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Applying A Markov Chain Model for Screening of New Product Ideas

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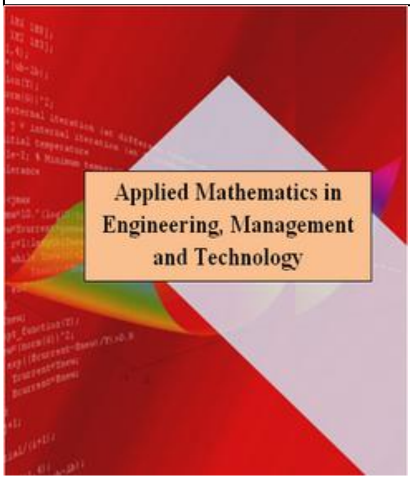

Abstract

Currently, economic activities, including providing services and producing products, take place in an intrinsically dynamic and uncertain atmosphere. Meanwhile, innovation, as an important indicator for business and effective strategy for economic growth, has gained prominence in the majority of services and production communities as well as governments. The purpose of this study is to primarily model production stages of a new product through Markov chains to answer the question how probable it is that an idea leads to a successful product. Secondly, the study seeks to propose a new tool for evaluating and screening new product ideas. To do this, data from Product Development and Management Association (2004, 2005) were used to divide the innovation process into 6 states: idea generation, idea screening, economic analysis, development, testing, and commercialization. Probability of success or failure of the project, at every stage of innovation, was modeled through the transition matrix and Markov chains, and then a solution was proposed for comparing the ideas. Criteria for comparison in the model proposed include time, cost, quality and risk. Results of Markov analysis revealed that the more the process approaches final states, the more likely the product will achieve success in market.

Keywords: new product, Markov chain, Markov analysis, idea screening

1. Introduction

As researchers and scholars agree, at present day, economic activities, both in fields of production and services, occur in a dynamic and uncertain atmosphere. High quality, low costs and prices, and short product/services delivery times are not factors that can merely guarantee the success of an economic activity. Although a good combination of these three factors can be beneficial for businesses, innovation is still another highly effective indicator that has gained prominence in production/services communities as well as governments.

The Canadian government, for instance, founded Canadian Foundation for Innovation about 10 years ago to support and promulgate innovative activities [1]. Innovation takes place when an idea is realized and developed into a product or service. Different definitions for innovation have been proposed so far, all of which emphasize the generation of a new idea or behavior [20]. Describing the phenomenon as a “creative destruction”, Schumpeter views innovation as an irreversible and historical change in doing activities, and a disturbance in the existing economic discipline and balance, leading to a new discipline and balance [19].

Drucker regards innovation, just like any other objective activity, as a phenomenon that, besides genius and talent, demands knowledge, attention and effort [2]. He further explains that the common trait of entrepreneurs is not a particular personality type but is systematic commitment to innovation. Tushman and O'Reilly (1997) describe innovation as a ground for “winning” in business that helps managers recognize the technology cycle and innovation streams to achieve advantages arising from discontinuous changes [16].

Creativity and innovation are not necessarily latent talents that people possess, but are everyday activities to make connections not previously observed and finding links between and among issues that are not normally put together. Still, innovation can exist as pure genius, although most innovators achieve success through conscious and purposeful exploration of opportunities [3]. Holt, proposing a broad sense of the term, defines innovation as a process for using relevant knowledge or information to create or introduce new and useful things [2]. Holt further explains that innovation is any revisited thing that is designed and realized, strengthening the position of the organization against rivals and providing a long-term advantage.

Innovation, in other words, is the creation of a new thing that follows and realizes a specific purpose. Urabe, too, states that innovation is the development and application of a new idea as a new product, process, or service that leads to national economic growth and increases employment for production in the innovative company. Innovation is not a phenomenon that occurs only once but is a continuous process composed of organizational decision-making at all stages, from the introduction of the new idea to its application.

