CENTER TITLE HE DESIGNING AND IMPLEMENTING A MODEL TO EXAMINE R&D SECTION´S CAPABILITIES WITH EMPHASIS ON REVERSED ENGINEERING IN CHEMICAL FACTORY

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ABSTRACT

Today, research and development and related activities to access new technologies in the industrial world have been challenging activities. R&D units were known as Technology pillars and are unique resources of innovation, creating R&D units and institutes or developing old ones to new effective ones for developing countries are inevitable issues.

There are various methods to access the Technologies and one of the most important ones, especially among developing countries is Reverse engineering which is Consciousness method taken from exist Technology.

This paper also reviews research background of (R & D) and reverse engineering, implements simulation software modeling to achieve the most effective parameters and their relationships and offer strategies for optimal per unit R & D and access to technologies of modern examined. This study contains R & D department of a chemical factory as selected population which is one of the important industrial factories in Iran. In conclusion some key effective factors have been extracted through this simulation. The company can consider them to develop R&D unit and improve the product quality.

Keywords: Research and Development (R&D), Reverse engineering**,** Technology Transfer, System dynamic.

1. INTRODUCTION

Research, development and management are the pillars of creation, development and utilization of technology and they are the needs of economic and social development in every country, in the developing countries which are seeking industrial and economic self-reliance, policy and planning research programs and development and management of practices impact on these activities are considered as priorities for national, industrial and manufacturing activities. Expansion and enhance of R & D activities, particularly "industrial research ", requires understanding the factors affecting research and development process and designing policies and effective activities of such mechanisms. In competitive conditions of the current industrial world, doing research and development activities is one of the most effective things that managers of economic enterprises can take on and in industrialized countries of the world, the costs allocated to these activities are being increased day by day, on the other hand referring to the research and development without creating the necessary infrastructure units such as: organizational structure, human resources characteristics and management of these organizations causes the failure of research and development process of economic institutions.(Kheradmand 2007)

Process of R & D includes: basic research, applied research and development. By using basic research, the scientific findings are presented in the form of hypothesis, theories and general rules and in the next stage, it would be the applied research which determines the possible applications for basic research findings. The stage of development, scientific knowledge obtained from basic research and applied research is applied in order to provide new and developed products or processes and innovation can occur. The main centers of the R & D process consists of industrial research institutes, academic research institutions and government R & D centers. Reverse engineering is extraction and development of technical information from available products. This method unlike the direct designing process meant to production according to customer requirements and the initial idea is based on the engineering analysis. (Amiri and others 2008)

Many activities in this area are done with different goals daily. Extraction of technical knowledge designed by R & D units in different industries, providing technical documentation of industrial equipment and probably copying the products are some examples in this field. Developing countries to access complicated technologies require a method that fills the technology gap between these countries and the developed countries at the right time and among different methods of having access to technology, reverse engineering is the most appropriate method.

This research was done in the context of systemic thought and to achieve research objectives and answer of research questions, System Dynamics modeling has been used. Modeling dynamic systems is an essential tool in systemic thought that in order to better understand the behavior of the system; imaging and strengthening the conceptive models and displaying the behavior of system are used. Since diversity of effective factors is very significant on issues, in order to obtain acceptable solutions, the least important factors are omitted by using modeling in the study. The general category type of research will also be an applied research.

This study utilizes a model (simulation), which includes relations with variables methods in reverse engineering in R & D units which will be done. This model can be considered as a new process in popular and applied industries. And the places where there is no new scientific and systematic approach in these projects, so this research and simulations can greatly help managers in making decisions and having reasonable controls. Thus, at first there have been gathered interviews and questionnaires with key members collaboration and make a systematic relation between variables and suitable parameters base on model and achieved the desired data will be collected and model validation is done and CLD related to basic parameters can be drawn. Then modeling using Vensim simulation software based on raw data and descriptive statistics are done and the parameter sensitivity analyses also take place.

Finally, based on the model output and parameters sensitivity analysis software, necessary suggestions and performed conclusions are provided.

