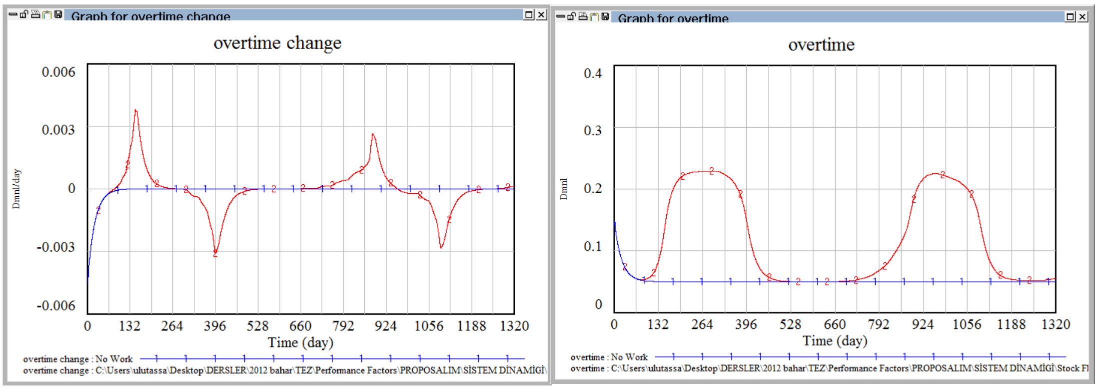

Figure 5.23. Overtime.

Extreme Condition 11: If the training days ratio or days-off ratio would 100% of a day, the model should give the available days as 0%. As seen in Figure 5.24, available days are 0% of a day since the training days were set as 100%. The equation of available days can be seen in Equation 4.4.

$$\text{availabledays} = \text{MAX}(0{,}1 - \text{daysoffratio} - \text{training days ratio}) * \text{workday} \quad (4.4)$$

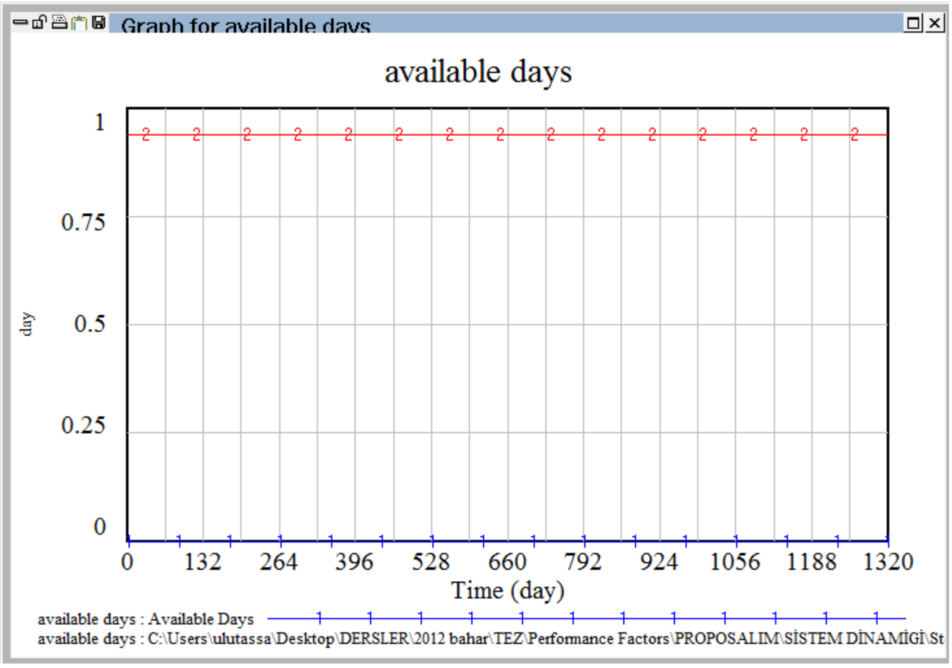

Figure 5.24. Available Days.

Extreme Condition 12: If there are no inexperienced employees in the model, the assimilation amount for the time 0 should be 0 according to Equation 4.5. The result indicates that assimilation amount for time 0 is 0.

$$\text{assimilation rate}=\text{inexperienced employees}/\text{assimilation adjustment} \quad (4.5)$$

As extreme condition test, we tested some other critical parameters and variables under extreme condition as well and those are all validated. The parameters and variables are seen in Table 5.1.

5.1.2. Sensitivity Analysis

Behavior sensitivity test includes determining the parameters to which the model is highly sensitive, and inquiring whether the real system would show similar high sensitivity to the corresponding parameters [8]. Most of the parameters are tested to explore if there are any parameters to which the model is highly sensitive. The tests proved that the model is valid in terms of those parameters. Some of the most sensitive parameters tested are briefly mentioned in the following sections. We analyze the sensitivity by conducting 200 simulations for each analysis; however, we just put the results of 10 simulations for each analysis in order to display the graphs more comprehendible.

Table 5.1. Equation-tested parameters under extreme conditions.

Parameter& Variables Name	Extreme Condition Test
Experienced employees	Validated
Inexperienced employees	Validated
Quit rate inexp	Validated
Quit rate exp	Validated
Employee pool	Validated

Sensitivity Analysis 1: The training days amount was set to values between 0 and 0.3. The base model has the value 0.023 for the training days ratio. The sensitivity analysis graph indicates that training days amount can be set in that gap since the behaviors of total employee parameter, average cost of per man-day, and productivity parameter do not change much as seen inFigure 5.25, Figure 5.26, and Figure 5.27 respectively. Thus, the training days parameter is numerically sensitive. Moreover, the model reacts as expected since increased training ratio increases the total number of employees, cost, and productivity.

Sensitivity Analysis 2: For the second sensitivity analysis, the target throughput time is set to values between 22 and 132 days, and the distribution of the parameter is chosen as uniform. As seen from Figure 5.28, motivation repeats the same behavior for that parameter value interval and the behavior is shifted according to the value of target throughput time. Furthermore, similar shifted behavior for the change of total number of employee variable is seen in Figure 5.29. Furthermore, the model reacts as expected since decreased target throughput time decreases motivation and increases the total number of employees. The total number of employees increases immediately if the target throughput time is set 132. However, if it is set 22, the number of employee start to decrease at the beginning of the run.

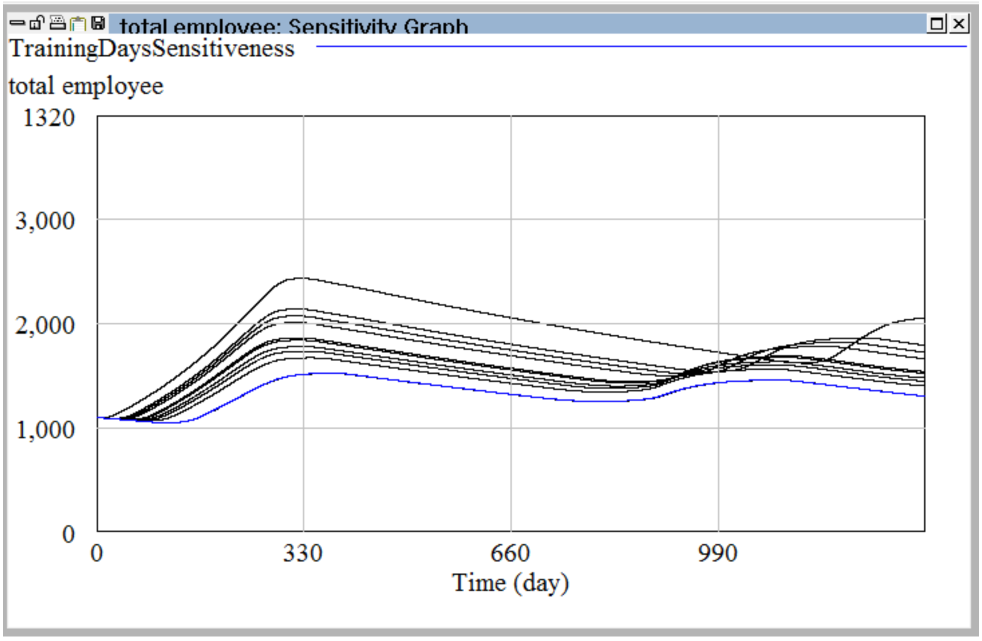

Figure 5.25. Total employee sensitiveness according to training days.

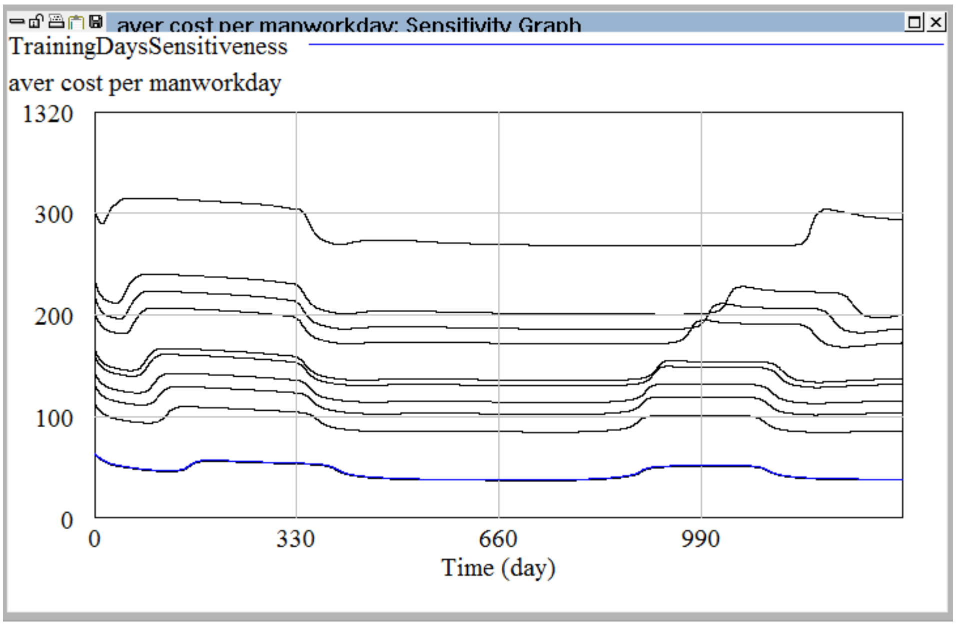

Figure 5.26. Average cost of a project sensitivity to the training days parameter.

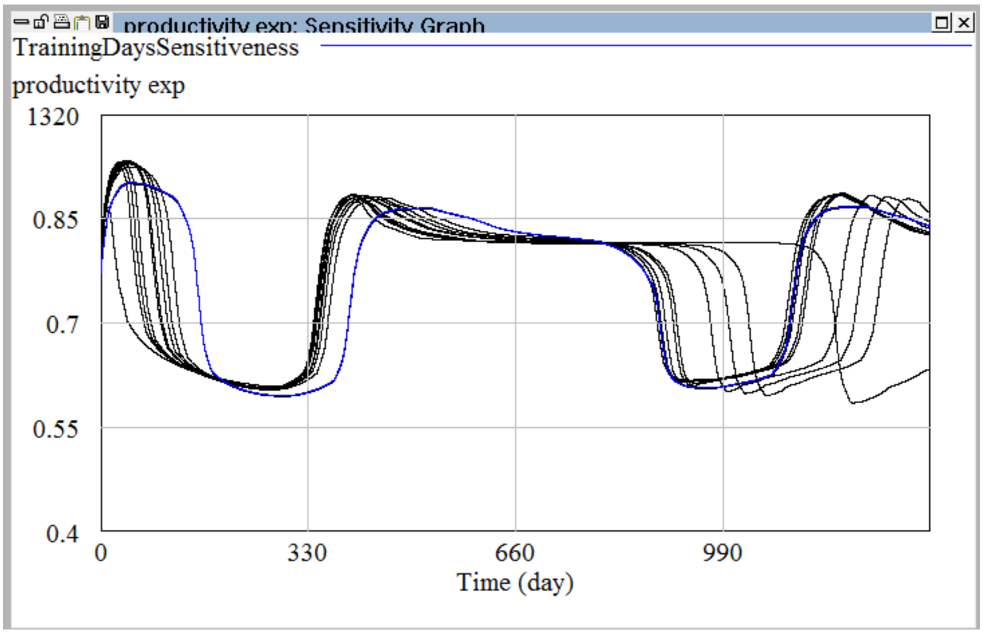

Figure 5.27. Experienced employees' productivity according to training days.

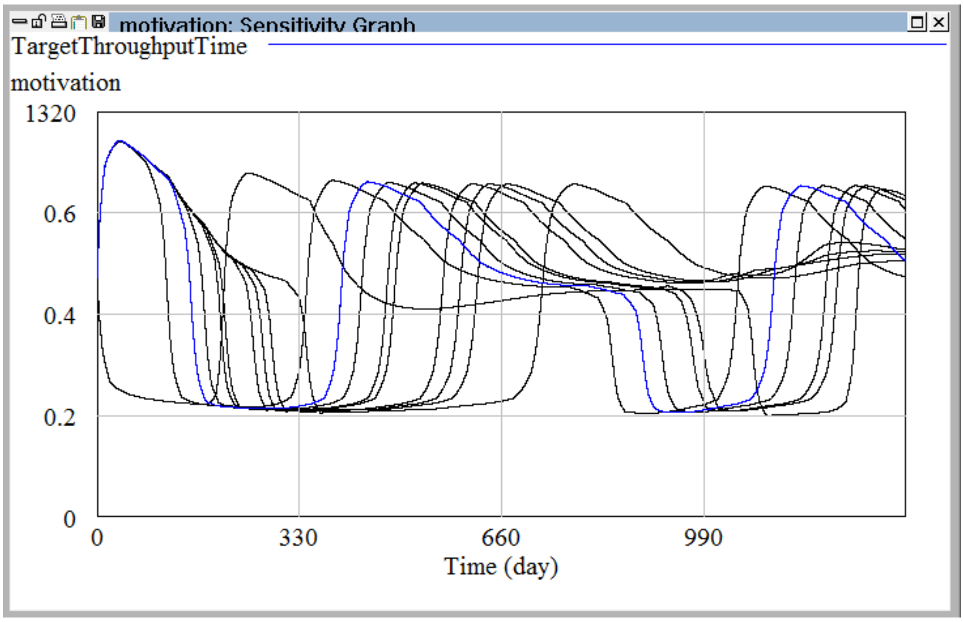

Figure 5.28. Motivation sensitiveness.

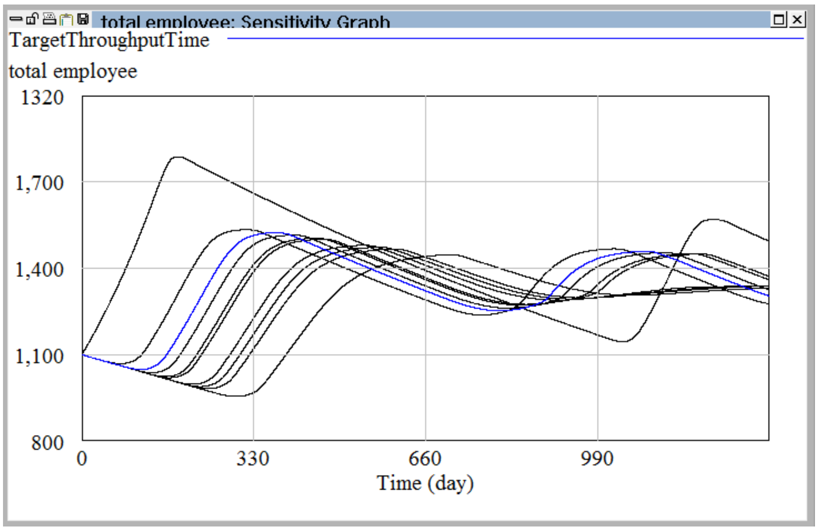

Figure 5.29. Total number of employee according to target throughput time.

Sensitivity Analysis 3: For the sensitivity analysis of overtime adjustment time amount, we set it between 1 and 66 days uniformly. According to the results, there is not a noticeable difference between the behavior of total number of employee variable, motivation levels and gap of scores as seen in Figure 5.30, Figure 5.31 and Figure 5.32 respectively. Thus, we set the value of overtime adjustment parameter to 22 according to our interviews conducted with managers.

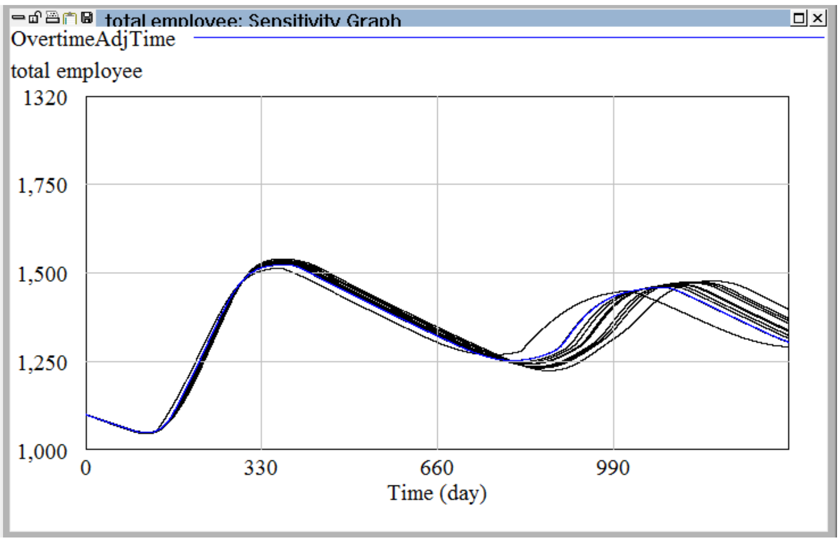

Figure 5.30. Total number of employee according to overtime adjustment time.