The new idea, in fact, involves understanding costumers' new needs or new production methods, and it is developed through data collection and with an entrepreneurial approach. In the process of operationalizing the new idea as a product, the process or service should also take into account cost-effectiveness and efficiency [3]. Innovation, as a long-term factor of success, has been increasingly playing an important role in comparative markets, because enterprises with a high capacity are able to respond to environmental challenges faster and more effectively [17]. Innovation can also involve risk particularly in today's business space which is dynamic and hypothetical.

All of these factors are reasons justifying the need for risk analysis in innovation and new products development. The important point is that over 95% of innovation and new design projects either end up with failure or cannot return the financial investments of companies [1]. In every industry, future-looking and customer-centric companies are often more successful in competitive markets. The most valuable asset of these companies is the information the possess about costumers and their buying patterns [14].

The purpose of the present study is to model innovation states of a product through Markov analysis to answer the question how probable it is that an idea leads to a successful product. In fact, the main question is twofold: (a) what percentage of research and development projects inaugurated in a system leads to a desired result in the long run? (b) At each innovation stage, how likely it is that the product achieves success? To answer these question, a matrix will be constructed for idea screening and selecting the best idea. In the following sections, first the literature will be reviewed and, following methodological concerns, findings will be discussed as well as the results of the model analysis.

2. Review of Literature

2.1. A review of researches conducted

Melisa points out that a successful new product design and development should simultaneously meet three criteria: (a) to maximize the product's adaptability to costumers' needs; (b) to minimize the time for the design circle; and (c) to control development costs [4]. In another study, Swink et al. (2006) stated that a successful process of new product design depends on the efficiency of the process, development costs, lead time, product prices, and product quality [5]. Swink and Song (2007), too, introduce four basic stages for introducing the new product development process. They contend that market analysis, technological competencies, product testing, product commercialization [6].

Rosenthal product divided the new product development into four stages: ideas generation and conceptual design, definition and specification, prototype and development, and commercialization [7]. Cooper, however, outlines a five-stage process including scoping, building the business case, development, testing and validation, and launch [8]. What is important is that many researchers believe that the multi-stage new product design and development are not precisely sequential, and some stages may take place in parallel [1].

New product design processes are a matter of decision-making based on evaluative comparisons of new products according to various aspects such as costs, quality, and time. Multi-Attribute Utility Theory (MAUT) and Analytic Hierarchy Process (AHP) are among the major methods used over the past decade for modeling multi-attribute problems in case of new product development [1]. Focusing on such attributes as price and quality, Marquez and Blanchar (2006) used dynamic systems and simulation techniques for modeling marketing innovation in case of major investment decision-making [9].

Liu et al. (2008) proposed an analytic approach to determine customer satisfaction, taking into account different costumers' needs and related technological specifications [10]. Also, Chan & Cho (2010), using dynamic systems approach along with Markov chains, proposed a customer lifetime value prediction (CLVP) model based on product attractiveness and market strategies [11]. Cheng et al. (2011) investigated CLVP by a Markov-chain-based data mining [12]. Razmi and Ghanbari (2009), too, proposed a new CLVP model, relying on the probability of costumer's extending contracts in their future and their commitment to the organization in question [13].

Basiri (2007) also used data mining in customer relationship management, studying the whole process as far as innovation is concerned [14]. Sohrabi et al. (2010), employing multiple-criteria decision analysis and costumer categorization, created a model for measuring CLVP in the banking industry [15]. What has been relatively addressed in the previous studies is a combination of costumer needs, costs of new product development, and product specifications, which all together, lead to the generation of new ideas and find a basis for decision-making in this regard. More importantly, idea screening in product development and design projects is vital in the primary stages of the new product design process, because it helps verify the good projects have been adopted and they will result in product success after commercialization.