2. MAJOR RESEARCH AND DEVELOPMENT ACTIVITIES IN THE STAGES OF REVERSE ENGINEERING PROCESS

The experiences of advanced countries suggests that technological progress in these countries owe R & D activities and technological infrastructure more than anything and without implementing such activities there is no way to achieve the desired technology for that, though by buying the product or purchase process, the required parts can be obtained, but even successful technology business by buying technology (research and development activities necessary for building or research strategies to produce copy that is necessary) also requires research activities and industrial engineering services. For example, before attempting to determine how to access to technology, knowledge and action for defining technology needed to meet demands and needs of development projects such countries need some activities which won't be fulfilled without collaboration of involved ones engineering services directly.(Colin Bradley 1998), (Jokar 2008), (Book of technology comercialization)

2.1. Subheadings

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2.1.1. Secondary Subheadings

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3. SELECTING APPROPRIATE TECHNOLOGY AND REASERCH AND DEVELOPMENT REQUIRED ACTIVITIES

The process of selecting technology and appropriate product includes all actions and activities which are contiguous with the objectives, conditions and specifications and technological needs to determine the most appropriate technology requirements and also the most appropriate strategy to achieve the goals is done by considering the circumstances and technical, economic and legal relations. (Akhbari and others 2008), (Allahyari 2009), (Ebrahimi), (Fort collins and kaufman 1989)

This process typically includes steps such follows:

1-Information on market needs consumer preferences and market traction for new products.

2-Information about status of competition, situation of required innovation, research and development activities, products and environmental threats.

3-Having Information about the required global situation of technology and explanations of their pattern in some period of times by using technology forecasting techniques.

4-Identification of technical and scientific facilities of country and possibility of access to materials, energy, and production processes.

5- Analysis of investment company status among others in terms of scientific, technical, economic support and technical ability, communication and marketing.

6-Strategic planning to determine and select the required technology, according to data collected.

7-Designing strategies to achieve product and selecting the most appropriate strategy (according to the results of technical and economic feasibility studies later we will pay attention to this issue.)

Marketing efforts, policy and strategic planning and selecting the required technology to achieve the set of activities that make up except those involved with research and development activities and research and development, so reaching them is not possible except with effective management of information and technical experiences of engineers. The sensitivity of this action is so much in a way if investments policy and managements not to be done accurately and according to practical techniques and if a comprehensive analysis not to be done, the rest innovation activities will be overwhelmed and they eventually might lead to investment plan failure.

4. SELECTING APPROPRIATE TECHNOLOGY AND REASERCH AND DEVELOPMENT REQUIRED ACTIVITIES

(Ghani 2009)], (Houshangnia 2009), (Laghvi 2010),(Mardi 2011)

1 - Controlling the possible technical and economic studies, making plans to copy a subset of product or product requirements inside the factory.

2 - Researching for understanding mechanisms of functioning components for realization of working mission for products and discovering the relationships between components during operation.

3 - Departing the components that we have decided to copy them and registering charts for the products and its details during operation.

4 - Providing maps and photos, or piece or pieces that they're going to be copied.

5 - Identifying, testing and determining the raw materials used to manufacture any component of product.

6 - Identifying, testing and diagnosis process for production of any component of product.

7 - Identifying, testing and diagnosis of complementary operation performed to achieve mechanical, physical, metallurgical, chemical properties… which are required.

8 - Detecting required machineries and tools for manufacturing and assembly.

9 - Compiling technical knowledge for production and assembly and its components.

10 - Preparing production drawings, maps, templates, models and tools needed for production and control stages.

11 - Monitoring the prototyping operation specifically or under direct supervision.

12 - Controlling samples made and matching them with the profile of desired standards.

13 - Assessing and analyzing test results and in case of necessary, revision of sizes and tolerances.

14 - Designing production and estimating required machinery and equipment.

15 - Planning of factory and designing factory production and assembly line.

5. METHODS

This paper aims to achieve a model to evaluate the capabilities and competencies of R & D of a chemical factory based on modeling system. This model is provided to managers and decision makers as a tool and it plays the role of easing in decision process and opting organizational strategies. So according to this view, this article is considered in the category of applied research. On the other hand the type of approach used in the paper is in a way that by dynamic modeling, the effective components on planning present a new model and it solves the problems that current planning methods are facing with. In this study it is tried that modeling (simulation) and all factors and important variables and influencing patterns, trends empowerment of R & D unit for the chemical industry to be considered with an approach of reverse engineering in order to strengthen R & D unit.(Fort collins and kaufman 1989),(Roussel and saad 1991),(Chiesa and masella 1996)

First stage: gathering effective factors on research and determining the primary assumptions

Second stage: determining the most important factors affecting research and inserting them in the initial model and draw CLD to determine relationships between factors and variables for the basic model.

