Journal of Industrial Strategic Management, Year۲۰۲۱, Volume ٦ (Issue۱), Pages: ۱٤-۳۱

Journal of Industrial Strategic Management

# An Integration of System Dynamics Modelling Approach into the Balanced Scorecard for a Case Study

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**CHRONICLE**

***Article history***
*Received: 10/11/2020*
*Received in revised: 26/01/2021*
*Accepted: 10/02/2021*

*Keywords:*
*Financial Perspective*
*Service-based Firms*
*Strategic Planning*
*Simulation*

**Abstract**

Since work on dynamic aspects of balanced scorecards is just in an early state and a company may gain great insight from simulation results, this paper seeks to develop a dynamic model based on the financial perspective of a balanced scorecard (BSC) in a case study on the basis of a telecommunication company. The value of this paper, at first is related to the application of system dynamics (SD) in a BSC which overcome the limitations of BSC. At second, the paper provides causal loop diagram, dynamic modeling, simulation results, and validation results in the period ۲۰۱۵ to ۲۰۲۰ for the financial aspect to present suitable scenarios such as creation of new infrastructure, increasing the quality of services, diversification of product portfolio, and value-added services. At third, the paper is based on a case study of Tehran Telecommunication Company-Data Network which is a service-based company. Thus, it provides knowledge and information for academician and practitioners of BSC and SD to implement SD based on a BSC in companies, especially service-based firms.



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## Introduction

A combination of strategy and strategy formulation with management accounting is the most popular fields in the area of business management both scientifically and practically. Typically, the usual method of strategic planning has been that each business operating area based on financial measures defines its plan. Now, managers with the help of balanced scorecard (BSC) have the opportunity to focus their efforts on its specified common language and objective. The purpose of the BSC is to implement and explain the company's strategy through more operational terms. In a competitive global economy, financial development actions may tell only part of a company's story. Therefore, the financial accounting model should be expanded to include the assessment of intangible and intangible assets of the company that satisfy customers and employees (Nielsen and Nielsen, ۲۰۰۸).

In studies that have been done on BSC so far, there are two different assumptions that are as follows: ۱) as a measurement instrument in order to improve organizational performance, ۲) as a tool for strategic management that organizations use to remove obstacles in the implementation of organizational strategy like translating organizational strategy into goals (Ebrahimi et al., ۲۰۱۳). In other words, BSC has evolved from a performance measurement system into the strategy map approach. The viable and continuous improvement of an organization depends on the organization's ability to evaluate and measure the performance of key organizational processes. Organizations have recognized the importance of stable and consistent assessment, and therefore have used varied performance evaluation systems over the years. Additionally, it is required to review and monitor the performance of the organization's processes and their subsequent alignment with the organization's strategic goals. Thus, the organization needs an efficient model that focuses on strategic management, guides all elements of the organization in four perspectives: financial, customer, internal processes, and learning and growth, aligned with the organization's vision, and examines the organization's performance in the present and future.

In the current era, organizations face a host of sophisticated and dynamic issues. Dynamic characteristic means changing over time, and related issues require continuous and dynamic management actions. In the area of strategic planning, dynamic issues are of a continuous and recurring nature. In other words, in these cases, the results of management actions are monitored and evaluated, and new measures are taken that will result in new results and actions and in this way, closed loops are formed. Feedback issues are the result of complex interactions between system variables. Since a BSC is an organizational excellence tool, it is essential to focus on this model to eliminate the degeneration of the organization and thus can lead to the organization's sustainable success. Besides, on account of the high status of strategy and decision making in the process of progress and organizational excellence, compliance of a BSC with the concepts of a system dynamics (SD) becomes significant.

This research focuses on dynamic implementation of a BSC model in a case study based on a telecommunication company. Strictly speaking, the main aim of the study is to develop a dynamic BSC and to demonstrate the use of SD as a method to advocate feedback loops rather than unidirectional causality, delays

between cause and effects, provide rigorous validation by quantification of the qualitative insights, propose strategies and present their links to operational processes and performance indicators, define endogenous and exogenous variables in the developed model for the purpose of presenting various scenarios/strategies to improve system's performance

The value of this paper, at first is related to the application of SD in a BSC which overcome the limitations of BSC such as ignoring time dimension and causal loop in a BSC, lack of integration between strategic and operational levels, and wider view to consider competitors and supplier contributions. At second, the paper provides information and scenarios that are helpful for the company to develop strategic management systems based on both BSC architecture and system dynamics methodology (SDM). At third, the paper is based on a case study of a telecommunication company as a service-based organization. Thus, it provides knowledge and information for academician and practitioners of BSC and SD to implement SD based on a BSC in companies, especially service oriented firms.

By the use of SD a dynamic model is developed and structured in accordance with financial perspective of the BSC. To gather necessary information, all key performance indicators of the case study were mapped via interviews and internal documents. The dynamic model was meant to give a better understanding of the dynamics and complexity of the organization and support strategic decision making. The developed model is representing a boundary of the system, variables including stock, rate, and auxiliary. After defining variables, their relations are formulation by mathematical equations by using Vensim. It therefore enables observing the behavior of each variable and the whole system in current situation, predicting the behavior of the variables over time, and testing the model by several methods. Finally, it is possible to have analysis and provide insights of applicable strategies to improve future performance of the system.