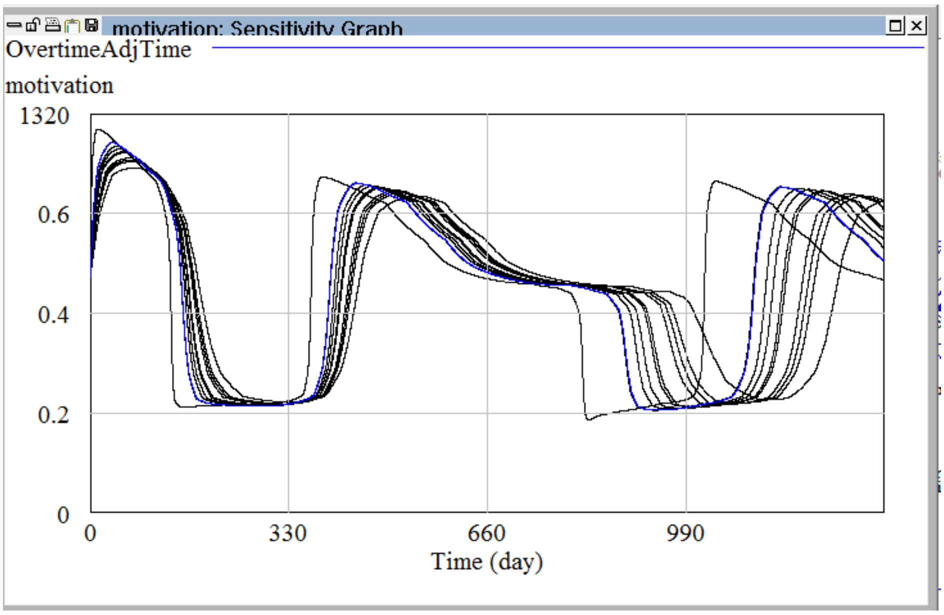

Figure 5.31. Motivation.

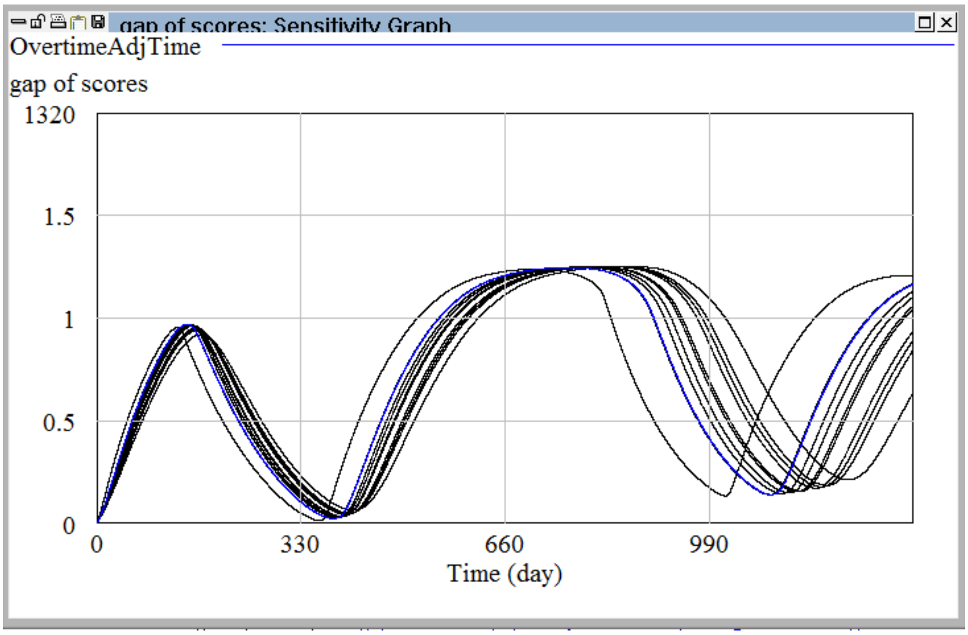

Figure 5.32. Gap of scores.

Sensitivity Analysis 4: For the sensitivity analysis of quit-time of experienced employees we set that parameter between 1 and 500 uniformly. The result for the total number of employees indicates that the parameter is highly sensitive because the total number of employees varies between 200 and 2000 at time 660. The result is close to the expectations and can be seen in Figure 5.33.

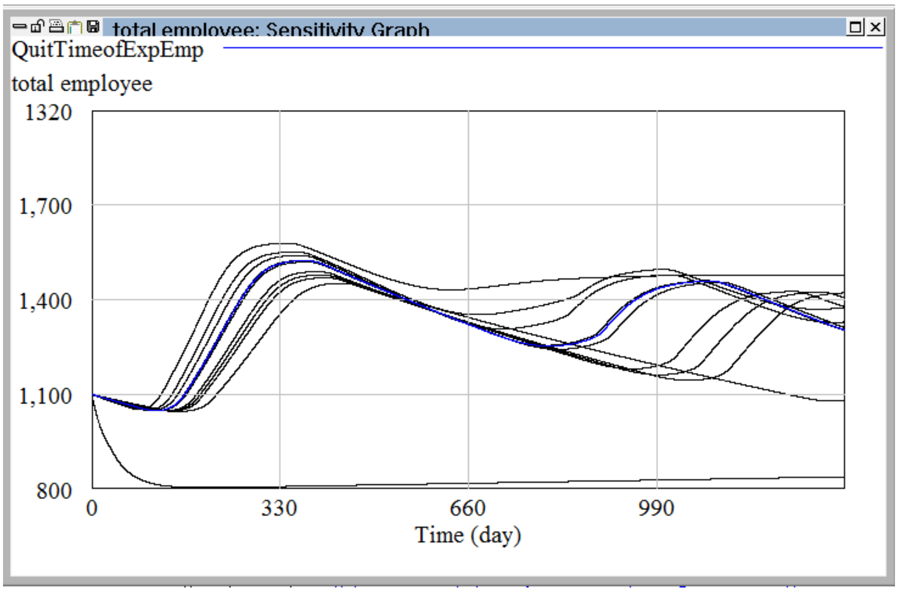

Figure 5.33. Total number of employees.

Sensitivity Analysis 5: For the sensitivity analysis of project inflow parameter, we set it between 1 and 1000 uniformly. The result for total number of employees indicates that the parameter is highly sensitive since the total number of employees varies between 600 and 1600 at time 1000. The result is close to the expectations and can be seen inFigure 5.34.

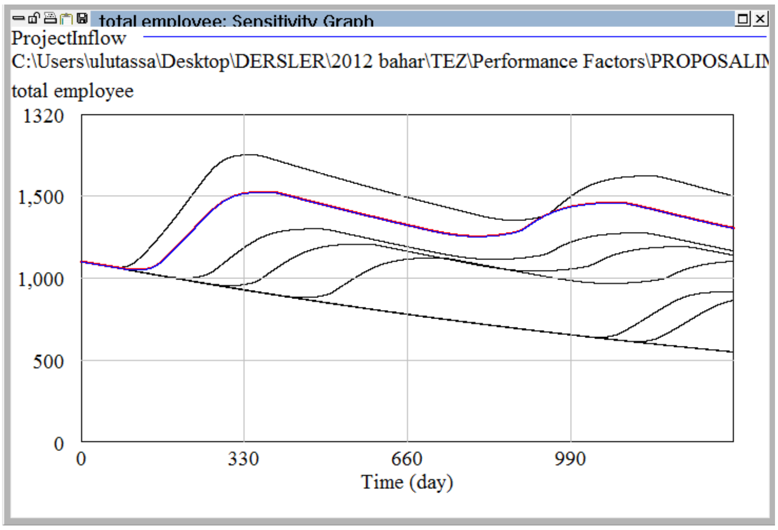

Figure 5.34. Total number of employees.

Other parameters analyzed for the sensitivities are listed in Table 5.2. They are all numerically sensitive.

Table 5.2. Sensitively analyzed parameters.

Parameter Name	Sensitivity Analysis
Assimilation adjustment	Numerically Sensitive
Productivity inexp.	Numerically Sensitive
Quit rate inexp.	Numerically Sensitive
Exp. salary per month	Numerically Sensitive
Days-off	Numerically Sensitive

5.2. Behavior Validity

Afterthe validity of the model, structure wasensuredby structure validity tests, which weredesigned to measure the level of accuracyof the model. They can reproduce the major behavior patterns expressed by the real system. It is essential to note that the emphasisin behavior validity testing is on pattern prediction (periods, frequencies,trends, phase lags, amplitudes, and so on), rather than (event) prediction [8].

Using real data, behaviors generated by the model and real behaviors of total number of employee was compared to each other for the pastfour years. The model generatedsimilar behaviors as the real life behaviors are. The future behavior was found to be consistent with the assumptions here in all aspects. Real behavior of the system versus model results for the tested parameters is presented in the following subsections.

The most significant variables that given performance scores, overtime amount,and total employee change were tested behaviorally for last five years and validated as seen in Figure 5.35, Figure 5.36and Figure 5.37respectively.

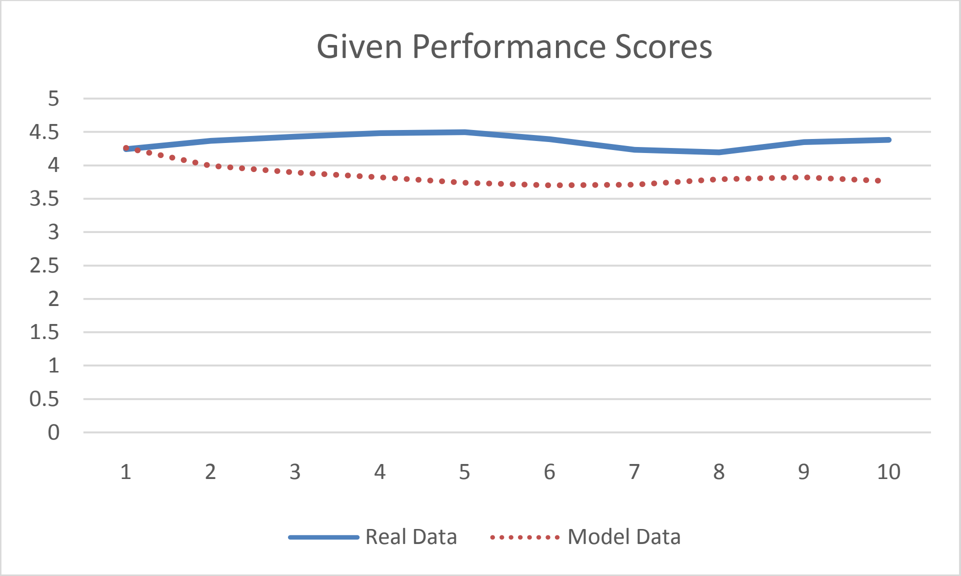

Figure 5.35. Simulated given performance scoresvs real given performance scores.

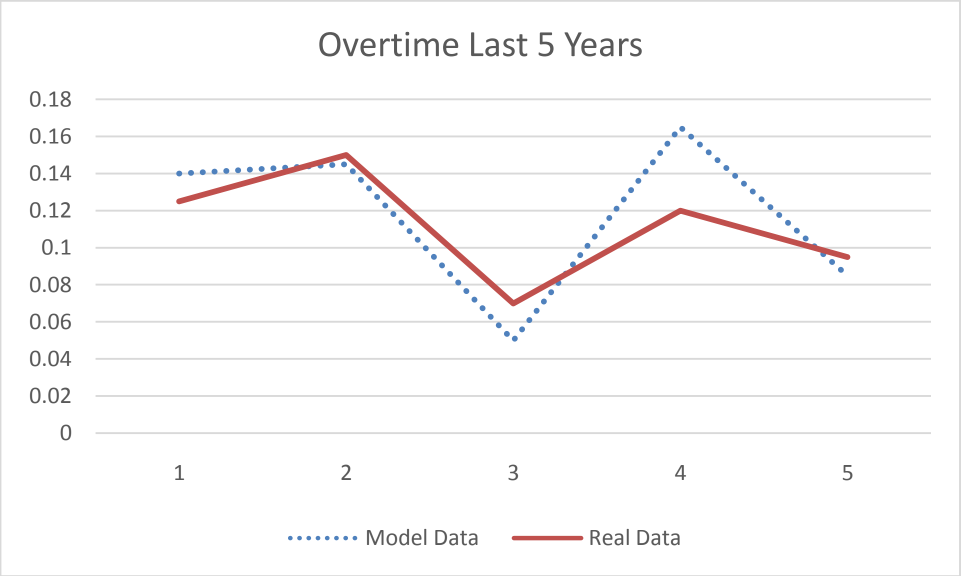

Figure 5.36. Simulated overtime amount vs real overtime amount.

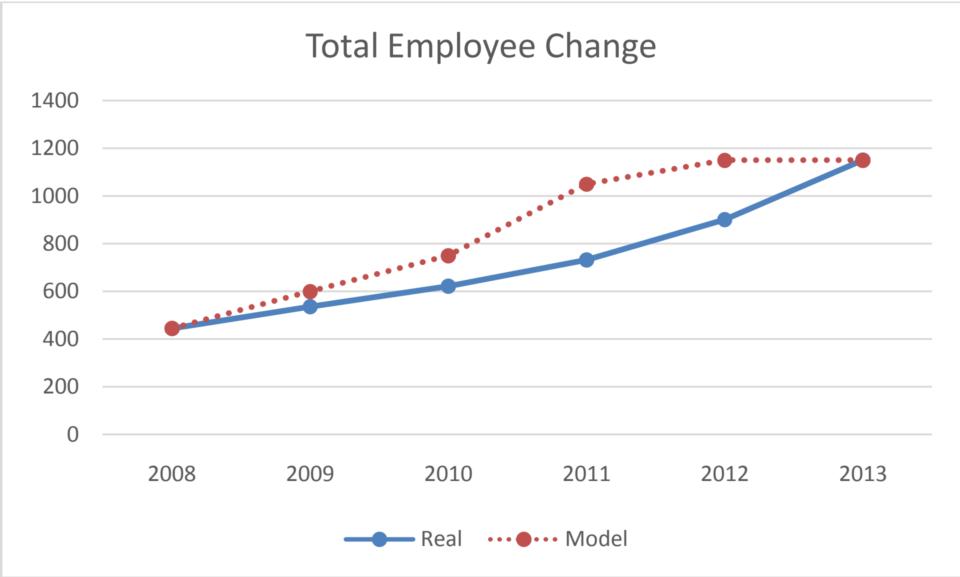

Figure 5.37. Total employee change for last 5 years.

6. BASE BEHAVIORANALYSIS

According to the base behavior, simulation model was run for 1320 workdays, which means six years since 264 workdays equals to one work year in the model. According to the base simulation given performance scores, productivity based score, total employee, project workload, overtime, hiring rate, and motivation change can all be seen in following figures. From a critical point of view, we can start with the performance score gap figure as seen in Figure 6.1. The gap between two different types of score is wavy and varies between 0 and 1.2.

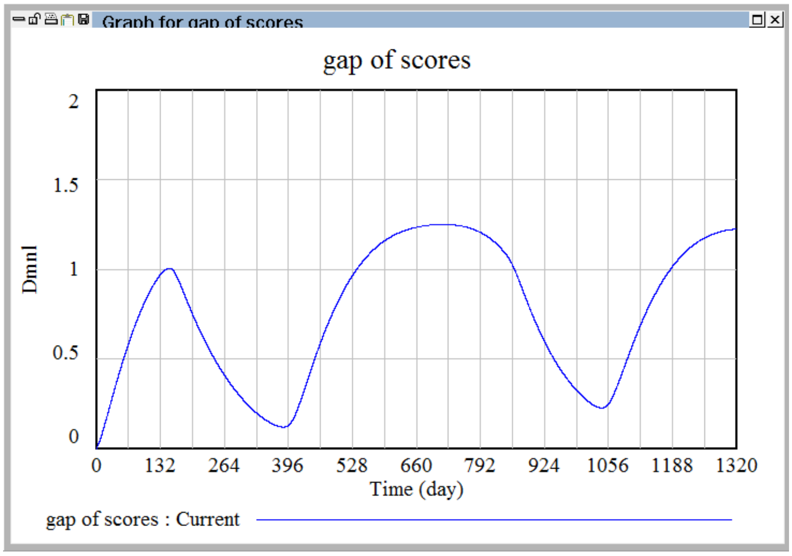

Figure 6.1. Gap between given performance score and productivity-based score.