2.2. Markov analysis

Markov analysis is a hypothetical technique dealing with probabilities that may occur in the future and that are analyzed by presently identified probabilities. If time were divided into three periods of past, present and future, the future of the process would not depend on the path taken in the past, but only on its present state. Markov analysis is often used in systems which are in transition from one state to another. Transition matrix shows the probabilities of transitions from one state to another, and Markov analysis can help predict the occurrence of any of the states in the future. Long-term system transitions are called stable state or limiting distribution, which refers to the system state in the long run the future. The probability of future system states is independent of the preceding system states. Markov processes are classified based on two parameters:

1. Time: which can be discrete or continuous
2. System state: which can be discrete or continuous

Markov chains are a special type of Markov processes which involve discrete time and discrete states. Markov model states can be the following types [18]:

- Accessible: state i and state j are accessible when there is a possibility of reaching i from j.
- Communicating: when two states have bidirectional accessibility
- Class: the set of all communicating states
- Uniform: a system with only one class is called uniform
- Closed: a set of states is called closed when none of the states in the set can reach any outside state
- Absorbing: when a state creates a closed set
- Recurrent: state i is called recurrent when the system reaches it and will definitely reach it again in subsequent stages
- Transient: a transient state is one to which the system will not come back in future events

3. Methodology

The research method is a Markov analysis applied to new product design and development process from the idea generation stage to commercialization. The data needed for Markov modeling were collected from the studies published by the Product Development and Management Association (2004-2005). In the published findings, only 14% of the ideas led to success in market. Table 1 shows the probability of the success of an idea in innovation stages.

Table 1. An idea’s probability of success in the innovation stages

Stage	Likelihood of success
Idea generation	100
Idea screening	68
Economic analyses	47
Development	33
Testing	28
Commercialization	24
Success	14

Considering the issues reviewed in the literature, we take account innovation a 6-stage process, which totally involves 8 stages if we introduce 2 more states, namely, successful marketing of the idea and failure of the idea. The 8 states are defined as following with their corresponding parameters:

- State 1, idea generation (S_1): the assumption in this state is that a new idea has been introduced.
- State 2, ideas screening (S_2): better ideas are selected in this state.

- State 3, economic analyses (S_3): the ideas selected in the previous state are analyzed economically and the ideas without any economic justification are eliminated.
- State 4, development (S_4): at this step, economically justifiable ideas are developed.
- State 5, testing (S_5): a prototype of the product is manufactured and all related testes are conducted on the product. If the product is found suitable, its trial production is inaugurated.
- State 6, commercialization (S_6): at this step, the mass production of the product is started as a commercial brand.
- State 7, successful marketing of the idea (S_7): after the commercialization state and customers' appreciation, the idea is considered a successful innovation.
- State 8, failure of the idea and its shutdown (S_8): this state takes place when the idea fails and is not further pursued. In any of the first 6 states, the idea may face failure, entering this state.

Figure 1 illustrates the transition diagram of Markov model. In this model, each of the 8 states of the Markov model is diagrammed, while all possible transitions between and among states are demonstrated. As Figure 1 shows, transitions can only move to a subsequent state, and all states, except state 7, may lead to state 8. Of course, states 7 and 8 cannot undergo transition to any of the other 6 states, meaning that they are absorbing states. In fact, in the Markov model, it is assumed that an idea will be either successful or end in failure, which are two absorbing states. The idea, as mentioned earlier, may end in failure at any stage.

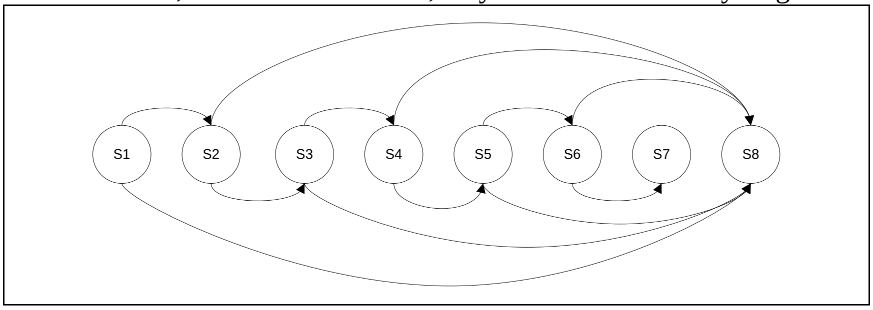

Figure 1. Markov transition diagram

As a result, the transition matrix of the proposed model would be as following with two absorbing states. P_{ij} values represent the probability of transition from state i to state j.