## Theoretical Background

As the need to improve performance management in organizations grows, a balanced scorecard (BSC) can be more recognized as a valuable tool to meet the need for improvement and change, particularly for companies that are in a highly competitive or monopolistic market (Chan, ٢٠٠٤). The four aspects of a BSC are as follows (Ebrahimi et al., ٢٠١٣):

A) **Financial**: These indicators are very important in most organizations. Such organizations strive to increase revenue, reduce costs and risks, make better use of real estate, and increase productivity.
B) **Customer**: Managers need to be aware of this - can the organization meet the needs of its customers. To do this, the entire value transferred to the customer must be determined and measured. The goals of this aspect are: customer loyalty, adding value, attracting customers, improving quality and increasing productivity.
C) **Internal processes**: Measuring the degree of value generation and how processes are related can help managers understand the effects. Therefore, it is essential to identify and review the processes that are required

to achieve the goals of customers, shareholders, etc.

D) **Learning and growth**: An organization can only grow and innovate if it can develop its skills and leadership, learn from mistakes of its own and other organizations, and develop new methods. Measuring the performance and development of skills and knowledge of staff is one of the goals of this aspect

Creating BSC makes organizations to merge strategic planning and market and customer processes together. Users of BSC select all of four perspectives and determine the activities of each goal as well. So, using the BSC can link market and customer perspective and strategic objectives together.

Economic and social systems are complex as they consist of many different parts that are potentially heterogeneous and their mechanisms may interfere with each other and interaction effects. System dynamics (SD) is as a methodology of modeling and simulation. It has been applied to various types of systems that change over time, particularly to socioeconomic systems. In the case of issues related to business, it is common to be used to present strategic issues in the wide horizon. The complex dynamic systems are featured by feedback loops, accumulation, delays, and nonlinearities. Application of SD makes an enhancement of knowledge about structure and behavior of such systems and to give the ability to design more robust systems. SD is recognized as a learning tool and engage with mental models which hold the most important information about a system and are the foundation of decision making in SD (Ebrahimi, ٢٠١٦). SD can be used for the process of policy making via three phases: analysis, planning, and control (Lyneis, ٢٠٠٩).

This paper applied a system dynamics modelling (SDM) approach in order to overcome some limitations of BSC, as proposed by Kaplan and Norton (٢٠٠١) which has some similarities to the classic approach. In the literature, there are few studies that combine BSC and dynamic simulation approach. However, the system dynamics method has already proven to be a very useful method in other similar fields such as planning, inventory control, and forecasts. Nielsen and Nielsen (٢٠٠٨) used SDM for a BSC. They showed that a change in at least one of the basic variables may have a major impact on other indicators which is impossible to predict without using a dynamic model. Nielsen and Nielsen (٢٠١٣) showed how an SDM approach can be integrated into the BSC. Nielsen and Nielsen (٢٠١٥) tried to improve the conceptual as well as the methodological aspects of BSC as a quantitative model by combining elements from traditional BSC thinking with the systems thinking with the use of SD.

As an important tool for strategic performance management, the BSC introduces three non-financial aspects of evaluation indicators that compensate for the lack of traditional performance evaluation emphasizing just on financial indicators. On the basis of a strategic perspective, this can help managers focus on the key elements that lead to success. The main idea of the BSC is to balance a set of indicators such as short-term and long-term indicators, financial and non-financial indicators, leading and lagging indicators, endogenous and exogenous indicators. Using a strategy map, a BSC can describe the causality of indicators from different angles. After using the strategy map and BSC, the focal point of performance

management changes from short-term goals to strategic goals and from the reflection of results to real-time analysis of the problem. However, there are theoretically some drawbacks to a BSC (Zhang, ۲۰۱۲).

Akkermans and Oorschot (۲۰۰۲) discussed five limitations of BSC. BSCs focus on one-way causality, are unable to detect delays between actions and their impact on performance, do not have the ability to validate, and do not integrate inadequate strategy with operational actions. And suffer from internal prejudices. To overcome these limitations, they propose a SD approach to BSC development. Zhang (۲۰۱۲) combined the BSC and SD for performance management. Akkermans and Oorschot (۲۰۰۵) described a case study in which SDM and simulation was used in combination with the BSC. Barnabè (۲۰۱۱) focused on a case study related to a service-based business and discussed the maps, the mathematical model and the BSC developed according to SDM principles. Sales et al. (۲۰۱۵) aimed the development of an information technology balanced scorecard (ITBSC) based on SD approach.

## Case Study

Telecommunications provide communication via remote transmission of information. Early means of communicating over a distance included visual signals, such as beacons, smoke signals, semaphore telegraphs, signal flags, other examples of pre-modern long-distance communication included audio messages such as coded drumbeats, lung-blown horns, and loud whistles. In modern times, telecommunications typically involve using electronic devices (such as the telegraph, telephone and teletype), radio, microwave communications, satellites, and internet. In recent decades, telecommunication has been recognized as an organization for socio-economic progress in the world. At the same time, increasing demand for telecommunications services has greatly contributed to the growth of this industry, so that the number of phone service subscribers in worldwide are over billion and in every minute thousands of new subscribers are added. Recently, phone services are essential part of World Trade Organization and social life.

At present, Iran's telecommunication industry is experiencing profound transformation due to technological changes. Markets that were vertical having a distinct advantage over their competitors in the past led to new challenges, players, and markets with investments mainly from the private sector. Telecommunication Company in Tehran has been encountered with a variety of problems after the privatization efforts. Now, there are several telecommunications operators in the country. In the past, one of the competitive tool for expanding customers have been fighting over the price, but today more emphasis is on the services provided to the customer and customer needs become the central focus for service provider's activities. An industry with higher growth faces with more market unpredictability. These issues make telecommunications organizations to evaluate their performance to see if they are in the track of their strategic goals or not.