In order to investigate why there is a wavy gap, we can track the graph of two input variables, which includes given performance score and productivity based score. Both can be seen in Figure 6.2. Although there is a huge change in the productivity based scoring in time, the change in given performance score is not a high amount and does not fit with productivity based scoring. The given performance scores were not changed significantly and is potentially motivation stable; however, motivation is not only affected by given performance scores. It is also negatively affected by the gap between given performance score and productivity based performance score.

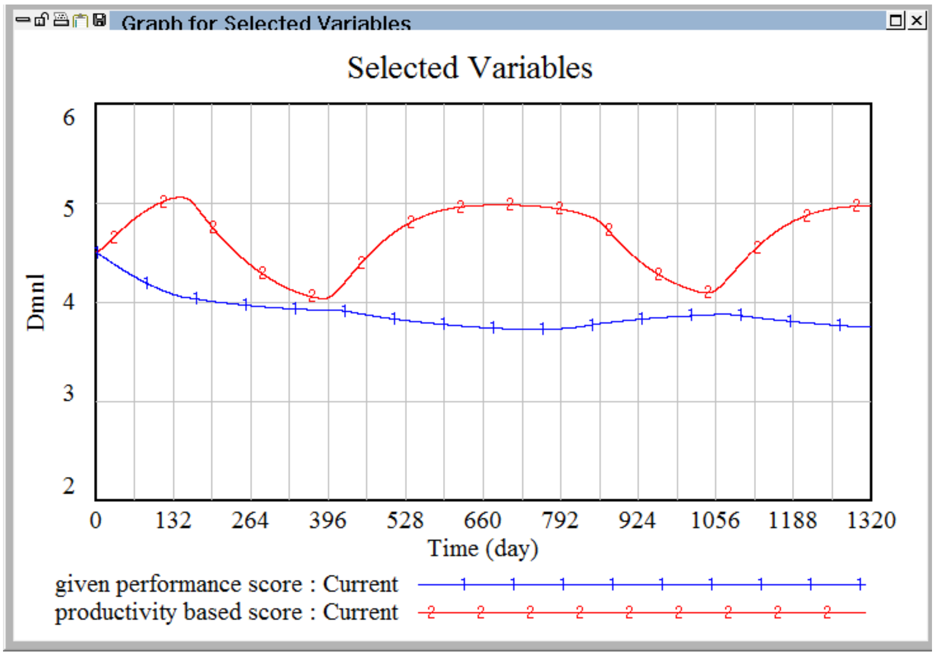

Figure 6.2. Given performance scores and productivity based scores.

The negative impact of gap on motivation will be seem delayed in Figure 6.3. Yet, it is clear that motivation is directly affected by gap of scores. Other factors affecting the motivation are overtime, given performance scores, training ratio, and days-off ratio. Overtime is seen in Figure 6.4. Overtime impact on motivation is negative. Given performance scores affect motivation positively and do not enact a significant change in time. Training ratio and days-off ratio are decision parameters and set 0.023 (6 days) and 0.038 (10 days) respectively.

Overtime is the most critical variable in the model since affects given performance score, motivation level, productivity and cost directly. Moreover, overtime is only affected by the expected to desired ratio of throughput time. XT Management prefers employees do overtime at least 5%. Thus, in our model, if throughput ratio is 1 or less, the model cause employees do overtime 5%. If the throughput time ratio is bigger than 1, the model causes employees increase the overtime ratio as seen in Figure 6.5. The change of throughput time is shown in Figure 6.6.

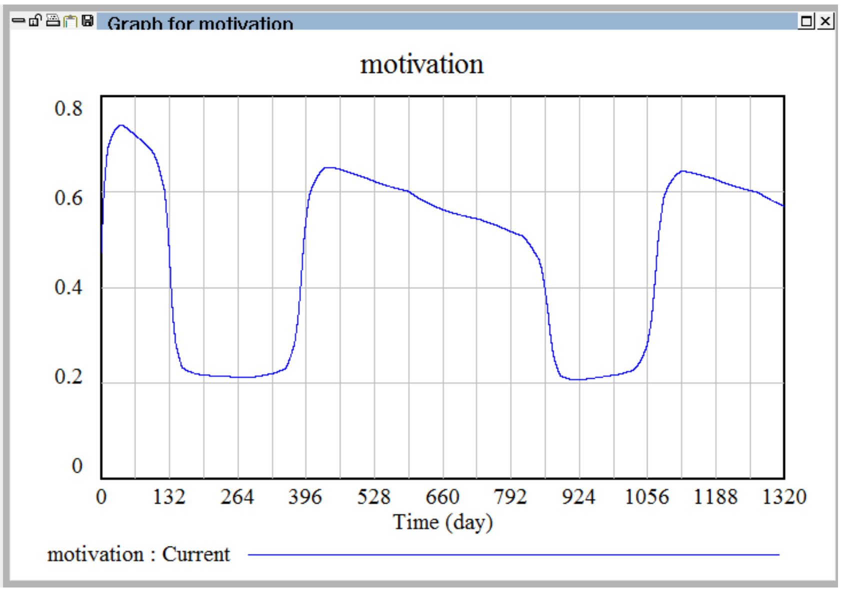

Figure 6.3. Motivation levels.

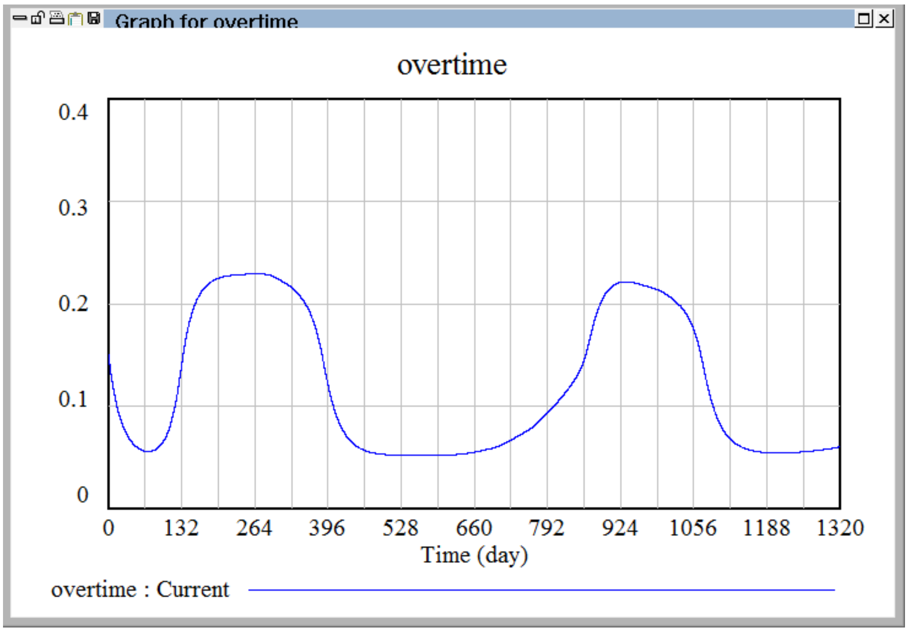

Figure 6.4. Overtime change.

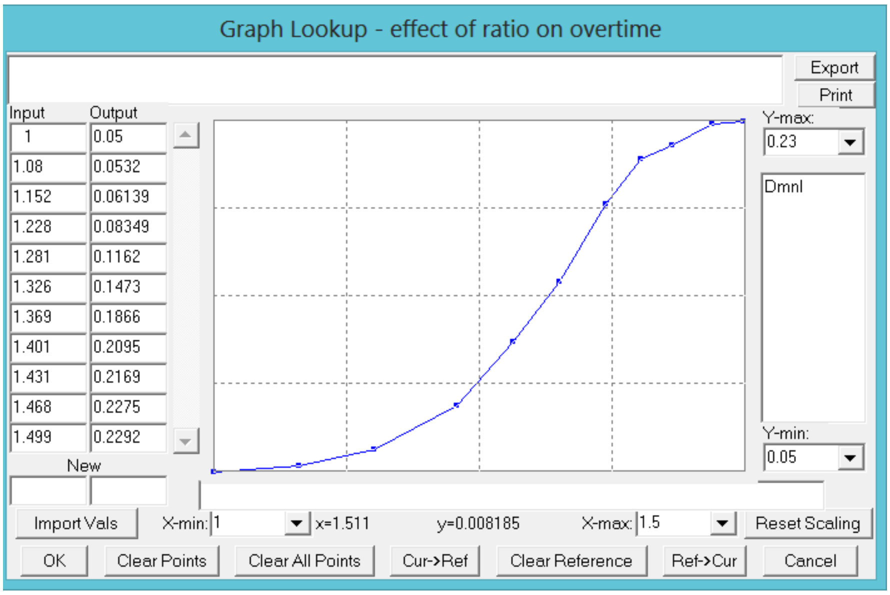

Figure 6.5. Effect of throughput time ratio on overtime.

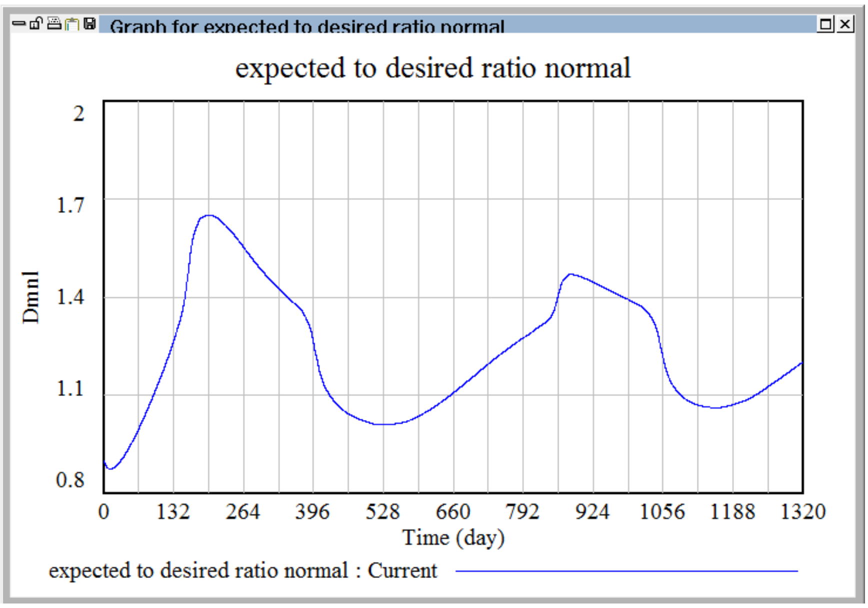

Figure 6.6. Expected to desired ratio of throughput time.

Throughput time ratio is affected by project workload and normal man capacity man-days. Those two variables are seen in Figure 6.7.

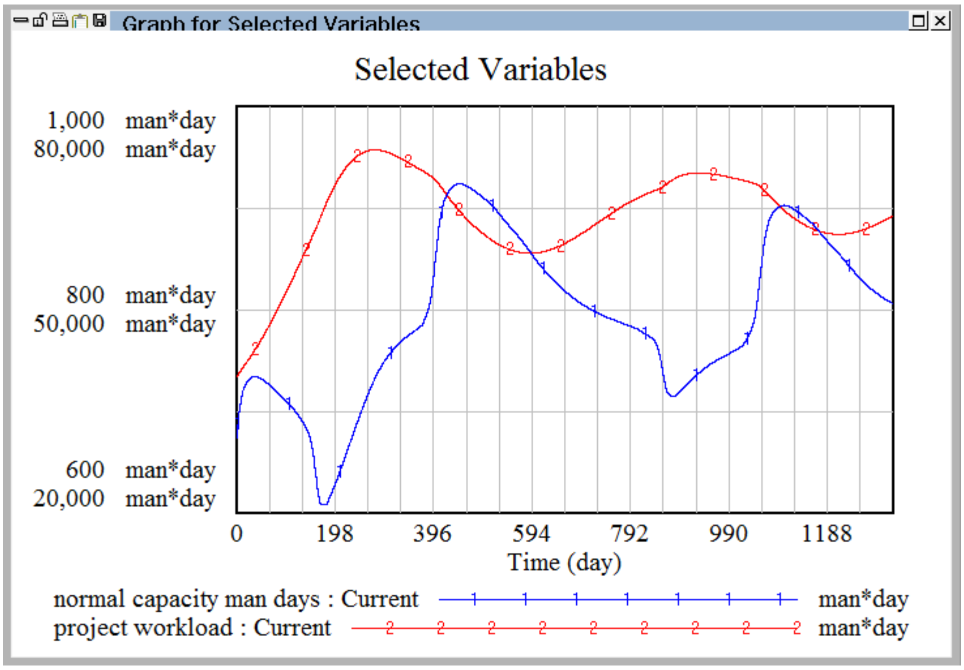

Figure 6.7. Project workload and normal man capacity.

There is high variation in the variable of normal capacity man-days. The variables affecting normal capacity are total number of employees, and productivities and available days of those employees. The total number of employees is seen in Figure 6.8. Furthermore, experienced and inexperienced employee numbers can be seen in Figure 6.9.

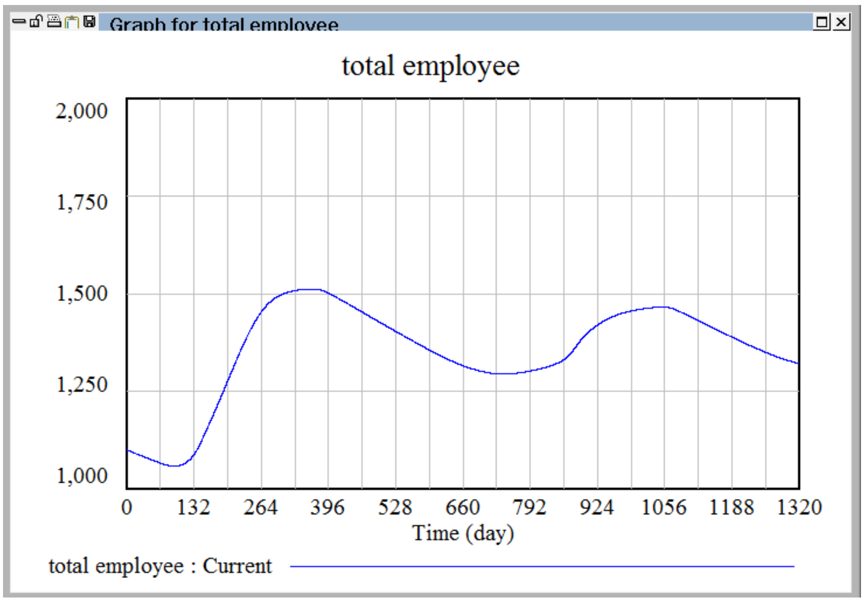

Figure 6.8. Total number of employees.

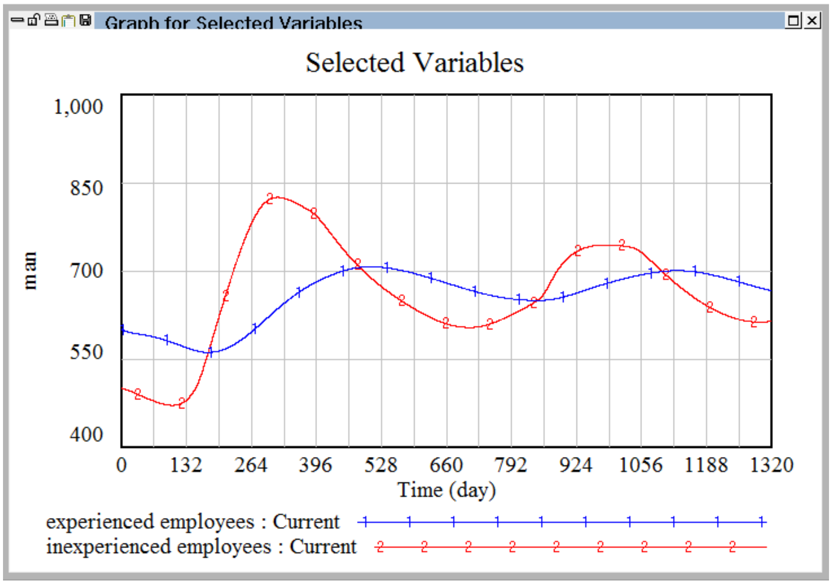

Figure 6.9. Experienced and inexperienced employees.

The hiring rate and quit rates can be seen in Figure 6.10. Hiring rate is affected by expected to desired ratio of throughput time along with overtime variables, and employee pool. If that variable does not exceed 1, employees can complete the work within the time bound but they have will have to maximize overtime. XT Management prefers to hire new people as 0.9 times of the need. However, if the variable exceeds 1 and gets closer to 1.5, XT prefers to hire new people 1.5 times of the need since they cannot evaluate the exact need immediately. The effect table of the parameter can be seen in Figure 6.11. As an exception, if model has no employee, the model will hire at least 10 employees at a time.