Third stage: extending the primary model and finding datum and formulas for model and model validation

Fourth stage: testing Software Model (simulated). (Sterman 2000),(www.system dynamics.org/conferences 1998)

5.1. . Introducing the basic components in capability of research and development (R&D) of the chemical Factory:

(Fadaei 2010), (Fort collins and kaufman 1989),(Chiesa and masella 1996)

This section is based on offering presumptions that simply realize modeling process and it is attempted to present the model which can be implemented in Vensim software.

Assumptions made are extracted based on the information of a Chemical factory and interviews with senior managers and library studies and the most effective variables and essential factors are mentioned bellow:

1 - Professional and skilled personnel (manpower)

2 - Identification of risk factors

3 - Market and customers needs

4 - If necessary interaction with industries and marketing and production units

5 - System inputs include raw and new materials (new requirements)

6 - Technical Knowledge

7 - Sufficient capital (cash flow)

8 - Cost market

9 - Planning

10 - Economic blockade

11 - Project Manager

12 - Skillful and risky management of R & D

5.2. Model validation test

In order to demonstrate the model validity, we use real tests K Square test to explain credibility. Since based on calculations done on questionnaires and interviews, the most effective factors and variables in the model were determined, and information relevant to the years 2001 to 2011 are available.

So by putting this information in the model, the information of next year is predicted and they are measured with realities so the credit degree of model could be provided.

It should be mentioned that information and figures of influential factors, including system inputs (raw materials, equipment, technical knowledge), human resources, including (motivation, working group, spontaneous, education, good environment, planning and project control, management empowerment and the number of projects done in R & D through the questionnaire were determined. Also system inputs, planning and control of projects, skillful management of Research and Development and human resources were considered as independent variables and the numbers of projects R & D were considered as the dependent variables.

The aim is that according to the four-term factors: 1) system inputs, 2) Planning and Project control, 3) strong management, 4) Human Resources with a number of projects to reach an acceptable quality. (Kheradmand 2007), (Rabelo 2004),(Sterman 2000)

Table1:Model validation test by using of real data test & square of KAY :

Human Resources	Strong management of R&D unit	Planning & Project Control	System Input	Number of ended project in R&D unit	Year
6.45	5.6	7.75	6	2	2001
6.75	5.92	7	6.16	5	2002
6.8	6.08	7.75	6.4	7	2003
6.55	6	8	6.75	2	2004
6.45	5.92	7.5	6.66	1	2005
6.4	5.33	7.25	6.5	1	2006
6.2	5.41	7.25	6.33	3	2007
5.9	5.5	6.75	6.41	0	2008
5.6	5.33	6.75	6.08	0	2009
4.95	5.1	6.5	5.91	7	2010
7.6	7	8	7.6	5	2011
7.6	7	8	7.6	5	)fit (Model EI-
2.949	2.872	0.983	2.237	$X^2_{(n-1)}=x^2_{9,0/05}$	X^2

According to figures contained in the questionnaire, the average number of variables and factors extracted from 2001-2011, they have been mentioned in above table and then for credibility and accuracy of model operation, the K Square test was measured by the following formula:

$$X^2_{(n-1)} = \sum \frac{Oi - Ei}{Ei}$$

And the figures of ^{2} **X** was extracted according to the above table; ^{2} **X** which was provided according to K Square test is ^{2}**X** $^{0.05,9}$ **=16.92** and since ^{2}**X** is four variables of model and is less than 16.92, so the modeling assumption is accurate and according to the figures and information listed above, the model is accepted with 0.95 confidence.

5.3. C.L.D draw

After extracting the effective parameters on model, in the second step of modeling, the causal relations between the parameters must be considered, so for this purpose, we extract C.L.D. It is noteworthy that due to the volume of datum and the high number of parameters affecting the issue, single-step extraction of C.L.D is not feasible.therefore for the purpose of understanding it easier, we divided the casual model of the issue into five stages and in each stage a loop of causal model has been drawn; and then finally according to the defined relations, we link each stage to the other stages and each component to the other components to achieve the ultimate causal model of the problem. Finally, the effective parameters of the model simulation, sensitivity analysis and the related results are also presented.