As it is shown in figure ۱, due to the end of monopoly and the entry of new competitors into the ADSL market in recent years, Telecommunication Company has faced with a serious threat to lose its market share gradually. At the end of ۲۰۱٦, Telecommunication Company had approximately ٥٠،۳ percent of the ADSL

market and the remaining belonged to other competitors in the market. Since Telecommunication Company has gained higher market share than the other competitors, it has no plan to promote sales and service quality for the future. Therefore, other competitors will seize the potential market share in future. In addition, the majority of the country's telecommunications system that belongs to the Telecommunications Company is not entirely consistent with the world's updated innovations. ADSL still remains the most popular choice for the exchange of information and communication, while most recently value-added services with high-speed internet connections are being offered by competitors. This causes a reducing pattern of future demand for Telecommunication Company.

In figure ١, the status of data in the past ٥ years is considered and it is the basis of discussion of modeling to improve and achieve the goals.

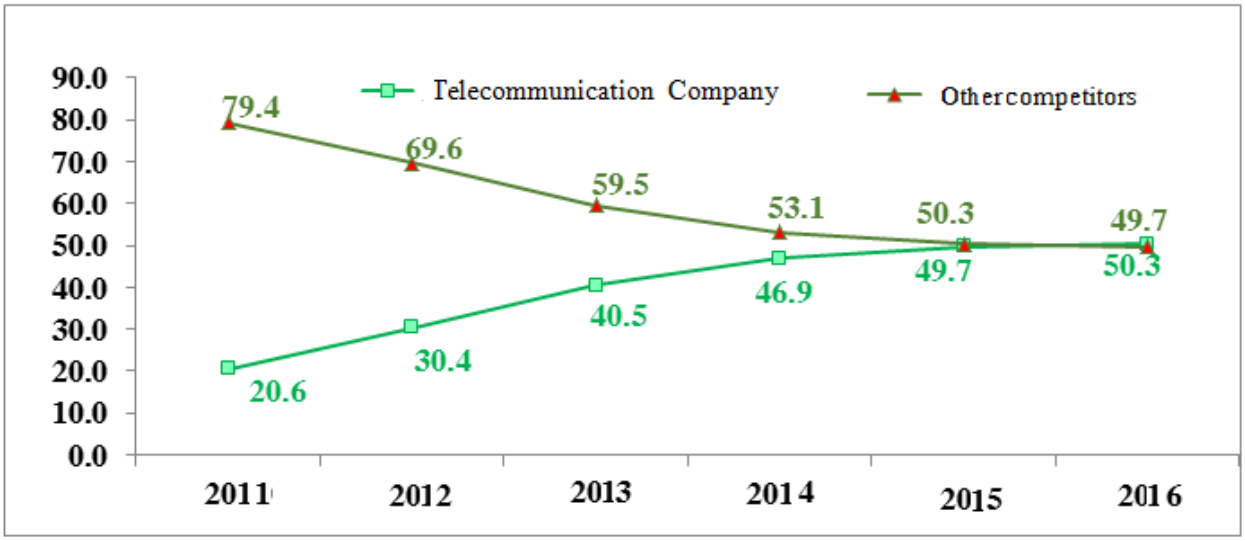


**Figure ١. Comparison of the percentage of market share**

Figure ٢ shows the trend of assigned ports in the ADSL Market. As it can be seen clearly from ٢٠١٥ to ٢٠١٦ there is a sustainable decline in assigned ports of the Telecommunication Company.

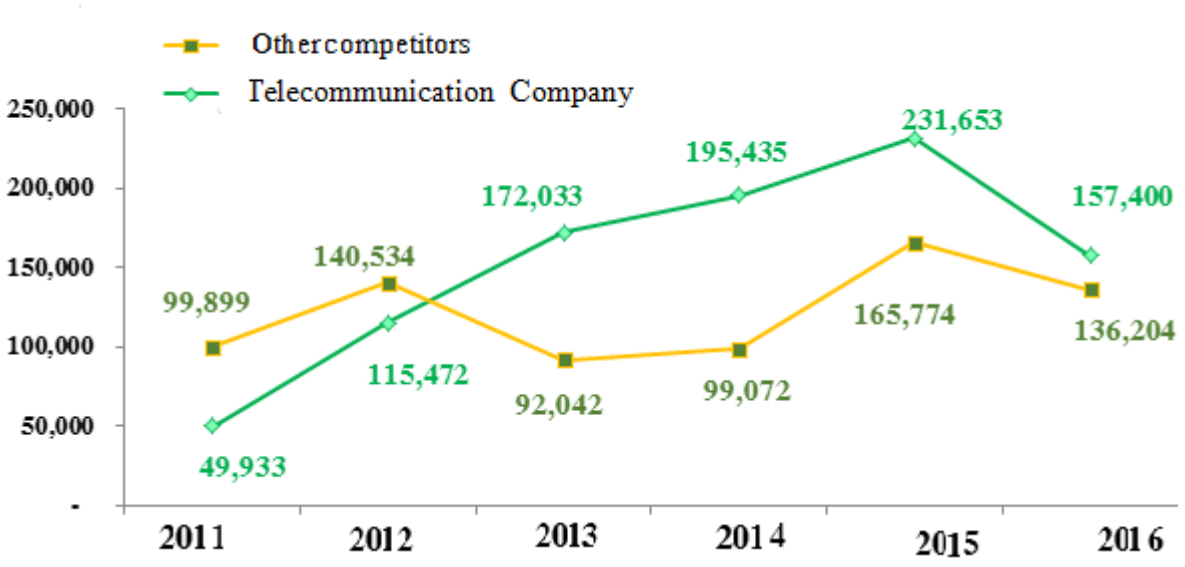


**Figure ٢: Comparison of ADSL assigned ports**

## Strategic Objectives of the BSC

As mentioned in the previous section, BSC includes four perspectives including financial, market and customers, internal business processes, and learning and growth that strategic objectives of the organization is expressed regarding these four perspectives. The goal of any organization of planning or strategic planning is to express strategic goals briefly and transparently and document operations required by the organization to achieve its goals. In the Telecommunication Company, the basis for defining objectives is the Telecoms Operational Program in ٢٠١٥. The objectives of this program were formulated through library studies and interviews with telecommunication experts in Tehran and by referring to standard objectives and indicators of the International Telecommunication Union. As it is shown in figure ٣, strategic objectives of four perspectives were expressed separately.