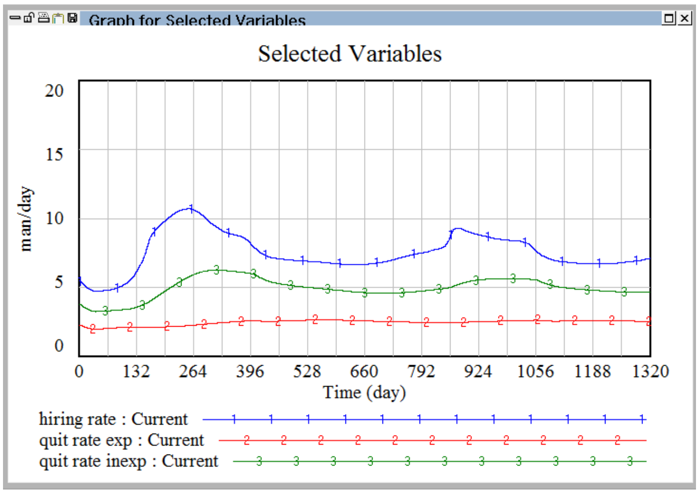

Figure 6.10. Hiresand Resignations.

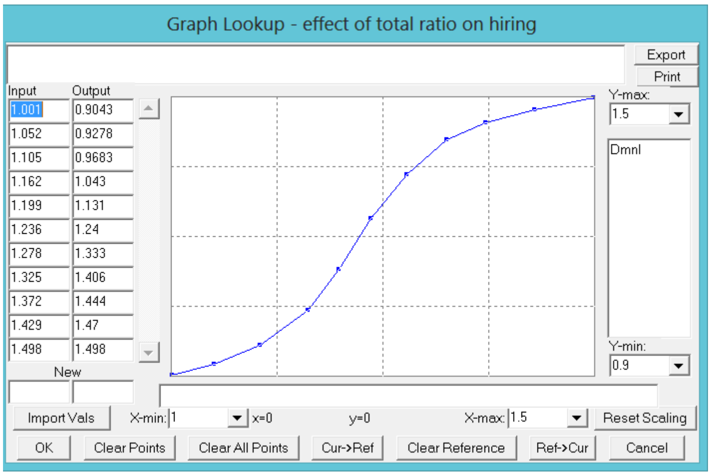

Figure 6.11. Effect of throughput time (with overtime) ratio on hiring.

One of the other factors affecting given performance score is the average experience of employees in XT. According to the observations, new employees behave as experienced employees after one year of their initial hiring. Furthermore, the current average experience duration of inexperienced employees is 0.5 years, whereas the average experience duration of experienced employees is 8.0 years. According to observations, the model generates average experience of XT as in Figure 6.12. Increasing average experience negatively affects given performance scores according to the SEM results.

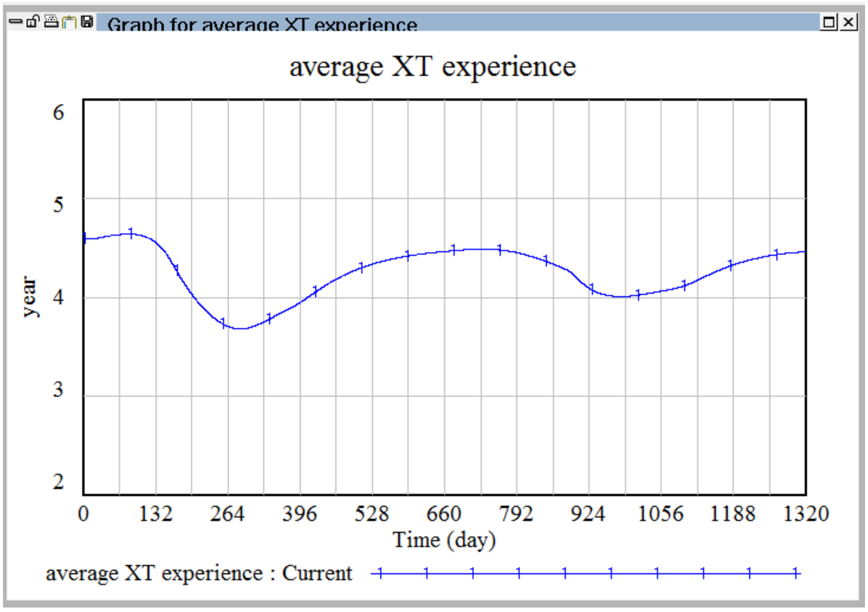

Figure 6.12. Average experience of XT.

Productivity is another factor affecting the given performance score. Productivity is positively affected by motivation, training amount, and average experience. However, overtime amount affects productivity negatively. According to the model productivity of experienced employees changes between 0.9 and 0.6 in the following six years as seen in Figure 6.13. Furthermore, the assumption for productivity of inexperienced employees is 0.5.

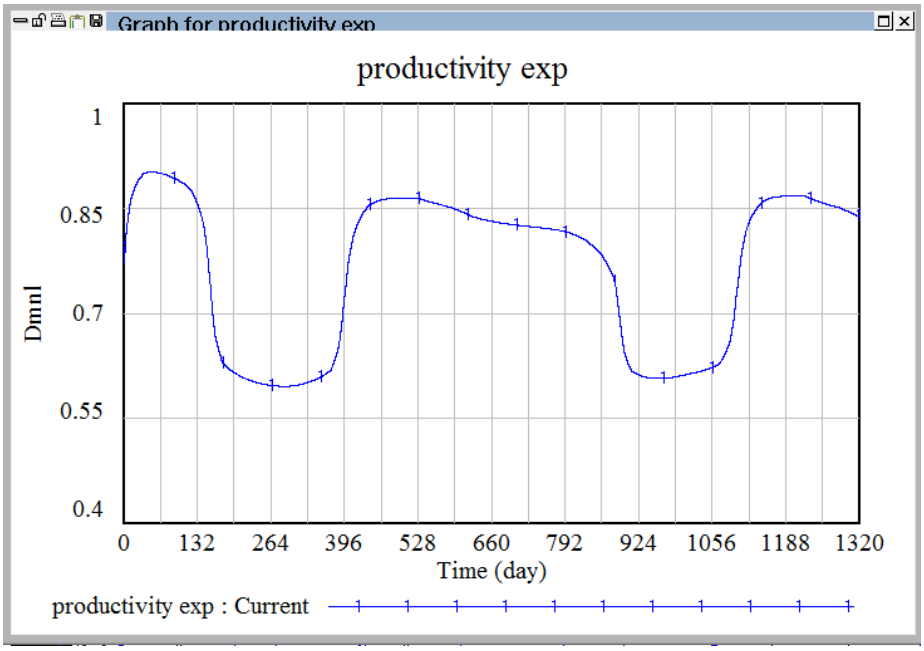

Figure 6.13. Productivity.

The last factor affecting the given performance score is cost. According to the observations, cost has a negative impact on given performance scores. The HR department explains if the cost for the related term is high, then the given performance scores can be lower. Cost variable is affected by base salaries, overtime costs, training cost given performance scores' cost (since they have direct relationship with base salary), and promotions. The average cost change for following years can be seen in Figure 6.14.

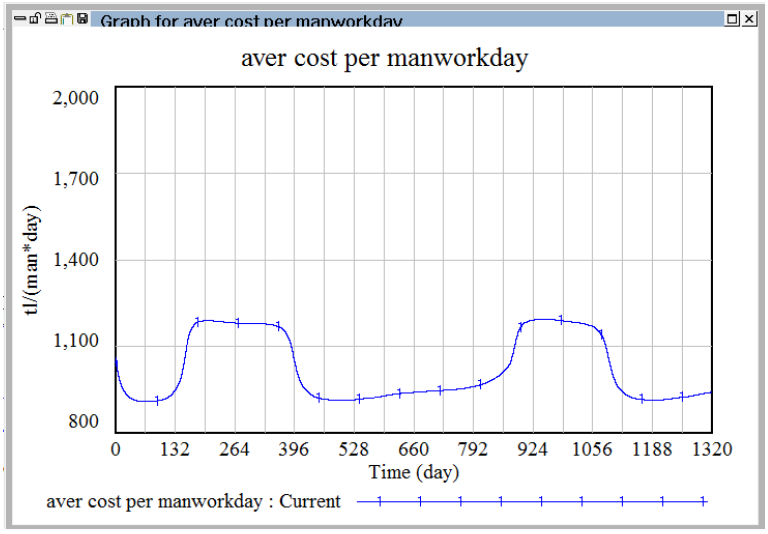

Figure 6.14. Average cost per man day.

The critical points of the SD model summarized above. According to the problems observed in the summary, we analyzenew scenarios and policies for the future. However, before analyzing the model, we validate it in the next section.

7. SCENARIO AND POLICY ANALYSIS FOR SD MODEL

In XT, the HR department is faced with many problems regarding hiring, ranking, and motivatingpeople. In this thesis, the proposed model is used as an instrument to investigate those problems and search for their appropriate solutions.Before we introduce the scenarios for investigation, we will first summarize the major problem areas in the HR department.

First, the hiring rate in the company is much higher than other similar companies. They hire 4-5 people in only one workday, which indicates an uncontrolled growth.

Second, there is a huge project demand from the X Bank, theprimary customer of XT, right now. However, there is no guarantee that demand will continue to increase at this high rate.

Third, although there is a high amount of backlog of work, the upper management of XT may agree with another bank to serve as their primary IT Company. Under such circumstances, the work backlog may instantaneously double.

The fourth problem is related directly to the employee dissatisfaction, which lead into high turnover rate. Currently, the performance score gap does not significantly influence the turnover rate. However, this effect is expected to be more dominant in the near future.

Another critical issue is related to theperformances assessment and the scores given by the managers. It is known that managers do not take into account the employee productivity level while deciding on the performance scores.

Below, we present fourin depth scenarios and two policies in order to create solutions for the problemsand demonstrate the results with graphs.

7.1. Scenario 1: Available candidates decrease

There is an employee candidate pool in the model. However, there is a well-accepted policy in the company, that if an employee quits or is fired, he can never bere-hired. In addition, we assume that every year 264 new graduates become eligible to be hired and added to the candidate pool.It is clearly seen that the intake rate to the candidate pool remains to be stable whereas the hiring and outflow rate from the company are consistently increasing in the recent years. Thus, the source of candidate pool is steadily diminishing. More specifically, the model indicates that in six years, finding new people to hire will be more difficult.

The initial employee pool value is set to 5000, which causes pool to drain at time 780 workdays. Since the pool drains, total number of employees of XT starts to decrease around the same time as seen in Figure 7.1. The side effects of this condition include the following: increasing overtime, increasing cost, and decreasing productivity as seen in Figure 7.2, Figure 7.3 and Figure 7.4, respectively. In order to alleviate this possible problem, thecompany can change its hiring policy and begin to hire ex-employees.

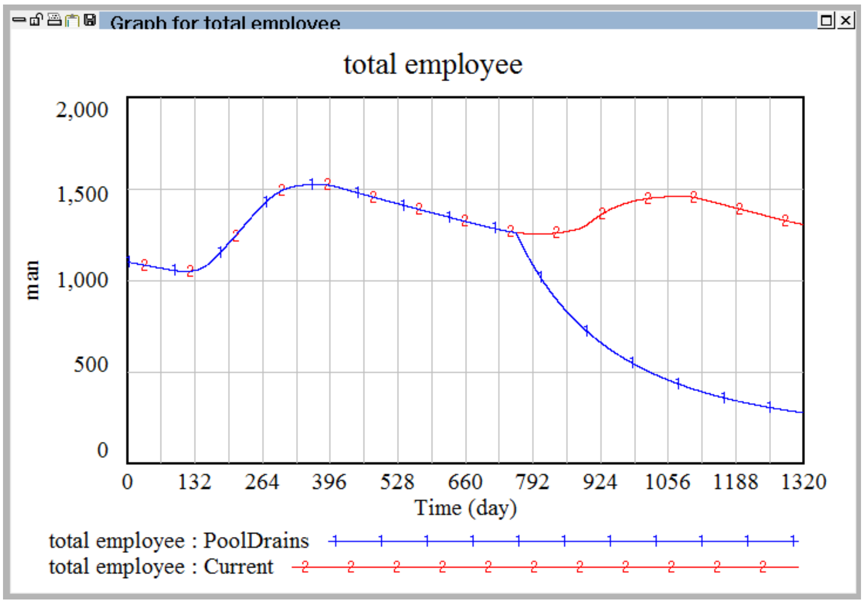

Figure 7.1. Total number of employees.

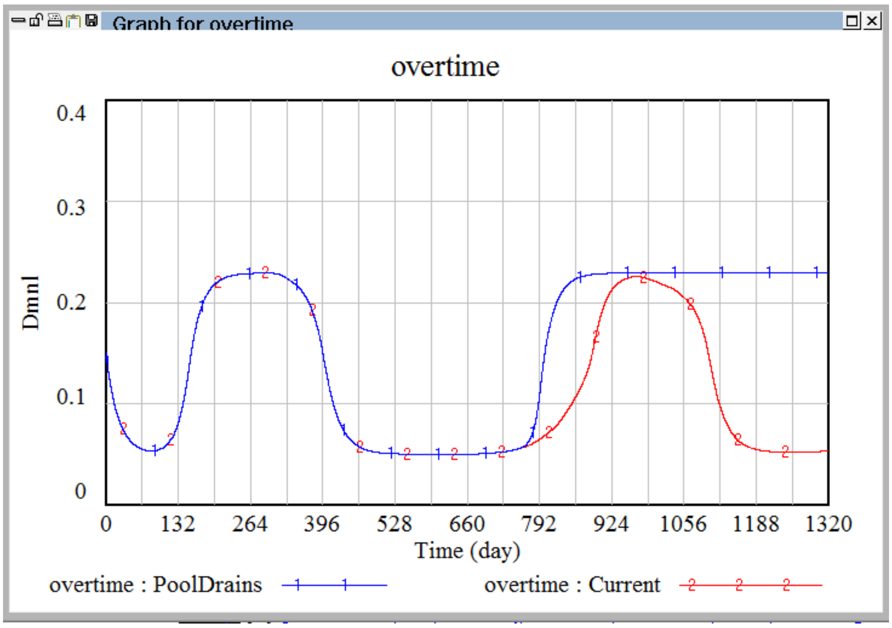

Figure 7.2. Overtime change.

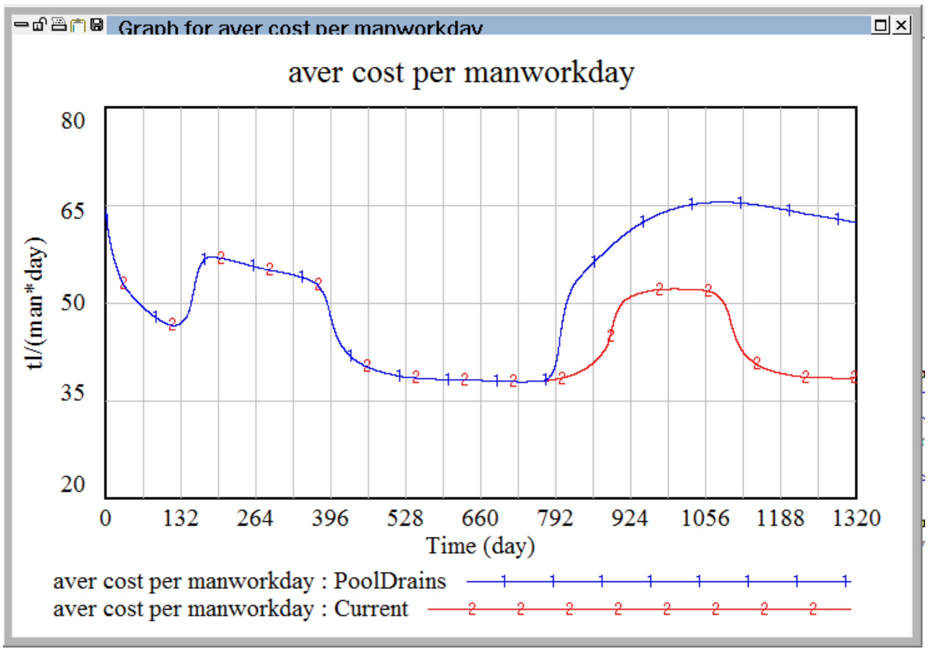

Figure 7.3. Average cost per man day.

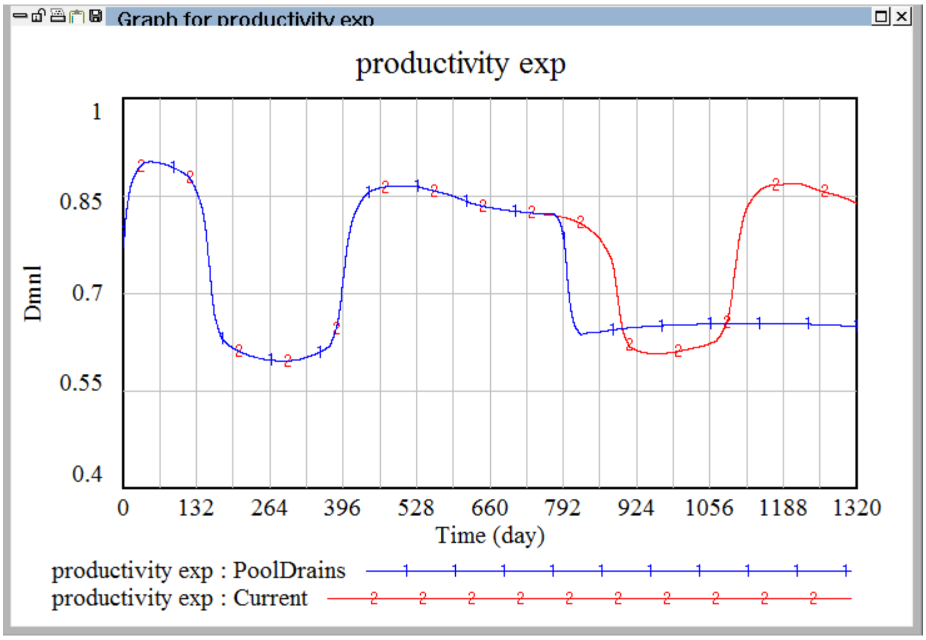

Figure 7.4. Productivity.