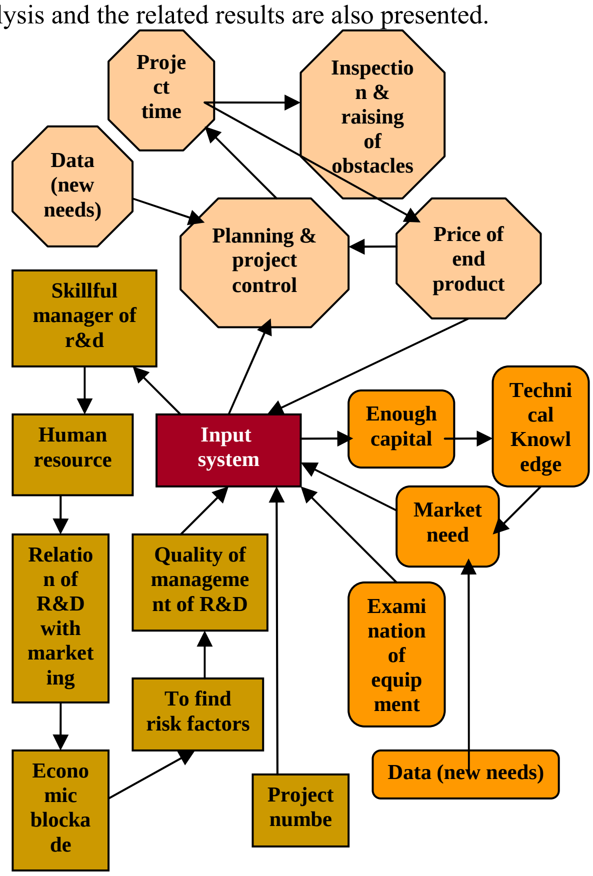


Chart 1: CLD(casual loop diagram),(Model)

(Amiri,farzad and others 2008), (Colin Bradley 1998),(Mardi 2011)

5.4. Draw of chart of stock &flow by vensim software:

(Craig W.kirkwood 1998), (Rabelo and Helal 2004)
Formula tray relation of Regression for Number of ended project in R&D unit:
Number = _0.61 Input+0.07 Planning control+0.72 Managenent of R&D_0.34 Human Resources.

Multiple Graphs relevant to the main parameters of the model
(Kheradmand 2007), (Rabelo 2004)