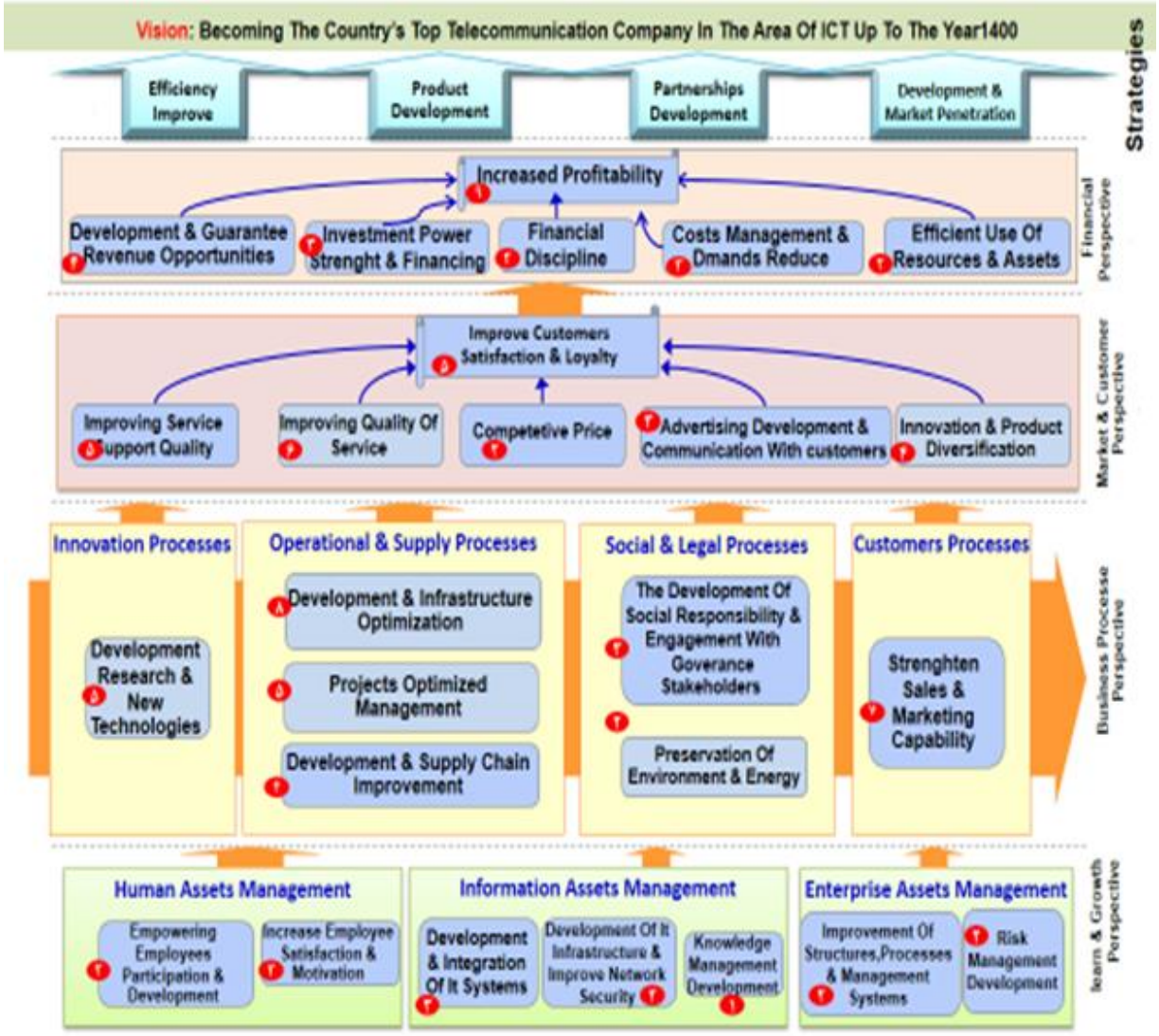


**Figure ٣. Strategic objectives based on four perspectives of BSC**

## Strategic Objectives and Indicators of the Financial Perspective

The main strategic objective of the financial perspective is increased profitability which is affected by four other objectives. In this paper, strategic objectives on the basis of financial perspective of BSC are considered to be development and guarantee of income opportunities (F١), and growth of profit of the company at the possible highest level (F٢).

An indicator is a measurable value that expresses how a goal is realized. Indicators were characterized by levels of organization and the different nature of tasks of each level. In this research, indicators related to each objective of financial perspective have been extracted based on the Operational Plan of the Tehran Telecommunication Company in ٢٠١٥. It is worth noting that the indicators of this program have been developed through library studies, interviews with experts, and by referring to standard indicators of the International Telecommunication Union. In BSC, the strategic objectives of each perspective are linked to key performance indicators.

In the table ١, indicators related to the strategic objectives of the financial perspective have been expressed.