7.2. Scenario 2: New project amount per day suddenly decreases

Let us assume that a destructive crisis occurs in the financial sector at time 264, which in turn decreases the new project rates dramatically. In this situation, although there is not much work to do, thecompany will still have an excessive workforce. Thus, there would be no work backlog as seen in Figure 7.5.Furthermore, the decrease in the total number of employee is shown in Figure 7.6. The significant cost increase is displayed in Figure 7.5. This significant impact results in a firing freeze and a workforce that remains under utilized.The sudden decrease of incoming work will negatively affect the motivation and productivity since the given performance scores will be decreased by managers. Furthermore, the gap between the given and productivity based scores will increase greatly. Motivation level and gap of scores can be seen in Figure 7.5 and Figure 7.6, respectively.

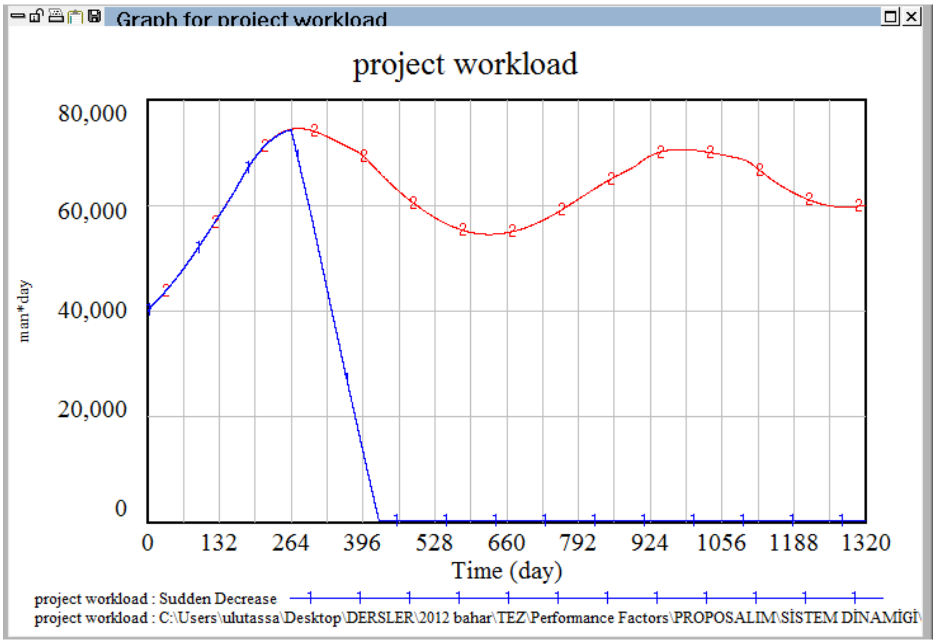

Figure 7.5. Project workload.

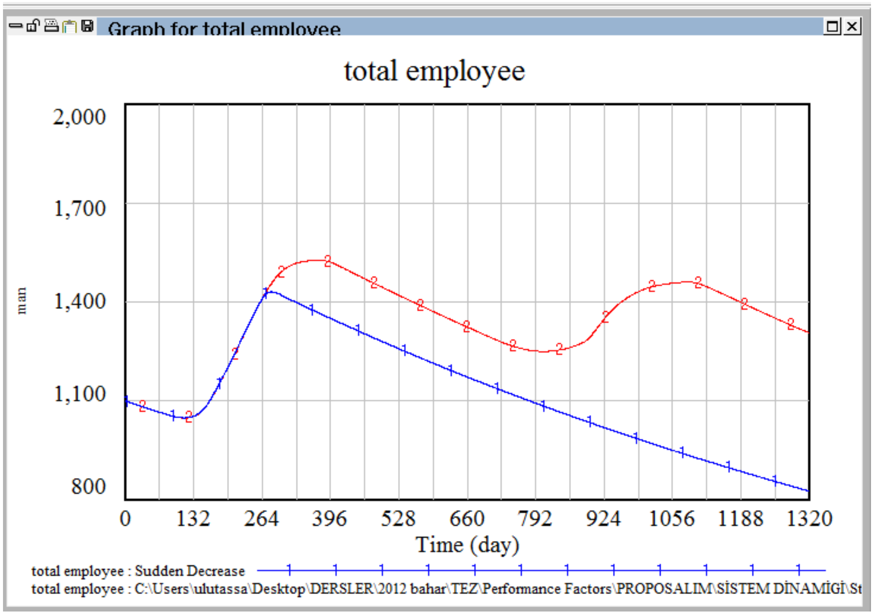

Figure 7.6. Total Employee.

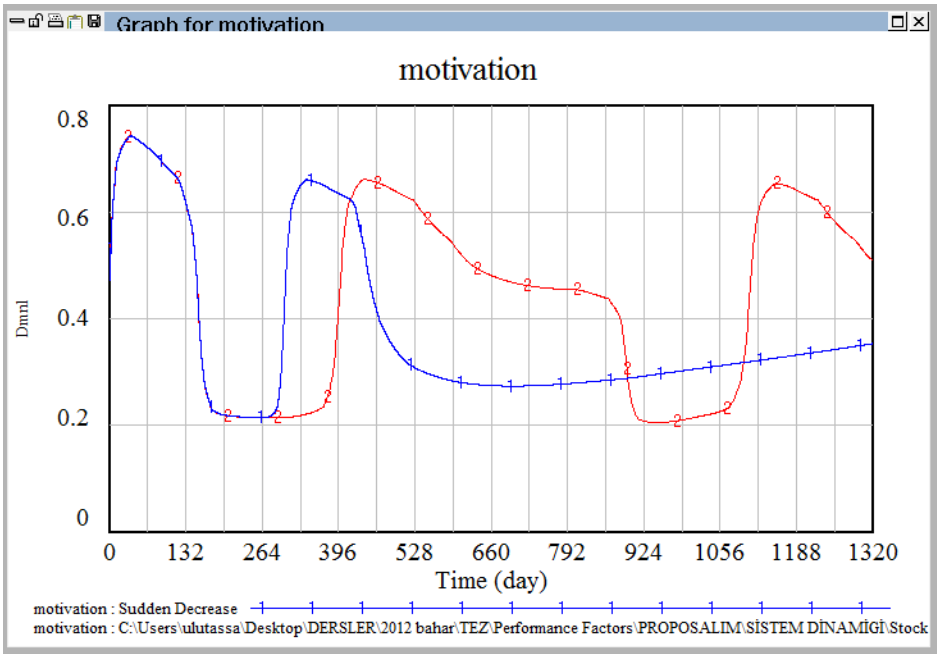

Figure 7.7. Motivation.

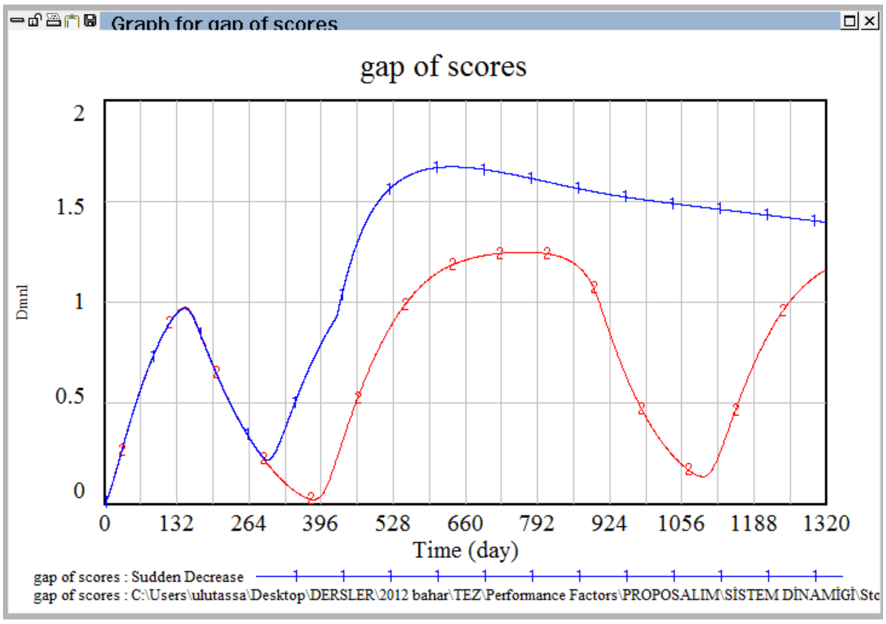

Figure 7.8. Gap of scores.

7.3. Scenario 3: Increase workload while avoiding motivationdecrease

If the upper management doubles the workload, what are the options the decision maker can utilize to prevent a decrease in motivation? There seems to be three options to compensate for the workload and to avoid motivation loss. The managers may decide to increase the work benefits such as amount of training days and vacation days, and further reducing the overtime limits. Although it sounds like the work benefits offered contradict the workload increase, they certainly help the employee motivation. As a result, the employees work more efficiently and effectively.

The scenarios are tested and the results indicate that increasing training days and days offare not sufficient to alleviate decrease in motivation. However, if the upper management makes a decision that limits the overtime to 10% instead of 23%, motivation level will be better than before as shown in Figure 7.9. Moreover, the average cost of working on a project will be much betteras seen in Figure 7.10.

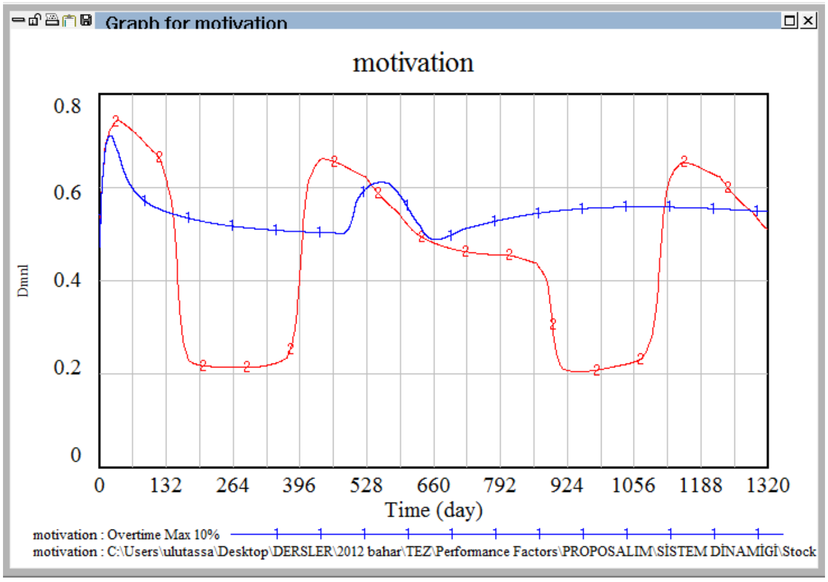

Figure 7.9. Motivation change.

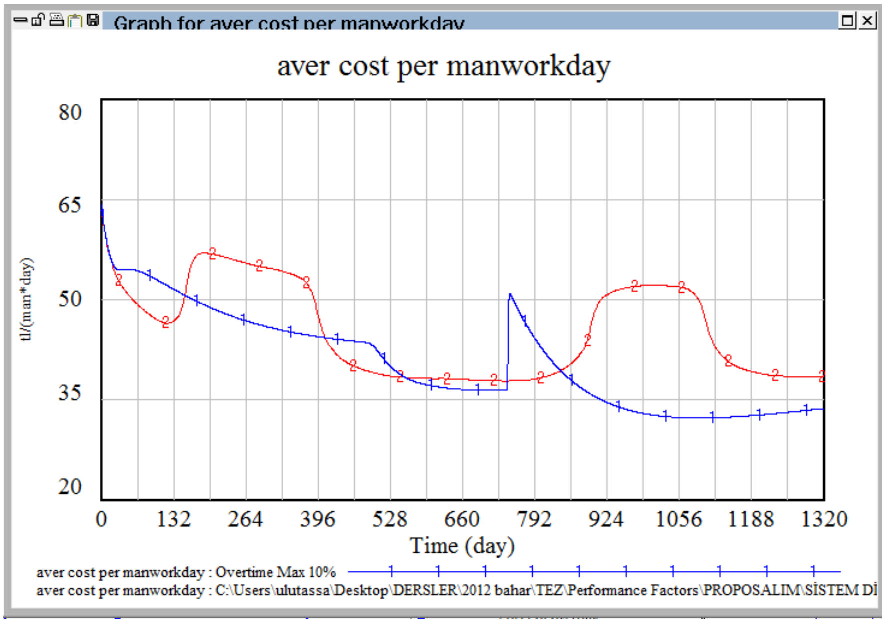

Figure 7.10. Average cost of per man day.

7.4. Scenario 4: Gap between productivity based performance and supervisor given performance affects turnover ratedirectly

We realize that if the gap between productivity-based performance and given performance has a negative effect on turnover rate, we canadd a new variable into the model for this relationship. According to the results of new condition, turnover rate will be much higher than before.

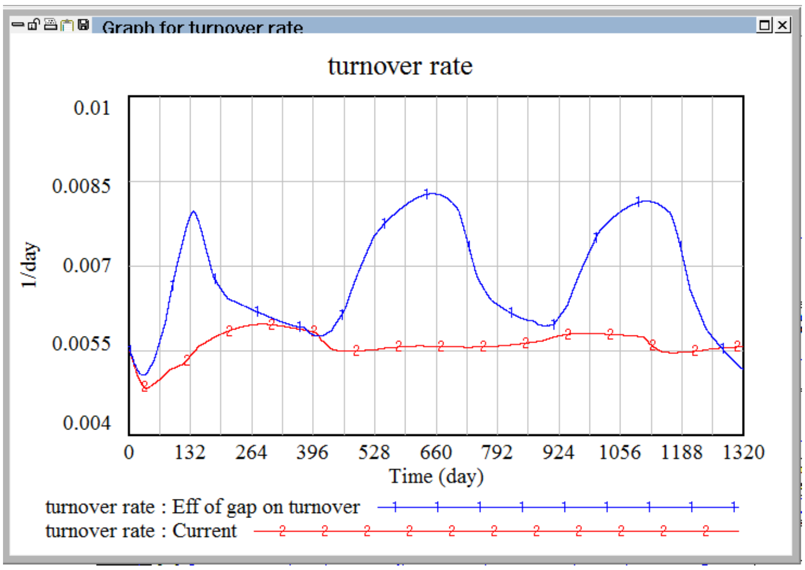

Figure 7.11. Turnover rate change.

7.5. Policy 1: Managers base the performance scores according to productivityonly

Performance scores neglecting productivity measures are certainly a serious problem in HR assessment system. In order to alleviate this problem, in Policy 1, the managers consider basing their scores strictly according to employee productivity level. In doing so, the motivation level will increase almost 100% as seen in Figure 7.12.Due to increasing given performance scores as seen in Figure 7.13, the productivity level will also increase. One last advantage is that turnover rate will fall down almost 50% as seen in Figure 7.14. However, the average cost per man-day will increase 100% as seen in Figure 7.15.

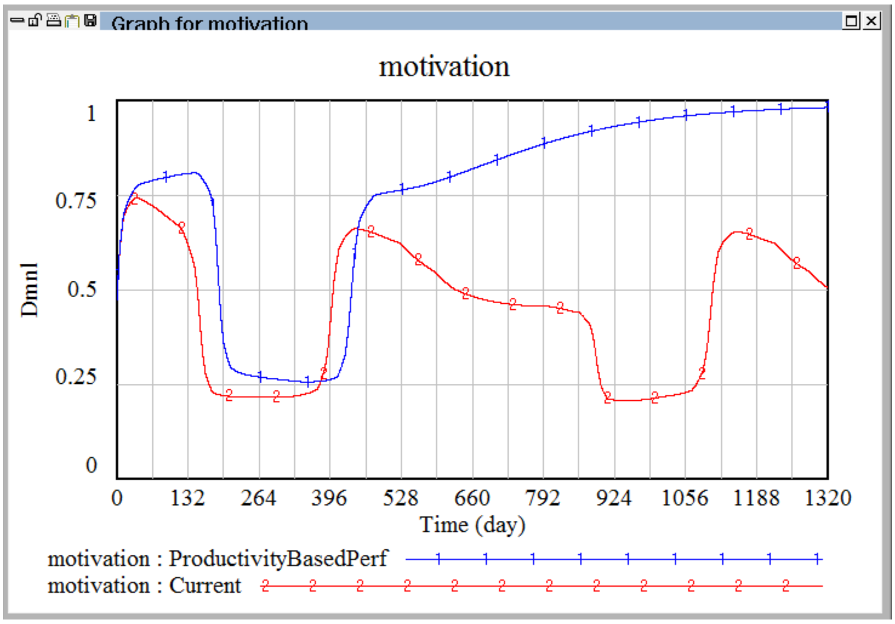

Figure 7.12. Motivation change.