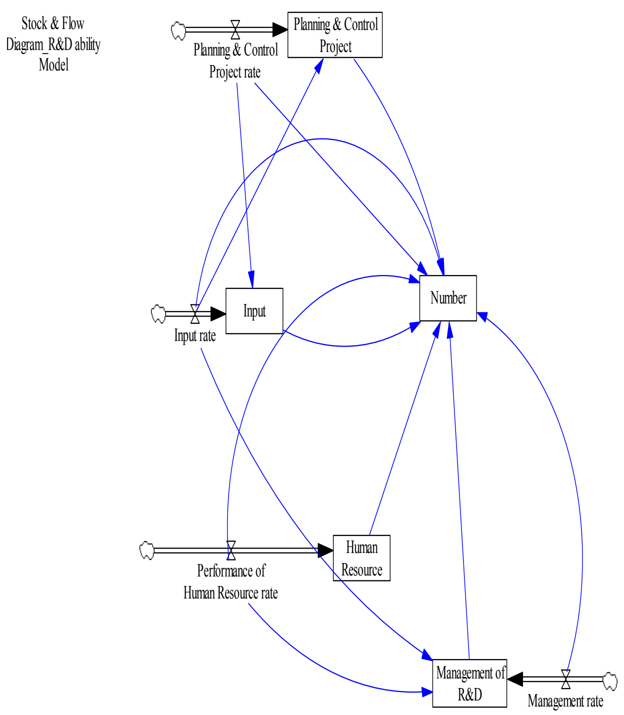


Chart 2: stack and flow

5.5. Multiple Graphs relevant to the main parameters of the model

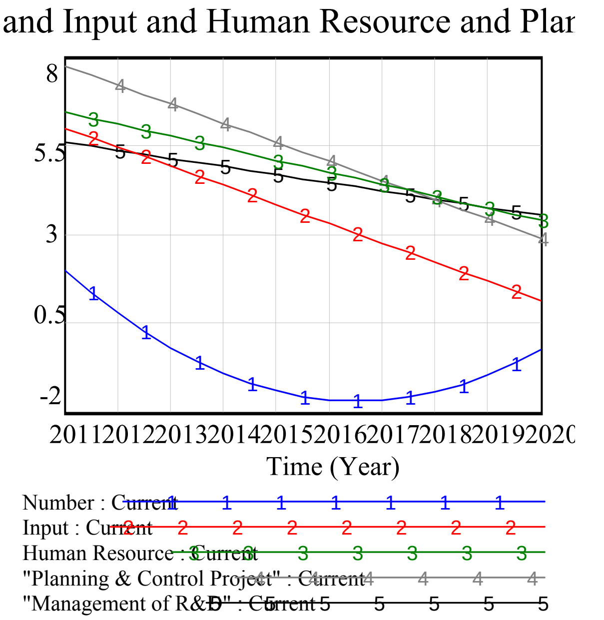
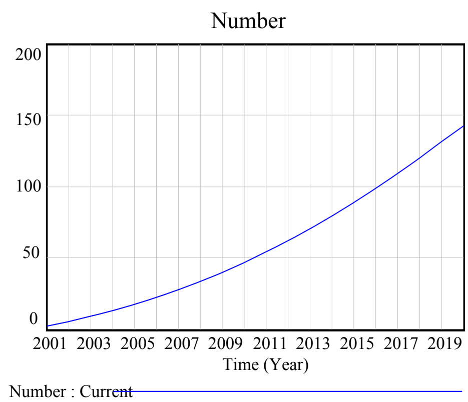
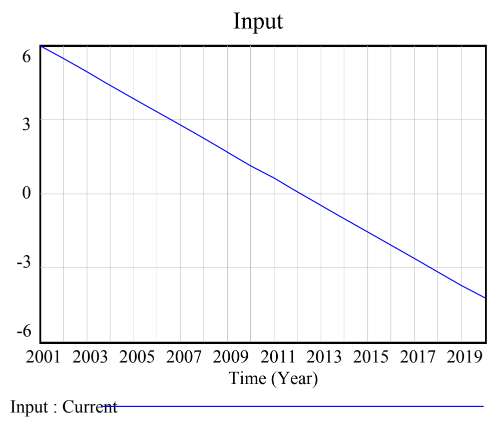


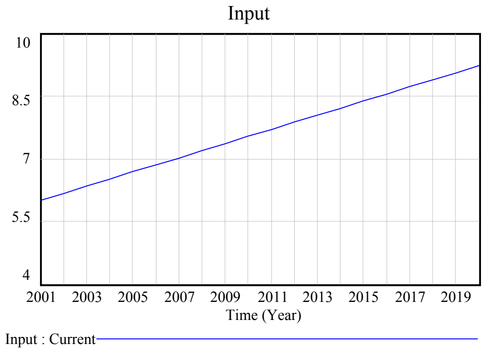
chart3: Multiple Charts of the basic model variable

5.6. Statistical analysis (sensitivity analysis):

(Houshangnia 2009), (Rabelo 2004),(Sterman 2000)

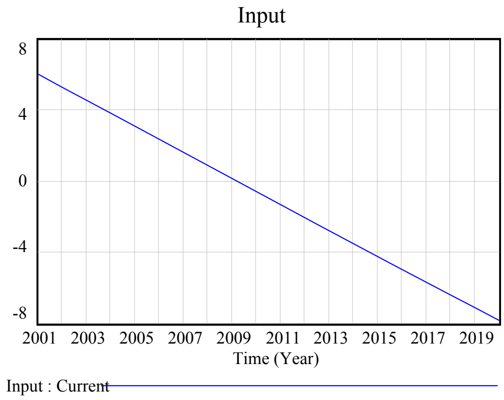


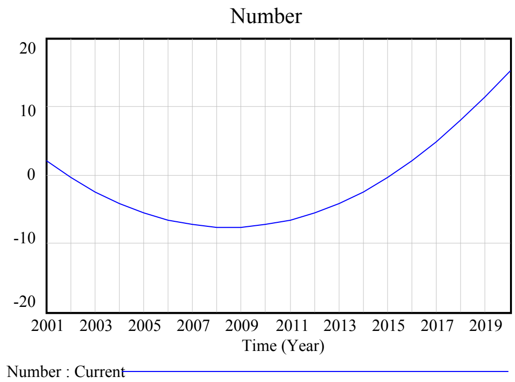


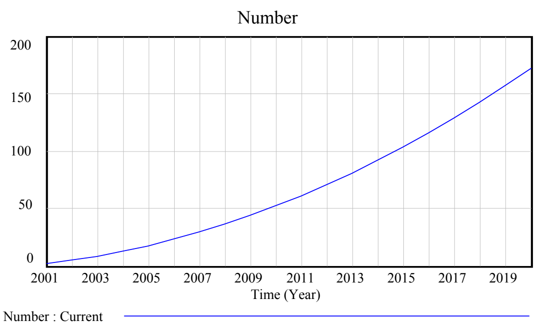


Year	Primary state for system input	Optimistic state for system input	Project numbers in optimistic conditions
2011	0.6	7.7	53.8
2020	-4.2	9.23	142.4

Chart4: Optimistic level conditions for System Input, Coefficient change from -0.61 to +0.1