**Table ١. Financial strategic objectives and indicators**

| Strategic objectives | Indicators | Wight Indexes |
|---|---|---|
| Development and ensuring revenue opportunities (F١) | Growth Percentage of Household Data Revenue | ٢٠ |
| | Growth Percentage of Business Data Revenue | ٣٠ |
| | Growth Percentage of Household Data ARPU† | ٢٠ |
| | Growth Percentage of Business Data ARPU | ٣٠ |
| growth of profit of the company at the possible highest level (F٢) | profit margin | ٣٠ |
| | Net profit | ٣٠ |
| | Operating Profit | ٤٠ |

## Integrating of System Dynamics into the Financial Perspective

Average revenue per user†

According to the purpose of the study, the goal of this model is financial analysis of the ADSL market. The key variables in relation to this model are number of users, revenues, and expenses.

## Dynamic Hypothesis and Causal Loop Diagram

Dynamic hypothesis presents a structure that might be capable of generating real behavior and is shaped based on cause and effect relationships among the rate and stock variables. Based on dynamic hypothesis, a causal loop diagram (CLD) can be presented which visualizes the way variables in a system are interrelated.

As shown in the causal-loop diagram of a financial perspective, figure ٤, the growth of increase rate causes an increase in profitability of the company which is a stock variable in the dynamic model. On the other hand, decrease rate of profit makes a decline in the final profit. Increase in profitability leads to a growth in the profit decrease rate, which causes a decrease in the final profit. Increase in profitability causes a growth in the profit increase rate, which leads to an increase in the final profit.

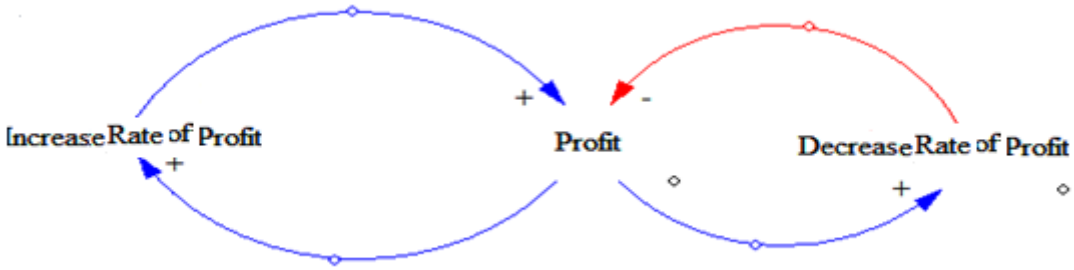


**Figure ٤. Causal loop diagram of financial perspective**

## Dynamic Modeling

In this model, there are variables such as data revenue, revenue from value added services, commercial data revenue and home-based ADSL service revenue which considered having an increasing effect on the final profit. Data production cost including costs such as cost of staff, cost of equipment, and etc. cause reduction in the final profit. The time horizon is a ٥-year period for this model which is considered to simulate which begins from ٢٠١٥ and ends in planning horizon of the case study in ٢٠٢٠.

**Table ٢. Variables of financial perspective (Mostafavi, ٢٠١٩a)**

| Type of dynamic variable | Description | Variable |
|---|---|---|
| Stock/level | Profitability: shows the profitability of an organization each year. | Profit |
| Inflow rate | Increase Rate of Profit which increases the level of the profitability. | Increase Profit |
| Auxiliary | Data revenue variable: Income from Internet service | Data Revenue |

| | | |
|---|---|---|
| Auxiliary | Household ADSL service revenue: Income derived from home-based Internet service, which itself has information that varies over time. | Home ADSL Revenue |
| Auxiliary | Commercial ADSL service revenue: Income derived from commercial Internet service, which itself has information that varies over time. | Business Data Revenue |
| Auxiliary | Average annual revenue from home-based ADSL services: The average annual revenue for the subscription service, which is received from the customer | Yearly ADSL ARPU Accounting |
| Auxiliary | Average annual earnings from commercial ADSL services: The average annual revenue for a subscription service that is received from business customers | Yearly Data ARPU Accounting |
| Auxiliary | The annual revenue resulting from the surplus traffic of households ADSL service | Revenue Of ADSL Traffic |
| Auxiliary | The annual revenue resulting from the surplus traffic of commercial ADSL service | Revenue Of Data Traffic |
| Auxiliary | The revenue resulting from the sale of the modem for home-based ADSL services and installation of the modem | Revenue Of ADSL Modem Sales And Configuration |
| Auxiliary | The revenue variable resulting from the sale of the modem for the commercial ADSL services and installation of the modem | Revenue Of Data Modem Sales And Configuration |
| Auxiliary | Average revenue per annum home-based ADSL service | ADSL ARPU |
| Auxiliary | Average annual earnings per commercial ADSL service | Data ARPU |
| Auxiliary | The number of clients of home-based ADSL services annually | Count Of ADSL Customer |
| Auxiliary | The number of clients of the commercial ADSL service annually | Count Of Data Customer |
| Auxiliary | The number of modems sold for home-based ADSL services annually | Count ADSL Modem |
| Auxiliary | The number of modems sold for commercial ADSL per annum | Count Data Modem |
| Constant | Cost per each Gigabit of fixed surplus traffic | Cost Of Per Traffic |
| Constant | Cost of each modem and its installation | Average Cost Of Modem Sale and Configuration |
| Auxiliary | Revenue of value added services of data infrastructure | Value Added Service Revenue |
| Auxiliary | MPLS revenue | MPLS Revenue |
| Auxiliary | Intranet revenue | Intranet Revenue |
| Auxiliary | Urban MPLS | City MPLS |
| Auxiliary | Intercity MPLS | Between City MPLS |
| Auxiliary | Business firms | Business Company |
| Auxiliary | Number of MPLS links | Number Of MPLS |
| Auxiliary | Average income per urban MPLS link | ARPU City MPLS |
| Auxiliary | The number of intercity MPLS link | Number Of BCM |
| Auxiliary | Average income per intercity MPLS link | ARPU BCM |
| Auxiliary | The number of clients, companies, for intranet service | Number Of Company |
| Auxiliary | The average income from each company | Average Revenue |
| Outflow rate | Decrease rate of the profit | Decrease Profit |
| Auxiliary | The amount owed to the Telecommunication Company by institution and customers | Credits |
| Auxiliary | The amount owed to the Telecommunication Company in the case of Intranet | Intranet Credits |