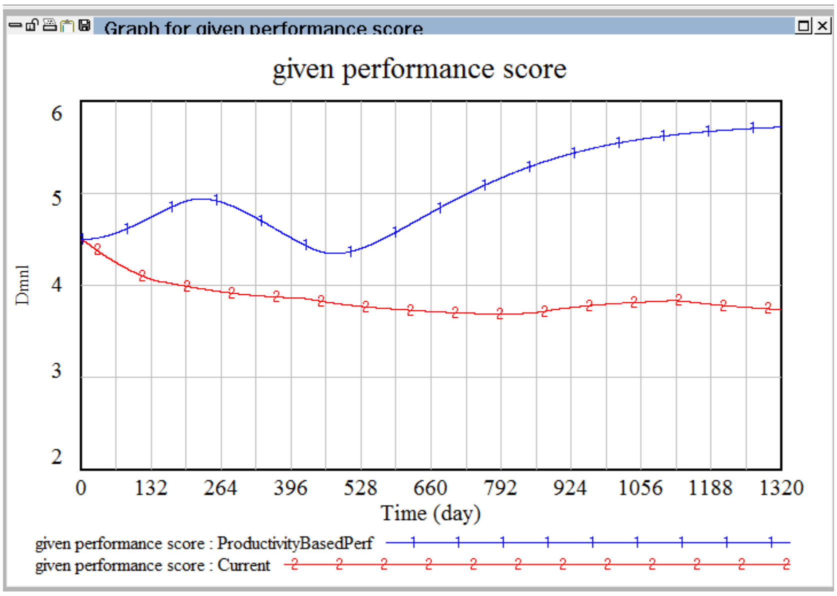

Figure 7.13. Given performance score change.

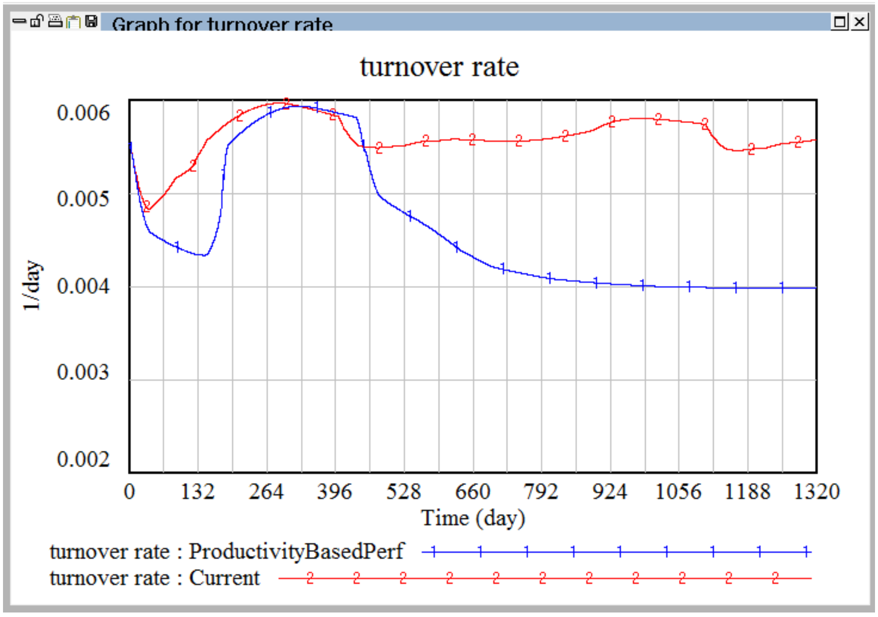

Figure 7.14. Turnover rate change.

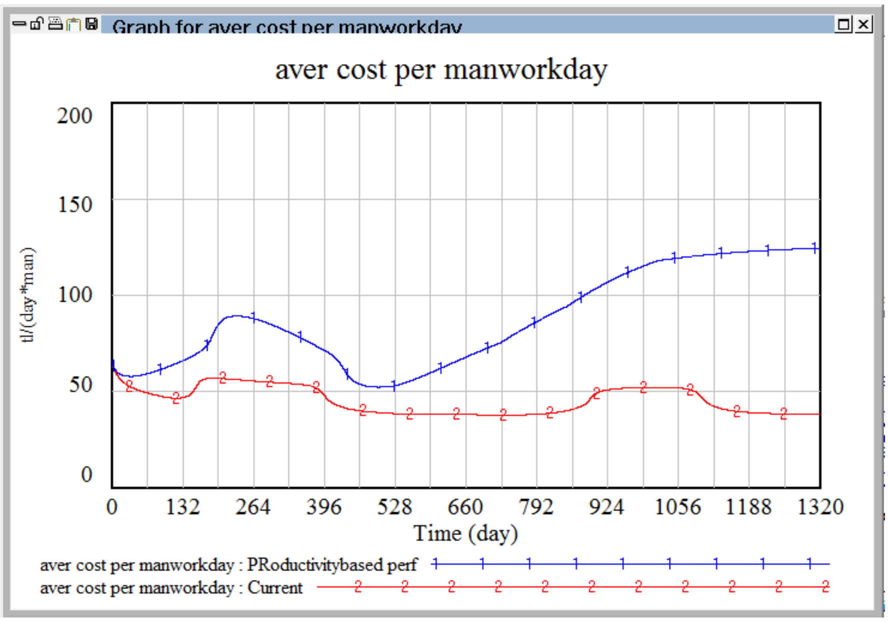

Figure 7.15. Average cost per man day.

7.6. Policy 2: If gap increases, managers tend to increase given performance scores

Our objective in the second policy is to modify the current practice by including productivity measure as a correcting factor for the scores given by the supervisors. As the gap increases, the scores are modified in such a way that they get closer to the productivity scores. This is accomplished by introducing a multiplier for the performance score. Consequently, the subjectivity of current performance assessment system is reduced.

As a result of this policy, given performance scores will positively affect the motivation and productivity. However, the average cost per man-day will increase almost 30%.

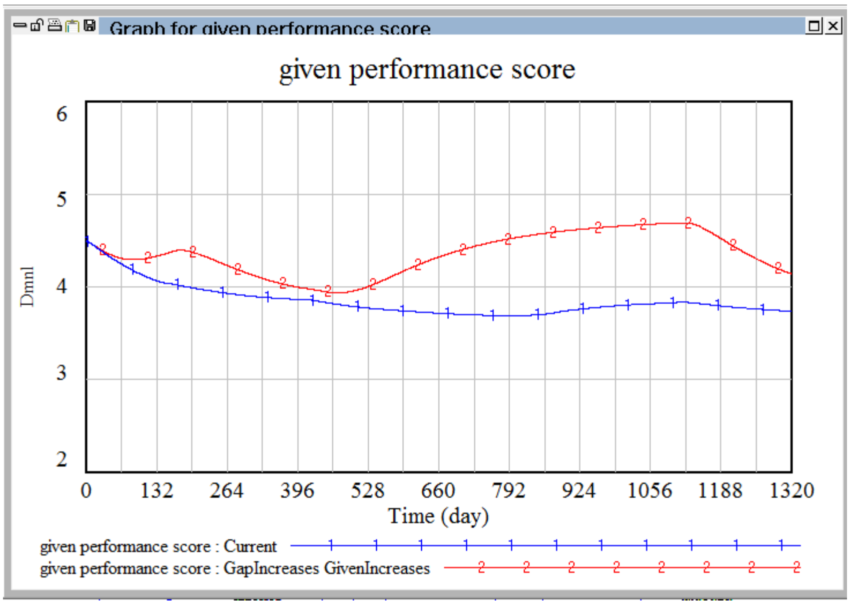

Figure 7.16. Given performance score.

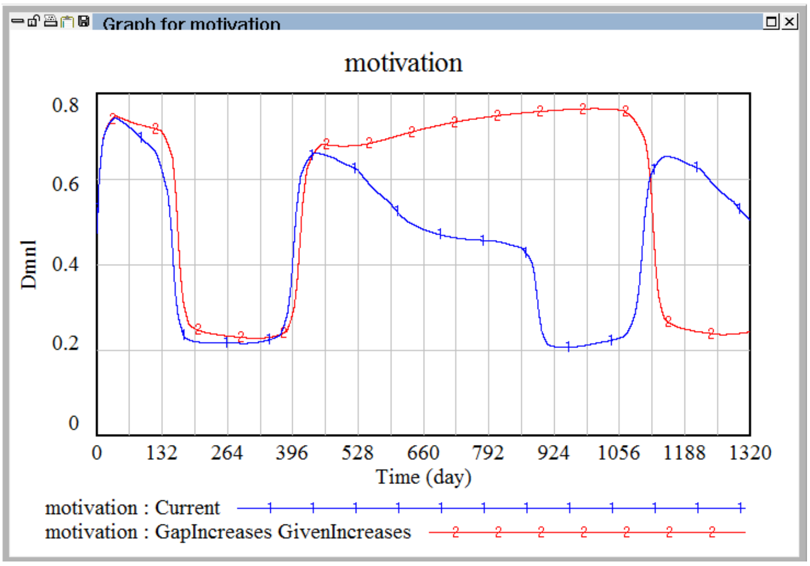

Figure 7.17. Motivation.

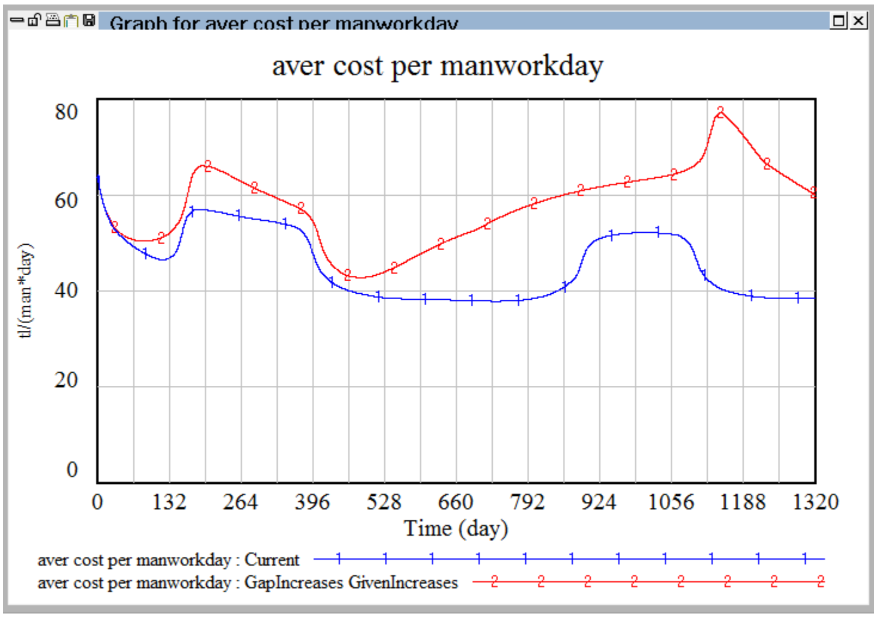

Figure 7.18. Average cost per man day.

7.7. Scenario & Policy Matrix

One of the most significant problems about employee performance management in XT is that even though the employee productivity changes, average score of employee performance evaluated by the managers is unaffected. The underlying reason is the existence of some other factors in XT such as number of projects, overtime amount and average experience duration of employees that affect the employee evaluations of the managers. However, this assessment process is not fair for employees since they may not calculate the scores according to their own productivity level. Thus, we propose a system dynamics model, which creates the scores according to productivity levelonly, and summarize the results accordingly. Predicted scenarios and proposed policies are explained briefly in the previous sections. In this section, we present a scenario & policy matrix and compare it with the base run, which is the most likely outcome. The performances obtained from the simulation runs under different policies and scenarios are summarized in Table 7.1and Figure 7.19.

According to the policy one under the first scenario, the average cost will decrease 20% because of the decrease of the total number of employees, which is caused by the draining of the employee candidate pool. However, motivation and productivity levels will increase owing to this policy, which helps to eliminate the gap of performance scores.

Increased motivation decreases turnover while increased productivity decreases overtime ratio. Currently, XT Company is not much attractive for employee candidates because of the high ratio of overtime. However, if Policy 1 is applied under the Scenario 1, the company will be more attractive for candidates. By the way, application of Policy 2 under the Scenario 1 will be more expensive than the first scenarios since the higher number of total employees.

Under the second scenario, average cost will increase 18% in Policy 1; however, it will decrease 15% in Policy 2. The average cost in Policy 1 is much more than Policy 2 since the performance scores given by the supervisors are much higher than the second policy. Because of the destructive crisis, the incoming workload will diminish, and it will cause overtime to decrease which in turn will help to increase motivation level to the highest level. However, in the second policy, the level of overtime will not change andthe motivation level will only be the indicatorimproving performance assessment scoring.

The third scenario is related to the commitment to another client. In this scenario, the project backlog will be duplicated and the result will be destroyed motivation. However, limiting the overtime amount under the Policy 1 will increase the motivation level 100%. The total number of employees will also duplicated but the average cost will not increase, moreover, it will decrease for 15% since the project outflow will be much more due to the increased productivity. In the second policy, the turnover cost will be higher but it will be compensated with the decreased total number of employees.

The last scenario sounds like a more utopic scenario, which assumes instantaneous influence of score gap on turnover rate. The observations show that, recently, employees start to communicate with the ex-employees. This situation helps employees to learn the real causes of resignations of the ex-employees, which may be related to the unfair assessment system. Currently, the turnover rate is not directly affected by the gap of scores, which means it takes time to be affected by that. However, the assumption of instantaneous influence is actually not an unrealistic one. Under this scenario, if Policy 1 is applied, the average cost will decrease 20% due to the decreased turnover rate and decreased total number of employees. However, if the second policy is applied, the turnover rate will increase 15% and, it will affect the average cost increase around 10%.

Finally, application of Policy 1 is more advantageous than the Policy 2 from the cost point of view in all of the possible scenarios. Furthermore, it is going to help the company for to become more appealing due to the decreased rate of overtime amounts.

The definitions of the key performance indicators:

(i) Motivation: Motivation level varies between zero and one scale. It is affected by the given performance score, training days amount and vacation days positively. However, motivation is negatively affected by the gap between the performance scores and productivity level.
(ii) Productivity: The common definition of productivity is the ratio of outputs to inputs in production. In our proposed model, productivity is highly affected by motivation positively. However, it is also highly affected by the overtime rate negatively. The productivity level varies between zero and one.
(iii) Overtime: It is the ratio of extra work hours owing to the normal work hours at a time. Its current limit is 23%.
(iv) Performance scores: The scores that are given by supervisors. The score range is measured with a one to six scale.
(v) Turnover: Turnover rate is only affected by the employee motivation in the proposed model and the effect is negative.
(vi) Total employee: Number of total employee at any time at XT.

Average cost / projects completed: Average cost is obtained by dividing the total cost to total number of project outflow at a time. The total cost is the summary of salaries, trainings, promotions, and turnover. Turnover cost for an employee is assumed equal to 150% times of the total amount of her annual salary because of the conversations with HR department.

Table 7.1Comparison of KPIs under different policies and scenarios with reference to the base run.