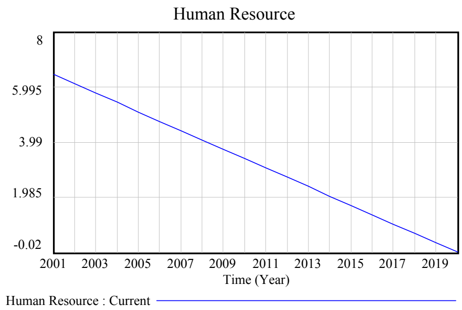


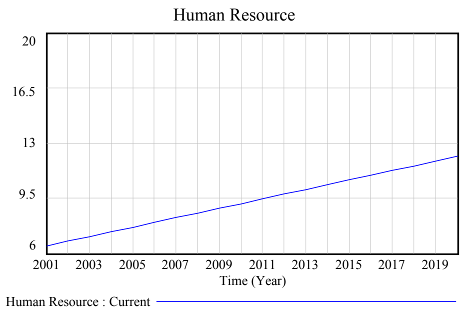




Year	Primary state for system input	Optimistic state for system input	Project numbers in optimistic conditions
2011	0.6	-1.3	-6.6
2020	-4.2	-7.8	15.23

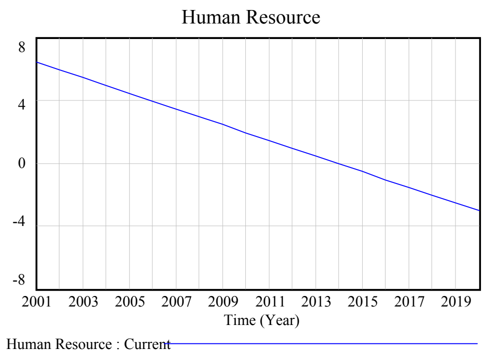
Chart5: Pessimistic level conditions for system input, Coefficient change from -0.61 to -0.80

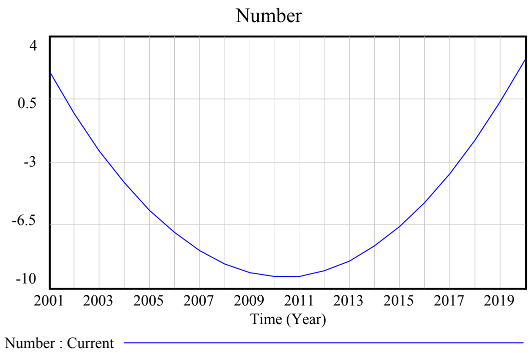




Year	Primary state for human resource	Optimistic condition for human resource	Project numbers in optimistic conditions
2011	3.05	9.4	60.9
2020	-0.01	12.15	171.8

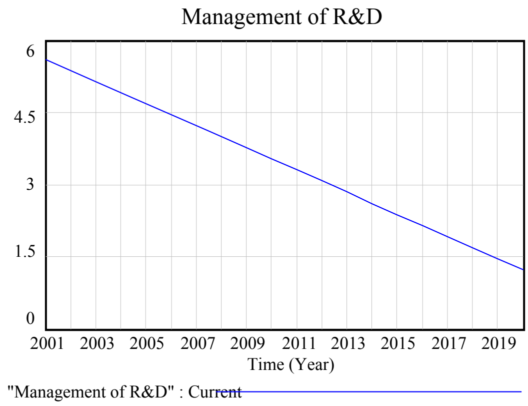
Chart 6: Optimistic level conditions for Human Resource, Coefficient change from -0.34 to +0.3

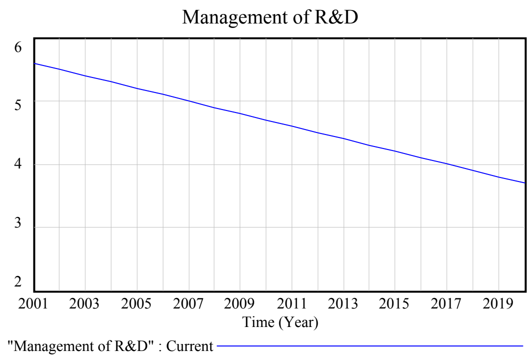


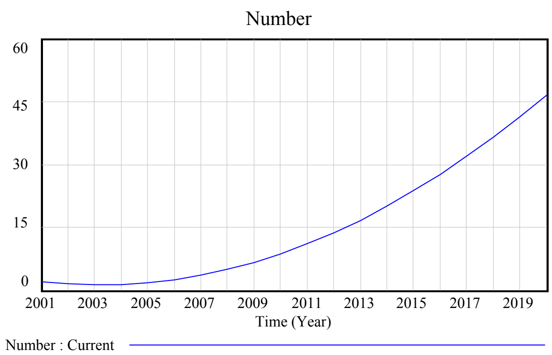


Year	Primary state for human resource	Optimistic condition for human resource	Project numbers in optimistic conditions
2011	3.05	1.45	-9.36
2020	-0.01	-3.05	2.69