| | | |
|---|---|---|
| Auxiliary | Debt rate of commercial firms | BC Rate |
| Auxiliary | Debt related to data | Data Credit |
| Auxiliary | Debt rate related to data | DC Rate |
| Auxiliary | Cost of production per data port | Data Port Production Cost |
| Auxiliary | Cost per each port | Cost Of Per Port |
| Auxiliary | Total cost of equipment | All Cost Of Equipment |
| Auxiliary | The total cost of infrastructure | All Cost Of Infrastructure |
| Auxiliary | The salary of all employees in the data area | Salary Of All Staff InData |
| Auxiliary | Total cost of installation and maintenance | All Cost Of Data Maintenance |
| Auxiliary | Total cost of energy and fuel of data equipment | All Cost Of Data Equipment Energy |
| Auxiliary | Other costs Including Infrastructure Company Charges, Taxes ... | Other Cost |

Profitability = Total factors increasing profitability – Total factors reducing total Profitability (١)

Increase rate of profit = Income from Data + Income from value added services (٢)

Data-Based Earnings = Income from home-based ADSL Service + Income from Business Data (٣)

Earnings Caused by Value Added Services = Intranet Service Income + MPLS Service Income (٤)

Total factors reducing total Profitability = Total Expenses + Total Claims and Liabilities (٥)

The cost of each data port = Total Energy Cost + Human Resources Cost per Port + Rental Costs of Infrastructure + Setup Costs + Equipment Costs + Other Costs (٦)

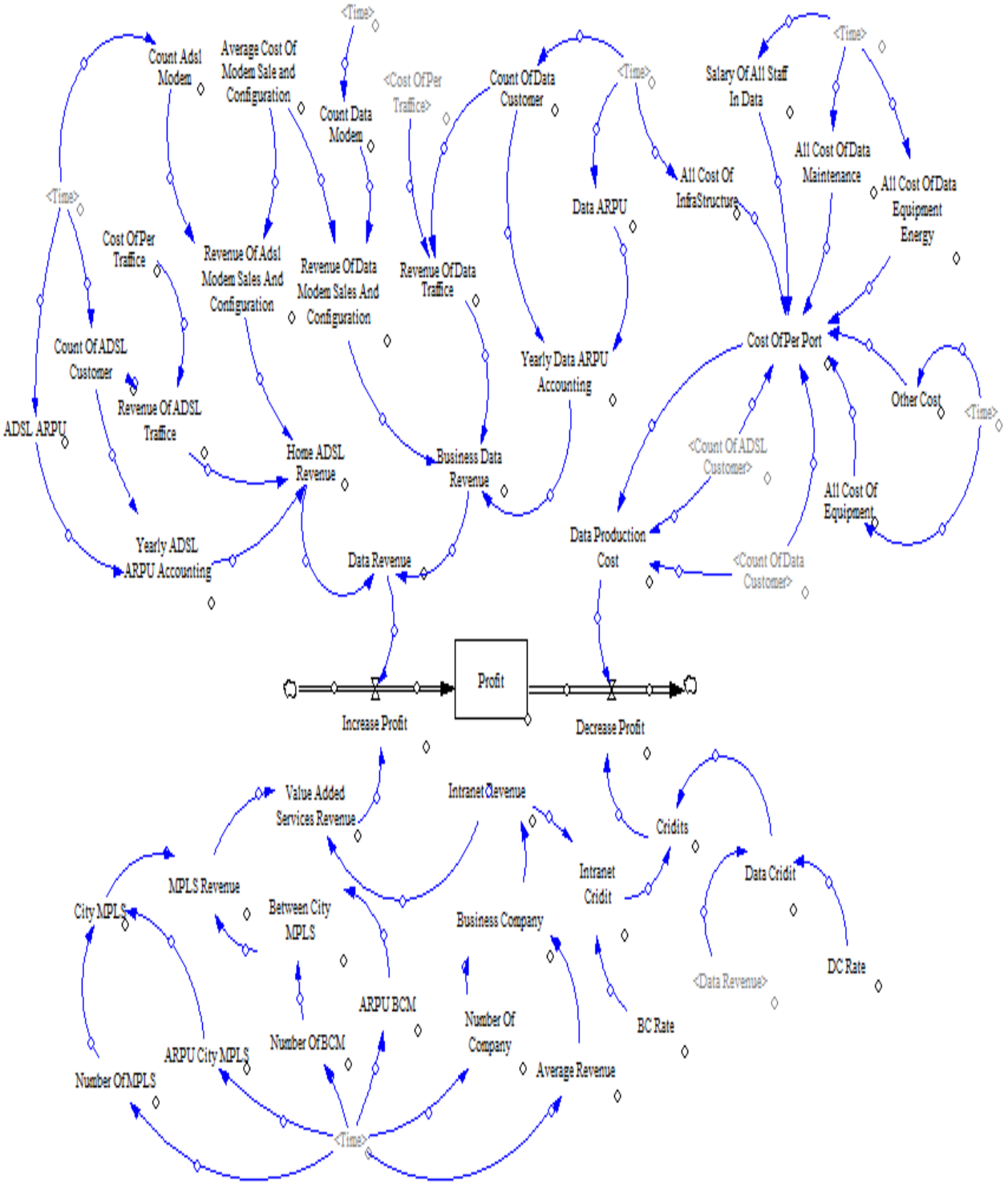


**Figure٥. Dynamic model of financial perspective (Mostafavi, ٢٠١٩a)**

## Results

To present appropriate scenarios, validation testing, and sensitivity analysis of the model are considered. After determining the dynamic model, to ensure its performance credentials there are several tests by Vensim software which is mentioned briefly below.