$$P = \begin{matrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \\ S_8 \end{matrix} \begin{bmatrix} 0 & P_{12} & 0 & 0 & 0 & 0 & 0 & P_{18} \\ 0 & 0 & P_{23} & 0 & 0 & 0 & 0 & P_{28} \\ 0 & 0 & 0 & P_{34} & 0 & 0 & 0 & P_{38} \\ 0 & 0 & 0 & 0 & P_{45} & 0 & 0 & P_{48} \\ 0 & 0 & 0 & 0 & 0 & P_{56} & 0 & P_{58} \\ 0 & 0 & 0 & 0 & 0 & 0 & P_{67} & P_{68} \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

As can be seen, the above matrix has two absorbing states, and if the system is in an absorbing state, there is a 100% chance that it will remain in the same state in the future. Now, the main question is how likely it is that the system will be in one of the two absorbing states in the long run. This question is important because it first reveals what percentage of research and development projects launched in the system leads to a result, and secondly what the likelihood of success is in each state of the innovation cycle. Another purpose of constructing the matrix is to use it for ideas screening.

In the first phase, constructing the fundamental matrix can help answer the question how likely it is that the system will be in a non-absorbing state in the long run. In fact, the fundamental matrix represents the probability of the number of times the system is found in the non-absorbing states before it moves to an absorbing state. The absorbing states in the innovation process, from idea generation up to commercialization and finally the absorbing states, refer to the successes or failure of the idea at each stage. To begin with, by a replacement in the rows of transition matrix P, another matrix can be resulted:

$$P=\begin{matrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \\ S_8 \end{matrix}\begin{bmatrix} 0 & P_{12} & 0 & 0 & 0 & 0 & 0 & P_{18} \\ 0 & 0 & P_{23} & 0 & 0 & 0 & 0 & P_{28} \\ 0 & 0 & 0 & P_{34} & 0 & 0 & 0 & P_{38} \\ 0 & 0 & 0 & 0 & P_{45} & 0 & 0 & P_{48} \\ 0 & 0 & 0 & 0 & 0 & P_{56} & 0 & P_{58} \\ 0 & 0 & 0 & 0 & 0 & 0 & P_{67} & P_{68} \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \Rightarrow P=\begin{matrix} S_7 \\ S_8 \\ S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{matrix}\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & P_{18} & 0 & P_{12} & 0 & 0 & 0 & 0 \\ 0 & P_{28} & 0 & 0 & P_{23} & 0 & 0 & 0 \\ 0 & P_{38} & 0 & 0 & 0 & P_{34} & 0 & 0 \\ 0 & P_{48} & 0 & 0 & 0 & 0 & P_{45} & 0 \\ 0 & P_{58} & 0 & 0 & 0 & 0 & 0 & P_{56} \\ P_{67} & P_{68} & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Thus, matrix P can be as follows:

$$P=\begin{bmatrix} I & 0 \\ R & Q \end{bmatrix}$$

where I is unit matrix, 0 is zero matrix, and R is a matrix showing probable transitions from non-absorbing to absorbing states, and Q is the matrix consisting of probable transitions between absorbing states.