Chart7: Pessimistic level conditions for Human Resource, Coefficient change from -0.34 to -0.5

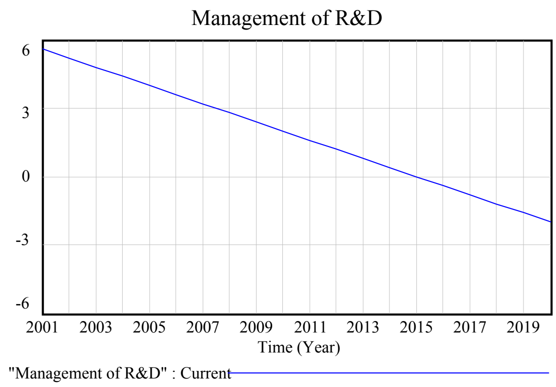


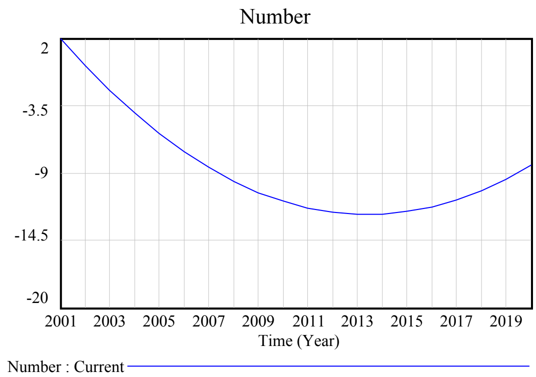




year	Primary state of R&D	Optimistic state of R&D	Project numbers in optimistic conditions
2011	3.3	4.6	10.99
2020	1.23	3.69	46. 63

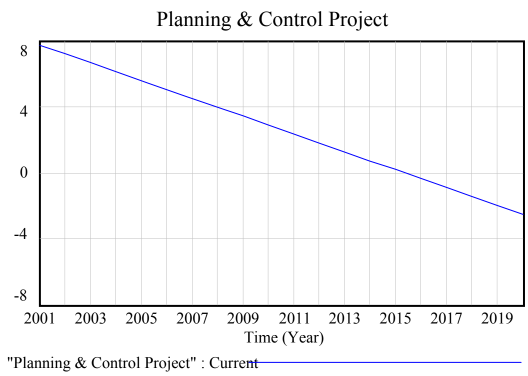
Chart8: Optimistic level conditions for Management of R&D, Coefficient change from 0.72 to 0.85

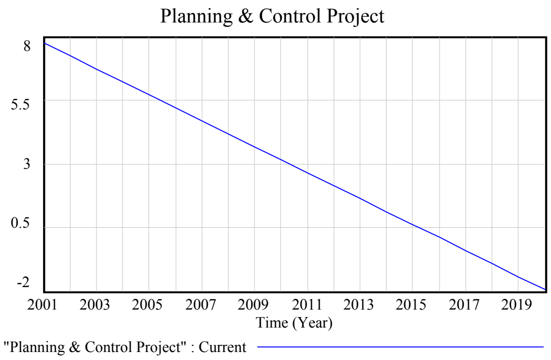


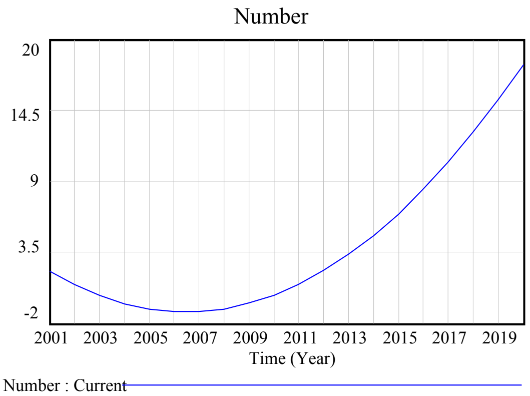


year	Primary state for R&D Management	Pessimistic conditions for R&D management	Project numbers in pessimistic conditions
2011	3.3	1.6	-11.88
2020	1.23	-2	-8.3