## Behavioral Test

The purpose of this test is comparing simulation results with real data of key variables to ensure the accuracy of the model behavior. Figures ٦ and ٧ show real information and simulation results of business data revenue, and household data revenue from ٢٠١٥ to ٢٠١٧ which demonstrate that behaviors of studied variables have been simulated well.

In these figures orange lines represent simulated data of the model and gray lines represent actual information.

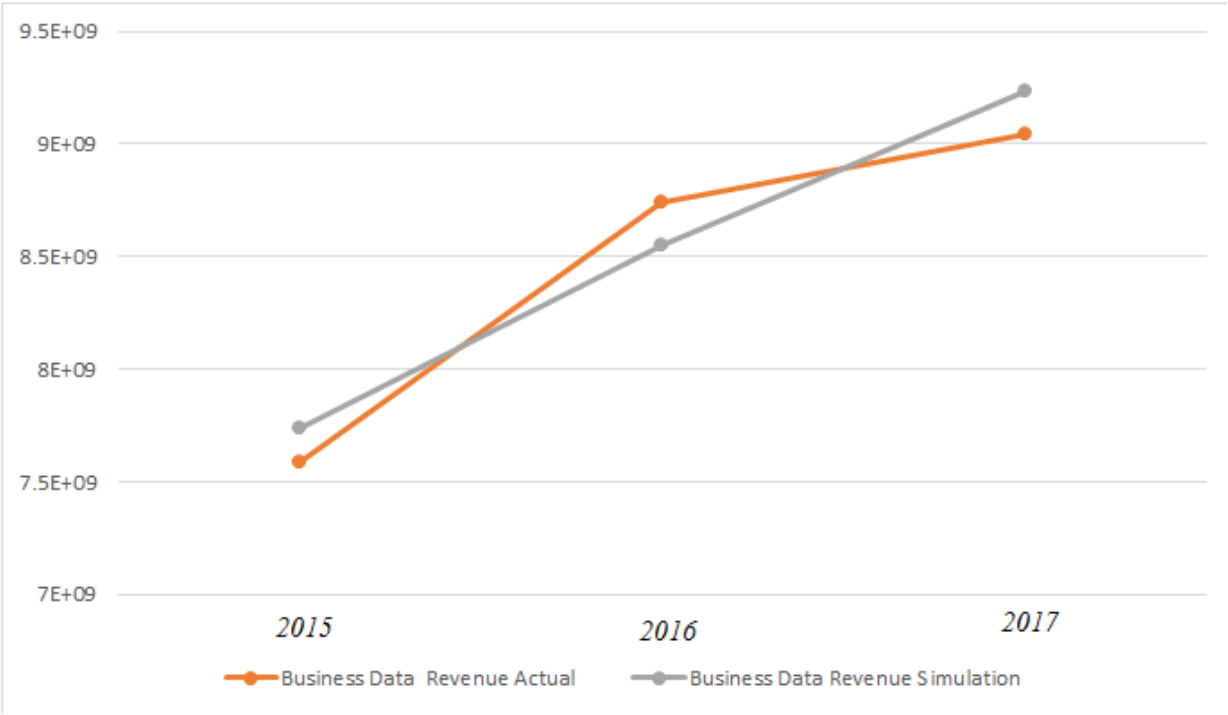


**Figure ٦. The comparison of actual and simulated business data revenue model behavior**

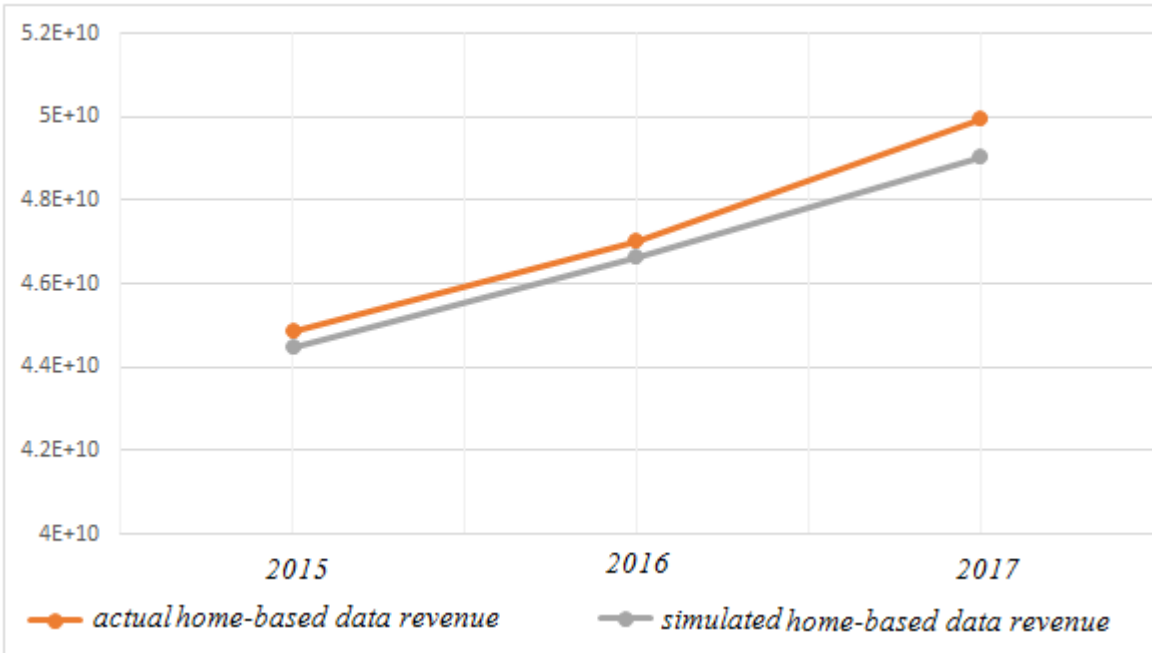


**Figure ٧. The comparison of actual and simulated home-based data revenue model behavior**

## Test Period

Since the accuracy of simulation results might be influenced by the time period, a time period up to ٢٠٢٠ is considered. Simulation results showed the accuracy of the model in the coming years.

## Sensitivity Analysis

The purpose of sensitivity analysis is to evaluate changes in the values of fixed variables on the final results of the model. Considering this issue, an important factor which is taken into consideration is profitability. This factor is calculated by "Total revenue - Total expenses" (Toman). The role of this factor is highlighted by ADSL market moving towards a competitive market. Figure ٨ shows the trend of profitability of the case study from ٢٠١٥ till ٢٠٢٠. It is shown that after the year ٢٠١٨, profitability reduces considerably.

Competition among providers is stronger when there are severe changes in the market while increasing profitability coincides with growing market share and penetration rate for each service provider. Profitability can be influenced by several variables. As the number of service providers in the market increases, the market will become more competitive and increase demand for a service with lower costs. One of the key variables of this research which influences on the profitability of each service provider and finally on market share and its competition factor is the revenue resulted of value-added services for each service provider.

## Discussion

According to the other perspectives of the BSC, the following scenarios are effective for the trend of profitability.

**Scenario ١**: Assuming just ١٠٪ improvement in marketing, infrastructure construction, and support quality and service quality to business customers.

**Scenario ٢**: Assuming only ١٠٪ improvement in marketing, infrastructure construction and support quality and service quality to household customers.

**Scenario ٣**: Assuming only ١٠٪ improvement in marketing, infrastructure construction and support quality and service quality to customers of value-added services.

**Scenario ٤**: Assuming ٠,٥ percent reduction of the unrecoverable cost of both business and home-based services.

**Scenario ٥**: Assuming to ٢٠ percent increase in experience.

Figure ٨ provides a comparison of the amount of profitability from ٢٠١٥ to ٢٠٢٠ before and after applying policies.