Scenarios	**Key Performance Indicators**	**Policy1:** Performance scores are based according to productivity only	**Policy2:** Performance scores are created taken into account productivity partially
Scenario1: Diminishing candidate pool	Motivation	50%	5%
	Productivity	20%	5%
	Overtime	-33%	10%
	Performance score	25%	10%
	Turnover	-18%	-5%
	Total employee	-50%	-30%
	Average cost	**-20%**	**-5%**
Scenario2: Destructive crisis lowering project inflow	Motivation	120%	50%
	Productivity	100%	10%
	Overtime	-60%	0%
	Performance score	30%	10%
	Turnover	-10%	-5%
	Total employee	-30%	-10%
	Average cost	**18%**	**-15%**
Scenario3: Project inflow increased due to the commitment to another major client	Motivation	100%	20%
	Productivity	20%	10%
	Overtime	-30%	-5%
	Performance score	30%	15%
	Turnover	-18%	-5%
	Total employee	100%	-10%
	Average cost	**-15%**	**0%**
Scenario4: Instantaneous influence of score gap on turnover rate	Motivation	100%	30%
	Productivity	30%	5%
	Overtime	-60%	0%
	Performance score	40%	10%
	Turnover	-20%	15%
	Total employee	-20%	-5%
	Average cost	**-18%**	**10%**

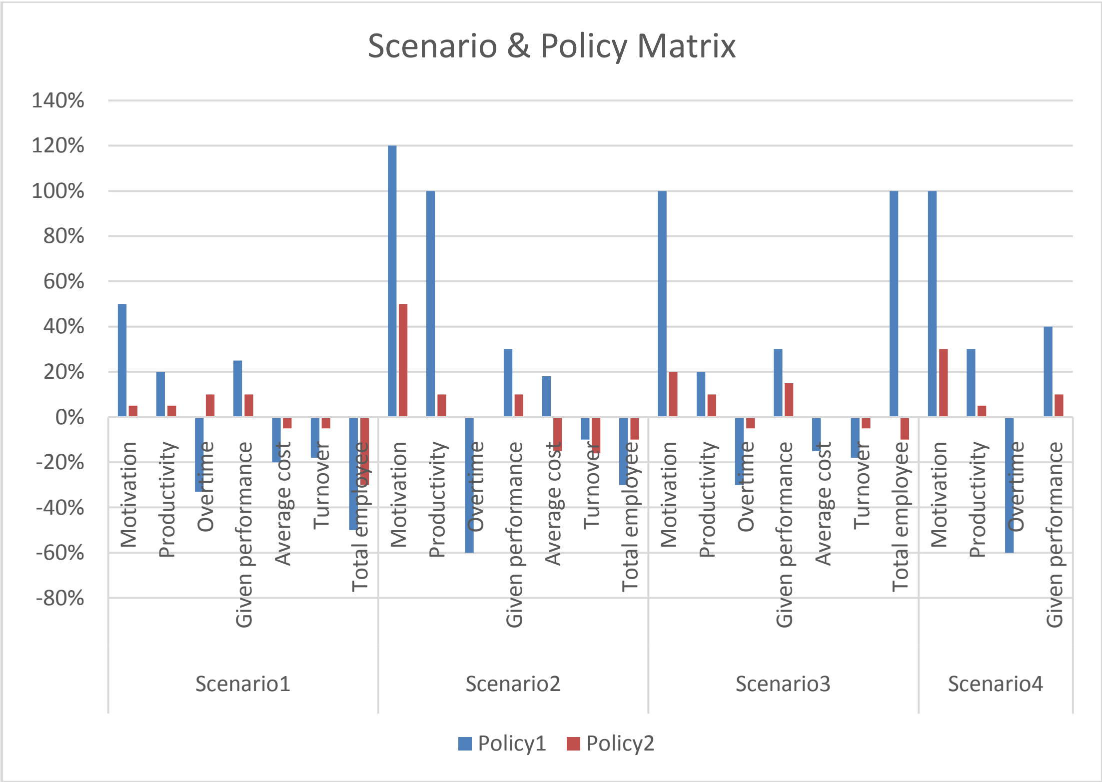

Figure 7.19Comparison of KPIs under different policies and scenarios with reference to the base run.

8. CONCLUSION & FURTHER STUDIES

Although employee performance assessment system is a well-developed approach for the manufacturing sector, it is going to take time to adapt it to an IT Company effectively. Since it is difficult to define the key performance indicators of an IT employee, it is also not possible to measure them. However, nowadays a lot of IT Companies in Turkey try to develop their own employee performance systemcontinuously based on their experiences. One such company in search of a more effective performance evaluation system is XT. At XT, supervisors assess their employees, and they determine a score according to certain measures, which are not clearly specified and publicized to their employees. In this study, we first define the measures, which supervisors utilize while evaluating their employees. Afterwards, we propose a SD model, which is going to help to increase employee motivation, productivity, performance and help to decrease average cost.

With the analysis of past performance scores and key performance indicators by SEM, it is concluded that managers are affected by three critical KPIs which are number of projects, overtime amount, and current experience. Those three variables are integrated to a system dynamics model as inputs. The SD model is validated through structural and validation tests. The structure of the model is tested in order to detect flaws by using extreme input values and observing the sensitivity of the model output to certain variables. The model is found to be structurally valid by these tests. Then, the model output iscompared with available actual past data in order to test the behavioral validity. The simulation period between the years 2008-2013 is used for these comparisons. After comparing major output variables with their actual values, the model behavior is evaluated to be a satisfactory representation of the actual behavior in terms of both dynamic pattern and numeric proximity. Finally, four extreme scenarios are analyzed as seen in Table 8.1and two important policies as seen in Table 8.2are introduced in order to increase employee performance and motivation for the subsequent years.

In the scenario analysis part, firstly, the possible diminishing employee candidates amount is handled. It is known that IT sector in Turkey is new and there seems like infinite number of employee candidates in the market. Moreover, the government stimulate to open new universities each year. Furthermore, XT generally hires more than it needs and never rehire an ex-employee. In addition, XT only hires graduates from the top Turkish Universities. Due to these constraints, the XT Company is expected to encounter a serious HR problem about finding eligible employee candidates in the near future. In this scenario analysis, it is concluded that after three to four years, the available candidates will diminish and XT will not be able to hire as much as it needs. In this condition, the overtime will increase very much and it will further cause to decrease in employee motivation around 50%. Motivational decrease will have a negative impact on productivity and turnover. However, turnover level will not change much since the company cannot replace employees who resign. Consequently, the total number of employees will decrease dramatically. The possible actions under this circumstance in this situation may be to rehire the ex-employees and try to apply new HR activities to the current employees in order to prevent resignations.

In the second scenario, a destructive crisis is assumed to happen. In this scenario, the crisis will lower the incoming project workload as expected dramatically. However, XT will not quickly adapt to the crisis; thus, it will have over capacity for that environment. The overtime levels will decrease to the lowest level and supervisors will under-assess the employees, which will decrease the employee motivation. Although, the total number of employees will decrease for 30%, there will be still over capacity which will cause average cost to increase 20%. In order not to come across with this kind of situation, XT will never work with an over capacity.

In the third scenario, it is assumed that XT will sign a commitment with a new major client. In this scenario, the incoming number of projects at a time will be duplicated. Although HR will try to compensate the lack of capacity with new hiring; there will still be a need for huge amount of overtime. The excessive burden due to effect of overtime will affect employee motivation negatively, which also cause productivity to decrease. Decreased productivity will also result in increased workload, which puts the system in a vicious circle. In this scenario, the average cost will increase 20%. In order to prevent this situation, XT should hire more people in advance before the commitment decision is realized.

In the fourth scenario, instantaneous influence of score gap on turnover rate is analyzed. Although, there is not a direct relationship between score gap and turnover rate, recently, increasing communication with the ex-employees helped current employees to learn more about the XT management policies. Generally, most of the ex-employees are disappointed with the unfairness of employee performance assessment system and reflecttheir negative experience to the current employees, which decrease the employee motivation. In this scenario, there may be two significant results which are increased turnover rate and average cost. In order to avoid this scenario to happen, XT Company should be more transparent about its performance assessment system.

In the policy analysis part, firstly, we propose supervisors to create performance scores according to productivity only. However, this policy is really cost effective compared to the current one, and also has a significant high positive impact on employee motivation and productivity. Furthermore, the need for overtime will decrease almost 60% which will also help XT to become more appealing for the young employee candidates. In addition, with the utilization of Policy 1, employees will be more involved with the performance assessment system since it is more transparent than the current system.

In the second policy, we do not request from the decision maker to change the whole employee performance assessment policy. Rather, we only propose them to modify it. Modifying means utilizing a multiplier in order to decrease the gap. For instance, there may be a huge gap between the productivity level and performance score of an employee; in this situation, we offer managers to increase the performance score according to the size of the gap. As a result of this policy, motivation and productivity will still become better than the current system but the average cost will not decrease as much as Policy 1. Since a big change is difficult to adapt in a short term, Policy 2 is more eligible for XT to apply than Policy 1.

Table 8.1 Comparison of KPIs under different scenarios with reference to the base run.

Scenarios	Key Performance Indicators	Results
Scenario1: Diminishing candidate pool	Motivation	-50%
	Productivity	-20%
	Overtime	30%
	Performance score	%5
	Turnover	0%
	Total employee	-60%
	Average cost	**-5%**
Scenario2: Destructive crisis lowering project inflow	Motivation	-20%
	Productivity	-5%
	Overtime	-70%
	Performance score	-20%
	Turnover	-2%
	Total employee	-30%
	Average cost	**30%**
Scenario3: Project inflow increased due to the commitment to another major client	Motivation	-30%
	Productivity	-10%
	Overtime	60%
	Performance score	10%
	Turnover	10%
	Total employee	120%
	Average cost	**20%**
Scenario4: Instantaneous influence of score gap on turnover rate	Motivation	0%
	Productivity	0%
	Overtime	0%
	Performance score	-5%
	Turnover	30%
	Total employee	0%
	Average cost	**25%**

The model constructed for this study provides a platform to promote the further study of interactions between the overall employee performance and management in a closed system. It would be beneficial to expand the number of main inputs to investigate and test new parameters that may have an effect on given performance scores such as employee satisfaction, talent, and ability scores. All these variables can be gathered via surveys. Moreover, the study was restricted to only one IT company.New companies from the IT business world should be incorporated in order to obtain more statistically meaningful results. The solutions found in this thesis may not necessarily applicable to companies in other work sectors. Thus, new variations of simulation models should be created to find out the details about the gap between employee performance scores and productivity.

Table 8.2 Comparison of KPIs under different policies with reference to the base run.

Policies	**Key Performance Indicators**	**Results**
Policy1: Performance scores are based according to productivity only	Motivation	125%
	Productivity	30%
	Overtime	-60%
	Performance score	30%
	Turnover	-30%
	Total employee	-15%
	Average cost	**-25%**
Policy2: Performance scores are created taken into account productivity partially	Motivation	50%
	Productivity	15%
	Overtime	-30%
	Performance score	15%
	Turnover	-10%
	Total employee	0%
	Average cost	**-15%**