Chart9: Pessimistic level conditions for Management of R&D, Coefficient change from 0.72 to 0.55

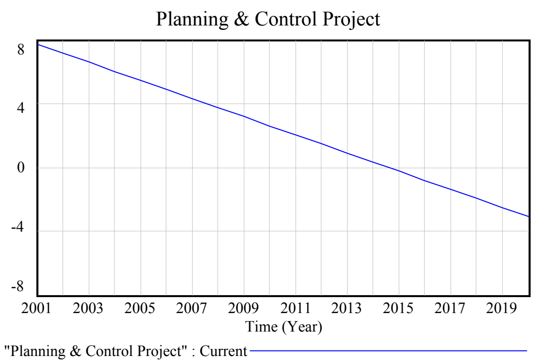


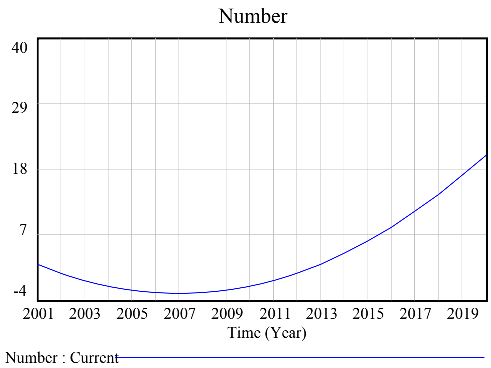




Year	Primary state for planning & project control	Optimistic state for planning & project control	Project numbers in optimistic conditions
2011	2.39	2.65	0.99
2020	-2.5	-1.9	19.05

Chart10: Optimistic level conditions for Planning & Project control of R&D, Coefficient change from 0.07 to 0.10





Year	Primary state for planning & project control of R&D	Pessimistic state for planning & project control of R&D	Project numbers in pessimistic conditions
2011	2.39	2.05	-0.7
2020	-2.5	-3.08	20.29

Chart11: Pessimistic level conditions for Planning & Project control of R&D, Coefficient change from 0.07 to 0.04

6. CONCLUSIONS

As noted, the purpose of this paper is presenting a local model to consider capabilities and abilities of Research and Development unit by emphasizing on reverse engineering in a Chemical Factory. Based on the pattern provided, indicators and parameters to measure Features and capabilities of R & D unit are available.

In this model, some of the basic parameters which were measured, analyzed based on sensitivity analysis include:

Number of Projects done in R & D unit, system inputs such as raw materials and new requirements, professional and skilled manpower, skilled management of R & D, Project Planning and Control of research and development project in analyzing the sensitivity of above indices and parameters, some results were obtained. By eliminating restrictions of indices, it means in terms of optimism for the variables, we can mostly observe that growth is very rapid rate for parameters and variables and also features R & D unit and ultimately the growth of parameters lead to significant increase in the rate of the number of projects conducted by R & D unit. Also by considering the conditions of reverse condition it means, the sensitivity test of variables in terms of increase of barriers in the parameters, we can mostly witness decrease of parameters and number of projects done in R & D.

Finally by reviewing the outputs of model software graphs and sensitivity test of parameters and effective factors for model, in this article the capabilities and abilities of Research and development (R & D) of chemical factory have been determined. We can use these indices and variables to achieve specific goals specific and by comparing them relatively with other industries of R & D and or by comparing them with research and development units of industrial plants located in other countries, the efficiency and effectiveness of R & D unit in the chemical factory to be measured.

Finally, this model can be used to identify desired features and capabilities of R & D and to use required managements to reach them and they be used to successfully control the programs. The model has the ability to generalize and use in most application areas for selection of strategies, policies and research and development projects and access to new technology and we can observe the basic parameters of the model by its effect on the capabilities and abilities of research and development unit.

By observing all tables and charts of the basic parameters we can conclude that in spite of reduced volatility variables and factors in the model during the years 2001-2010, the increase of projects number in R & D unit of chemical factory has had a good condition. This increase is relevant to the urgency and necessity of unfinished projects which are being done by the important factor of R & D Management.

According to the relations of all the basic parameters and doing regression and the corresponding formula model, we can conclude that the most effective factor on the number of projects is the factor of management, planning and control of projects and R & D unit of the chemical factory has a good condition in terms of R & D management, and the reason of this issue in addition to observing relations of variables and formulas coefficients, in addition to the information and graphs is due to necessity and emergency point of unfinished projects and coordination of the main parameters by skillful of Research and development (R & D).

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