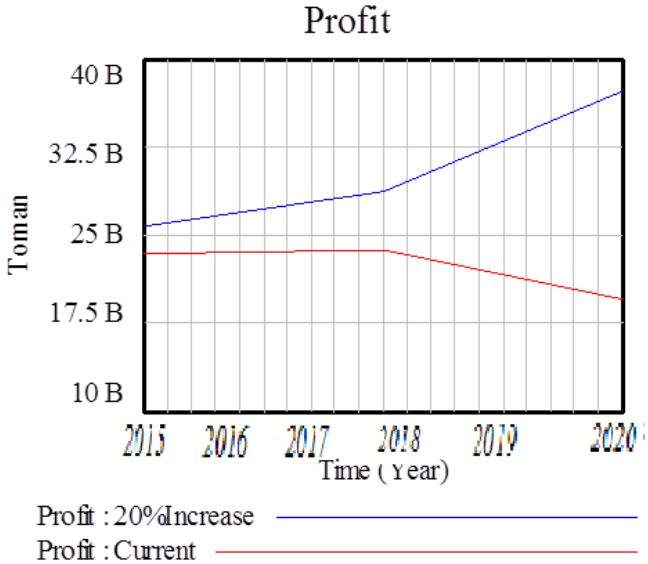


**Figure ٨. The profitability (٢٠١٥-٢٠٢٠) per 'Toman' before and after applying policies**

## Conclusions

Performance management is a continuous and comprehensive function of management that signifies mutual expectations and focuses on improvement in the future. This paper focused on the application of the balanced scorecard (BSC) in the Data Network Service of the Telecommunication Company of Tehran. Telecommunications has entered a new age of development with advanced technology and increased competition with established players. Each perspective of the BSC includes objectives which refer to the major objectives to be achieved. The present study focused on the financial aspect to increase profitability of the company.

This study applied system dynamics methodology (SDM) for the implementation of a BSC model in Tehran

Telecommunication Company – Data Network. The paper provided causal loop diagram and dynamic modeling of financial perspective which were used for the purpose of scenario planning. The results show that despite of the increase in the number of competitors, Telecommunication Company has gained majority of the market. However, it is anticipated that profitability of the company will be decreased after year ٢٠١٨ if the company doesn't change its directions. The Telecommunication Company can invest in new infrastructures and influence on the market to maintain its profitability or increase quality of services and value-added service compared to its competitors. Another scenario is to reduce the demands from the government agencies which increasingly occupy organization resources and has negative effects on the reputation of telecommunications services. The effect of each scenario in short-term causes change in current trends and competing factors in favor of Telecommunication Company. It is recommended for the Telecommunications Company to invest in providing value-added services for the superiority in the market.

The value of this paper is related to the application of SD in a BSC which overcome the limitations of BSC such as ignoring time dimension and causal loop in a BSC, lack of integration between strategic and operational levels, and wider view to consider competitors and supplier contributions.

## Acknowledgements

Special thanks to Mr. Esmail Mostafavi who support us through this study.

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