APPENDIX A: EQUATIONS FOR SYSTEM DYNAMICS MODEL

```
{UTF-8}
aver cost per manworkday=
      IF THEN ELSE(project outflow>1, ((quit rate
inexp*8000*12*1.5+quit rate exp*17000*12\
            *1.5)+(cost inflow*(inexperienced employees+experienced
employees)))/project outflow\
             , cost inflow/per man)
      ~     tl/(man*day)
      ~           |

RealOverTime= WITH LOOKUP (
      Time,
            ([(0,0.07)-
(1320,0.15)],(0,0.09),(132,0.16),(264,0.15),(396,0.15),(528,0.13),
(660,0.12\

      ),(792,0.12),(924,0.12),(1056,0.12),(1188,0.12),(1320,0.07)
))
      ~
      ~           |

project outflow=
      MIN(project workload/workday,IF THEN ELSE(normal capacity man
days/workday<1,0 , total capacity\
            /workday
      ))
      ~     man*day/day
      ~           |

workyear=
      1
      ~     1/year
      ~           |

experienced salary=
      exp salary per month / workday per month
      ~     tl/day
      ~           |

"effect of experience on prod."= WITH LOOKUP (
      average XT experience*workyear,
            ([(0,0.5)-
(6,1)],(0,0.501779),(1.05882,0.546263),(1.75059,0.619217),(2.24471
,0.761566\
            ),(3.17647,0.880783),(4.39059,0.967972
            ),(5.26588,0.985765),(6,0.998221) ))
      ~     Dmnl
      ~           |

inexp salary per month=
```

```
	8000
	~	tl
	~		|

per man=
	1
	~	man
	~		|

inexperienced salary=
	inexp salary per month / workday per month
	~	tl/day
	~		|

exp salary per month=
	17000
	~	tl
	~		|

perf score cost=
	IF THEN ELSE(inexperienced employees+experienced employees=0,
0,(0.1*inexp salary per month\
		/workday per month*effect of given perf on
cost*inexperienced employees+0.1
	*exp salary per month/workday per month*effect of given perf
on cost*experienced employees\
		)/(inexperienced employees+experienced employees
	))
	~	tl/day
	~		|

effect of aver exp on perf= WITH LOOKUP (
	average XT experience*workyear,
		([(0,0.08)-
(10,0.1)],(0.0470588,0.0999288),(2.35294,0.0991459),(3.48235,0.097
0107),\
		(4.89412,0.0920285),(5.81176,0.0875445

	),(6.37647,0.0846263),(7.17647,0.0820641),(9.03529,0.0801423)
,(10,0.08) ))
	~	Dmnl
	~		|

unit cost=
	1
	~	tl
	~		|

tl per manday=
	1
	~	tl/(man*day)
	~		|

cost inflow=
```

```
	MAX(0, base salary cost + overtime cost + training cost +
perf score cost  )
	~	tl/day
	~		|

effect of cost on perf score= WITH LOOKUP (
	aver cost per manworkday/tl per manday,
		([(0,0.5)-
(10000,1)],(47.0588,1),(1741.18,0.980427),(2917.65,0.955516),(3435
.29,0.903915\
		),(3858.82,0.854093),(4235.29,

	0.791815),(4588.24,0.720641),(5058.82,0.679715),(6517.65,0.58
0071),(8282.35,0.530249\
		),(9905.88,0.503559) ))
	~	Dmnl
	~		|

hiring rate=
	MIN(employee pool/workday,IF THEN ELSE (total
employee*turnover rate=0, 10, MIN(total employee\
		*0.01/workday,effect of total ratio on hiring
	*turnover rate
	*total employee)))
	~	man/day
	~		|

workday=
	1
	~	day
	~		|

effect of given perf on cost= WITH LOOKUP (
	given performance score,
		([(0,-1)-(6,1)],(0,-0.992883),(0.889412,-
0.886121),(1.75059,-0.743772),(2.51294,-0.572954\
		),(3.20471,-0.366548),(4.39059,-
0.0106762),(4.98353,0.288256),(5.29412,0.537367),(5.54824\
		,0.836299),(5.76,0.943061),(5.95765,0.985765) ))
	~	Dmnl
	~		|

change of score=
	(given score - given performance score) /adjustment time for
perf
	~	Dmnl/day
	~		|

base capacity=
	1
	~	day*man
	~		|

"exp throughput time total cap."=
```

```
	IF THEN ELSE (total capacity>0, project workload/total
capacity, project workload/base capacity\
		)
	~	Dmnl
	~		|

workday per month=
	22
	~	day
	~		|

price per manworkday=
	17000/22*1760
	~	tl/(man*day)
	~		|

training cost per workday=
	400
	~	tl/day
	~		|

productivity exp=
	effect of motivation on productivity*effect of overtime on
productivity*effect of training days on productivity\
		*"effect of experience on prod."
	~	Dmnl
	~		|

overtime cost=
	IF THEN ELSE(inexperienced employees+experienced employees=0,
0,(inexperienced salary\
		*1.6*inexperienced employees*overtime
	+experienced salary*1.6*experienced
employees*overtime)/(inexperienced employees+experienced
employees\
		)/workday per month)
	~	tl/day
	~		|

training cost=
	training cost per workday*training days ratio
	~	tl/day
	~		|

base salary cost=
	IF THEN ELSE(inexperienced employees+experienced employees=0,
0,(inexperienced salary\
		*inexperienced employees+experienced salary*experienced
employees)*effect of aver exp on salary\
		/(inexperienced employees+experienced
employees)/workday per month)
	~	tl/day
	~		|

income flow=
```

```
	project outflow*price per manworkday
	~	tl/day
	~		|

given score=
	((MAX(0, effect of productivity on given score  - effect of aver exp on perf)) * effect of overtime on perf

	* effect of cost on perf score
	 * effect of project outflow on perf)
	~	Dmnl
	~		|

effect of overtime on motivation= WITH LOOKUP (
	overtime,
		([(0,0.3)-(0.23,1)],(0,0.997509),(0.0357176,0.982562),(0.0676471,0.957651),(0.107153\

	,0.862989),(0.129882,0.743416),(0.147741,0.601424),(0.162353,0.491815),(0.176424,0.409609\
		),(0.199153,0.334875),(0.231082,0.302491) ))
	~	Dmnl
	~		|

motivation=
	(given performance score/6+days off ratio+training days ratio)*effect of gap on motivation\
		*effect of overtime on motivation
	~	Dmnl
	~		|

gap of scores=
	MAX(0,productivity based score-given performance score)
	~	Dmnl
	~		|

decrease rate of pool=
	IF THEN ELSE(hiring rate>employee pool/workday, employee pool/workday , hiring rate \
		)
	~	man/day
	~		|

new graduates=
	1
	~	man/day
	~		|

employee pool= INTEG (
	new graduates-decrease rate of pool,
		10000)
	~	man
	~		|
```

```
effect of gap on motivation= WITH LOOKUP (
      gap of scores,
            ([(0,0.5)-
(2,1)],(0.00470588,0.996441),(0.141176,0.994662),(0.301176,0.98932
4),(0.475294\

      ,0.976868),(0.625882,0.964413),(0.894118,0.928826),(1.00235,0
.873665),(1.10588,0.822064\

      ),(1.17176,0.756228),(1.25176,0.69573),(1.33176,0.640569),(1.
41176,0.604982),(1.54353\

      ,0.549822),(1.68,0.524911),(1.83529,0.507117),(1.98588,0.5017
79) ))
      ~     Dmnl
      ~           |

"change of p.score"=
      (productivity based perf-productivity based score)/adjustment
time for perf
      ~     Dmnl/day
      ~           |

effect of motivation on quit= WITH LOOKUP (
      motivation,
            ([(0.5,0.75)-
(1,1)],(0.503529,0.99911),(0.574118,0.989324),(0.625882,0.975089),
(0.696471\

      ,0.940391),(0.729412,0.895907),(0.762353,0.850534),(0.807059,
0.797153),(0.837647,0.774021\

      ),(0.891765,0.760676),(0.957647,0.752669),(0.998824,0.752669)
))
      ~     Dmnl
      ~           |

productivity based score= INTEG (
      "change of p.score",
            4.5)
      ~     Dmnl
      ~           |

effect of total ratio on hiring= WITH LOOKUP (
      expected desired ratio with overtime,
            ([(1,0.9)-
(1.5,1.5)],(1.00118,0.90427),(1.05176,0.927758),(1.10471,0.968327)
,(1.16235\

      ,1.04306),(1.19882,1.1306),(1.23647,1.2395),(1.27765,1.33345)
,(1.32471,1.40605),(1.37176\
            ,1.44448),(1.42941,1.47011),(1.49765,1.49786) ))
      ~     Dmnl
      ~           |
```

```
inexperienced employees= INTEG (
      hiring rate-assimilation rate-quit rate inexp,
            500)
      ~     man
      ~           |

expected desired ratio with overtime=
      "exp throughput time total cap."/target throughput time
      ~     Dmnl
      ~           |

turnover rate=
      IF THEN ELSE (total employee>0,(quit rate exp+quit rate
inexp)/total employee,0)
      ~     1/day
      ~           |

effect of project outflow on perf= WITH LOOKUP (
      IF THEN ELSE (project outflow >0, project outflow/total
employee, 0),
            ([(0,0)-
(1.5,3)],(0,0.0213523),(0.0952941,0.811388),(0.211765,1.20641),(0.
42,1.79359\

      ),(0.617647,2.18861),(0.857647,2.49822),(1.08706,2.70107),(1.
30941,2.87189),(1.5,2.97865\
            ) ))
      ~     Dmnl
      ~           |

effect of training days on productivity= WITH LOOKUP (
      training days ratio,
            ([(0,0.9)-
(0.03,1)],(0.000141176,0.9),(0.00310588,0.934875),(0.00684706,0.95
6584),(\

      0.0129176,0.975801),(0.0170824,0.986833),(0.0230118,0.993594)
,(0.03,0.999288) ))
      ~     Dmnl
      ~           |

effect of overtime on productivity= WITH LOOKUP (
      overtime,
            ([(0,0.9)-
(0.23,1)],(0,1),(0.0330118,0.996085),(0.0606118,0.984698),(0.07684
71,0.975445\

      ),(0.0968706,0.962278),(0.121224,0.940925),(0.141788,0.921352
),(0.173176,0.908541),\
            (0.198612,0.903915),(0.23,0.9) ))
      ~     Dmnl
      ~           |

normal capacity man days=
```

```
      available days*experienced employees*productivity
exp+available days*inexperienced employees\
            *productivity inexp
      ~     man*day
      ~           |

effect of aver exp on salary= WITH LOOKUP (
      average XT experience*workyear,
            ([(5,1)-
(10,1.5)],(5.02353,1.00178),(5.85882,1.05516),(6.37647,1.11922),(6
.81176,1.18683\
            ),(7.09412,1.27758),(7.58824,1.35765

      ),(8.12941,1.41815),(8.76471,1.46263),(9.32941,1.48043),(9.98
824,1.49644) ))
      ~     Dmnl
      ~           |

effect of productivity on given score= WITH LOOKUP (
      productivity exp,
            ([(0,0.9)-
(1,1)],(0.00470588,0.900712),(0.131765,0.905338),(0.261176,0.91245
5),(0.374118\

      ,0.920996),(0.472941,0.935943),(0.550588,0.96121),(0.635294,0
.972598),(0.715294,0.982918\

      ),(0.816471,0.991103),(0.931765,0.996441),(0.995294,0.998221)
))
      ~     Dmnl
      ~           |

productivity based perf=
      effect of productivity on perf
      ~     Dmnl
      ~           |

overtime change=
      (effect of ratio on overtime-overtime)/overtime adj
      ~     Dmnl/day
      ~           |

effect of productivity on perf= WITH LOOKUP (
      productivity exp,
            ([(0,0)-(1,6)],(0,0),(1,6) ))
      ~     Dmnl
      ~           |

overtime adj=
      22
      ~     day
      ~           |

effect of overtime on perf= WITH LOOKUP (
      overtime,
```

```
          ([(0,1.8)-
(0.23,2)],(0.00108235,1.80214),(0.046,1.81281),(0.0741412,1.83345)
,(0.104447\

     ,1.86975),(0.119059,1.9089),(0.140706,1.94235),(0.163976,1.96
94),(0.192118,1.9879),\
          (0.229459,1.99858) ))
     ~    Dmnl
     ~         |

overtime= INTEG (
     overtime change,
          0.15)
     ~    Dmnl
     ~         |

overtime capacity=
     normal capacity man days*overtime
     ~    man*day
     ~         |

expected throughput time=
     IF THEN ELSE (normal capacity man days>1, project
workload/normal capacity man days,\
           project workload/base capacity)
     ~    Dmnl
     ~         |

project inflow=
     900
     ~    man*day/day
     ~         |

profit=
     income-cost
     ~    tl
     ~         |

adj quit inexp=
     132
     ~    day
     ~         |

income= INTEG (
     income flow,
          2e+007)
     ~    tl
     ~         |

aver exp of experienced emp=
     8
     ~    year
     ~         |

aver exp of inexperienced emp=
```

```
      0.5
      ~    year
      ~         |

average XT experience=
      IF THEN ELSE (experienced employees+inexperienced
employees>0, (aver exp of experienced emp\
            *experienced employees+aver exp of inexperienced
emp*inexperienced employees)/(experienced employees\
            +inexperienced employees), 0)
      ~    year
      ~         |

adj quit exp=
      264
      ~    day
      ~         |

quit rate inexp=
      inexperienced employees*effect of motivation on quit/adj quit
inexp
      ~    man/day
      ~         |

total employee=
      experienced employees+inexperienced employees
      ~    man
      ~         |

quit rate exp=
      experienced employees*effect of motivation on quit/adj quit
exp
      ~    man/day
      ~         |

productivity inexp=
      0.5
      ~    Dmnl
      ~         |

assimilation adjustment=
      264
      ~    day
      ~         |

assimilation rate=
      inexperienced employees/assimilation adjustment
      ~    man/day
      ~         |

experienced employees= INTEG (
      assimilation rate-quit rate exp,
            600)
      ~    man
      ~         |
```

```
given performance score= INTEG (
	change of score,
		4.5)
	~	Dmnl
	~		|

cost= INTEG (
	cost inflow,
		0)
	~	tl
	~		|

adjustment time for perf=
	132
	~	day
	~		|

project workload= INTEG (
	project inflow-project outflow,
		40000)
	~	man*day
	~		|

total capacity=
	normal capacity man days+overtime capacity
	~	man*day
	~		|

effect of motivation on productivity= WITH LOOKUP (
	motivation,
		([(0,0.5)-
(1,1)],(0.00470588,0.503559),(0.0894118,0.6121),(0.171765,0.697509
),(0.298824\

	,0.781139),(0.388235,0.838078),(0.517647,0.886121),(0.64,0.91
8149),(0.776471,0.960854\
		),(0.889412,0.989324),(0.992941,0.996441) ))
	~	Dmnl
	~		|

expected to desired ratio normal=
	expected throughput time/target throughput time
	~	Dmnl
	~		|

target throughput time=
	66
	~	Dmnl
	~		|

available days=
	MAX(0,1-days off ratio-training days ratio)*workday
	~	day
	~		|
```

```
days off ratio=
	0.038
	~	Dmnl
	~		|

training days ratio=
	0.023
	~	Dmnl
	~		|

effect of ratio on overtime= WITH LOOKUP (
	expected to desired ratio normal,
		([(1,0)-
(1.5,0.23)],(1,0.05),(1.08,0.0532028),(1.15176,0.0613879),(1.22824
,0.0834875\

	),(1.28118,0.116228),(1.32588,0.147331),(1.36941,0.186619),(1
.40118,0.209537),(1.43059\
		,0.216904),(1.46824,0.227544),(1.49882,0.229181) ))
	~	Dmnl
	~		|

********************************************************
	.Control
********************************************************~
		Simulation Control Parameters
	|

FINAL TIME  = 1320
	~	day
	~	The final time for the simulation.
	|

INITIAL TIME  = 0
	~	day
	~	The initial time for the simulation.
	|

SAVEPER  =
        TIME STEP
	~	day [0,?]
	~	The frequency with which output is stored.
	|

TIME STEP  = 0.0625
	~	day [0,?]
	~	The time step for the simulation.
	|
```

APPENDIX B: STOCK-FLOW DIAGRAM OF THE SD MODEL

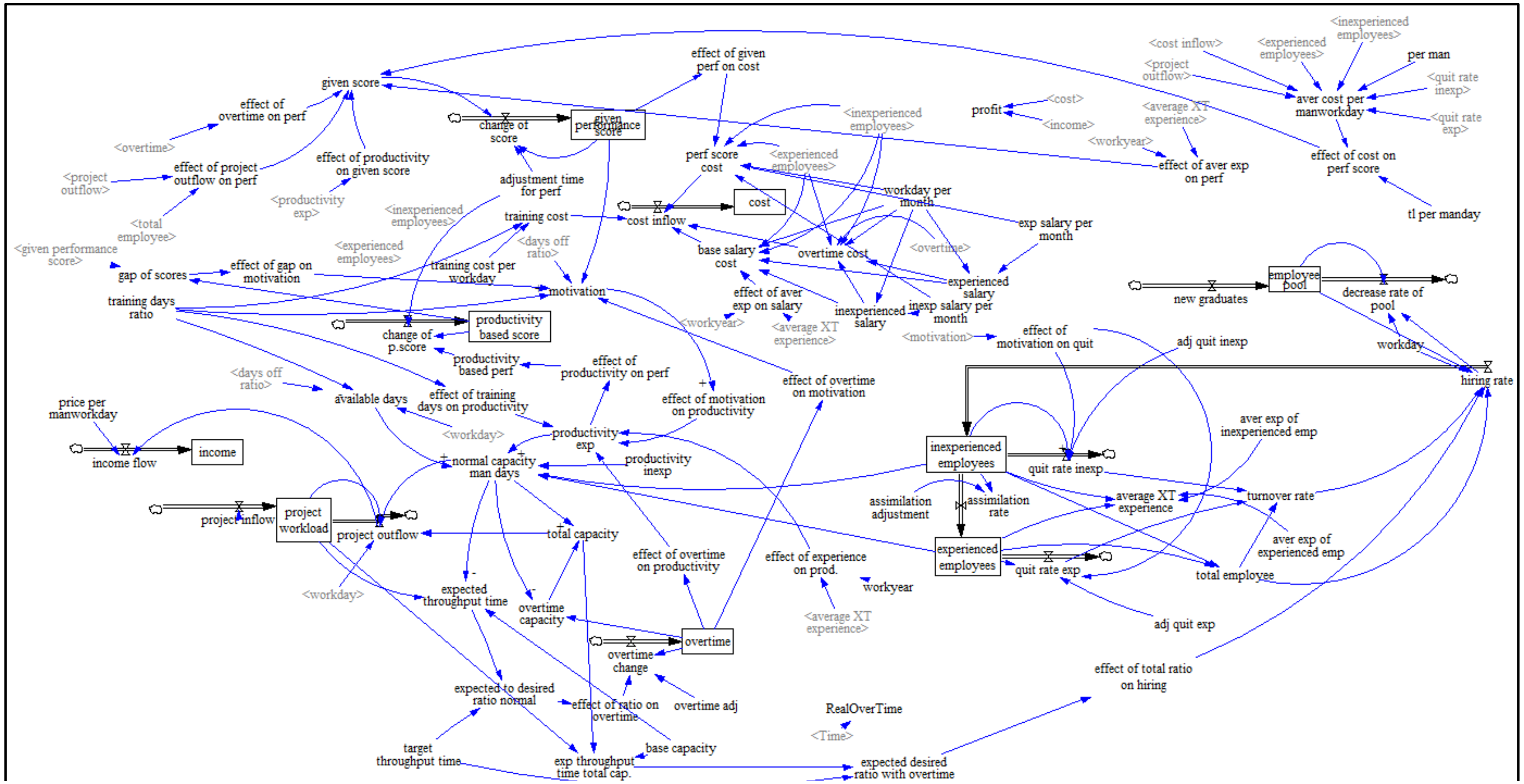

Figure B.1. Stock-flow diagram of SD model.

REFERENCES

1.TMMOB Computer Engineering Committee, 2009, IT Employees Survey, http://www.bmo.org.tr/wp-content/uploads/2011/08/Anket SonucRaporuv2.pdf, accessed at April 2013.

2. Salanova, M., S. Agut and J. M. Peiro, 2005, “Linking Organizational Resources and Work Engagement to Employee Performance and Customer Loyalty: The Mediation of Service Climate”,*Journal of Applied Psychology,* Vol. 90, No. 6, pp. 1217-1227.

3. Bartel, A. P., 1992, “Training, Wage Growth and Job Performance: Evidence from a Company Database”, *National Bureau of Economic Research,* Cambridge.

4. Delaney, J. T., and M. A. Huselid, 1996, “The Impact of Human Resource Management Practices on Perceptions of Organizational Performance”, *Academy of Management Journal*, Vol. 39, No. 4, pp. 949-969.

5. Tien, F. F. and R. T. Blackburn, 1996, “Faculty Rank System, Research Motivation, and Faculty Research Productivity”, *The Journal of Higher Education,* Vol. 67, No. 1, pp. 2-22.

6. Quinones, M. A., J. K. Ford and M. S. Teachout,1995, “The Relationship Between Work Experience and Job Performance: A Conceptual and Meta-Analytic Review”, Personnel Psychology, Vol. 48.

7. Huselid, M. A., 1995, “The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance”, *Academy of Management Journal,* Vol. 38, No. 3, pp. 635-672.

8. Sterman J.S. 2000, *Business Dynamics. System Thinking and Modeling for a Complex World.,* McGraw-Hill: New York.

9. Alvanchi, A., S. Lee, and S. Abourizk, 2012, "Dynamics of Working Hours in Construction", *Journal of Construction Engineering and Management,* Vol. 138, No.1.

10. Altaf, A. and M. A. Awan, 2011, "Moderating Affect of Workplace Spirituality on the Relationship of Job Overload and Job Satisfaction", *Journal of Business Ethics,* Vol. 104, pp. 93-99.

11. Kuvaas, B., 2006, "Performance Appraisal Satisfaction and Employee Outcomes: Mediating and Moderating Roles of Work Motivation", *International Journal of Resource Management,* Vol. 17, No. 3, pp. 504-522.

12. Poon, J. M. L., 2003, "Effects of Performance Appraisal Politics on Job Satisfaction and Turnover Intention", *Personnel Review,* Vol. 3, No. 3, pp. 322-334.

13. Kaplan, R. S. and D. P. Norton, 1996,*The balanced scorecard: translating strategy into action,* Harvard Business School Press Boston.

14. Kaplan, R. S. and D. P. Norton, 2004, *Strategy Maps, Converting Intangible Assets into Tangible Outcomes,* Harvard Business School Press: Boston.

15. Norreklit, H., 2000, "The balance on the balanced scorecard-a critical analysis of some of its assumptions", *Management Accounting Research,* Vol.11, pp. 65-88.

16. Mooraj, S., D. Oyon, and D. Hostettler, 1999, "The balanced scorecard: a necessary good or an unnecessary evil", *European Management Journal,* Vol.17, pp. 481-491.

17. Hudson, M., A. Smart, and M. Bourne, 2001, "Theory and practice in SME performance measurement systems*", International Journal of Operations and Management,* Vol. 21, pp. 1096-1115.

18. Neely, A., M. Gregory, and K. Platts, 1995, "Performance measurement system design: A literature review and research agenda*", International Journal of Operations and Production Management,* Vol. 14, pp. 80-116.

19.Akkermans, H.A., and K. V. Oorschot, 2005, "Relevance assumed: a case study of balanced scorecard development using system dynamics*", Journal of the Operational Research Society*, Vol. 56, pp.931–941.

20. Armitage, P. and T. Colton, 1994, *Encyclopedia of Biostatistics,* John Wiley, Susex.

21. Manoharan, T.R., C. Muralidharan, S.G. Deshmukh,2012."A composite model for employees' performance appraisal and improvement*". European Journal of Training and Development,* Vol. 36, pp. 448 – 480.

22. Bentler, P. M. and C. P. Chou, 1987, "Practical Issues in Structural Modeling", *Sociological Methods and Research,* Vol.16, No.1, pp. 78-117.

23. Statsoft Inc, 2013*, Structural Equation Modeling Electronic Textbook,* http://www.statsoft.com/textbook/structural-equation-modeling, accessed at August 2013.

24. Kline, R. B., 2011, *Principles and Practice of Structural Equation Modeling,* Guilford Press, New York.

25. Schumacker, R. E., and R. G. Lomax, 1996, *A Beginner's Guide to Structural Equation Modeling,* Lawrance Erlbaum Associates Publishers, New Jersey.

26. Marsh, H., and D. Hocevar, 1985, "The application of confirmatory factor analysis to the study of self-Concept: First and higher order factor structures and their invariance across age groups", *Psychological Bulletin,* Vol. 97, pp. 62-82.

27. Byrne, B. M., 1989, A *Primer of LISREL: Basic Applications and Programming for Confirmatory Factor Analytic Models*, New York.