At the first step, by converting the above matrix into the fundamental matrix, one can answer the question how likely the system will be in a non-absorbing state in the long run. In reality, the fundamental matrix represents the chances of times that the system is in a non-absorbing state before moving to one of the absorbing states. Non-absorbing states in the innovation process may occur from idea generation up to commercialization and absorbing states, which show the success and failure of the idea at each stage. The fundamental matrix can be calculated via relation 1:

$$F=(I-Q)^{-1}=\begin{bmatrix} 1 & x_{1,2} & x_{1,3} & \cdots & \cdots & x_{1,6} \\ 0 & 1 & x_{2,3} & \cdots & \cdots & x_{2,6} \\ 0 & 0 & 1 & \ddots & \ddots & \vdots \\ \vdots & \vdots & 0 & 1 & \ddots & \vdots \\ \vdots & \vdots & \vdots & 0 & 1 & x_{5,6} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

$X_{i,j}$ values show the probability of transition from state i to state j in the long run. That is, with $X_{i,j}$ probability, if the system is in state I, it will reach state j. After the construction of the fundamental matrix and multiplication of this matrix by matrix R, one can predict whether the idea or product will eventually achieve success or not, according to the states of the model in the long run.

$$A=F\times R=\begin{bmatrix} a_{1,7} & a_{1,8} \\ a_{2,7} & a_{2,8} \\ a_{3,7} & a_{3,8} \\ \vdots & \vdots \\ \vdots & \vdots \\ a_{6,7} & a_{6,8} \end{bmatrix} \quad (2)$$

Matrix A is called is absorbing states matrix. This matrix shows the probability of reaching absorbing states, when any of the non-absorbing states is in focus; $a_{i,7}$ is the probability of success in the i stage. In fact, in the Markov model proposed, after preparing the transition matrix, the fundamental matrix is constructed. Then, the question is answered concerning the probable states in which the system in each of the (non-) absorbing states in the long run. Matrix A (absorbing states matrix) represents the probability of transition to any of the absorbing system states, if the system is currently in a non-absorbing state.
In the second phase, after constructing the fundamental and absorbing matrices, a method will be proposed for evaluating new product ideas. During the development of a new product, there are normally different factors affecting the success or failure of the idea. In the research, four criteria are considered for ideas screening.

- Uncertainty or risk: which is represented in transition states of the Markov process and is determined by constructing fundamental and absorbing matrices.
- Quality: the degree of adaptability of customers' demands. The more the ideas match customers' needs, the more likely the ideas reach success. Clearly, an idea, at first, would meet customers' demands more, but the more the process approaches commercialization the degree of this adaptability would decrease. In the ideas screening model, this factor is represented by Q. Q^k is quality vector of the idea for product k at each of the 6 stages:

$$Q^k = \begin{bmatrix} q_1 & q_2 & q_3 & q_4 & q_5 & q_6 \end{bmatrix}$$

where q_i is idea quality in state i of the 6 states. These values are calculated according to statistical estimates and background data of the company in question.

- Time: is the time needed for converting the idea into an actual product. This period is also known as the time cycle for the new product development. The shorter the time, the more likely the idea successful, because a prolonged production process would result in changes in market structure and in costumers' demands. Therefore, it is clear that before costumers' demands undergo a change, the product should be introduced to market.
- Cost: this criteria refers to the expenses of turning the idea into a product. The costs for a new product development are also associated with market prices and marginal profit. This criteria is represented by C. C^k is the commercial costs vector of the idea for product k in each of the 6 stages:

$$C^k = \begin{bmatrix} c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \end{bmatrix}$$

where C_i is idea costs in state i of the 6 states. These values are calculated according to statistical estimates and background data of the company in question.
It is important to note that as the system moves toward commercialization, the values should be revisited and accordingly one column of the above matrices is removed. In the following section, a model is proposed to use the three parameters along with success of a new product development for ideas screening as well as their cross-comparisons in each of the 6 states.

4. Results and discussion

In this section, using the results published by the Product Development and Management Association (2004, 2005 see Table 1 above), we calculate fundamental and absorbing matrices, proposing a model for ideas screening in each of the 6 stages.

4.1. Markov model of a new product development

Considering Table 1, one can consider the probability of transition of matrix P as follows. The values of probabilities shown in Table 1 are based on the research conducted by the Product Development and Management Association (2004, 2005):

$$P = \begin{matrix} S_7 \\ S_8 \\ S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{matrix} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & P_{18} & 0 & P_{12} & 0 & 0 & 0 & 0 \\ 0 & P_{28} & 0 & 0 & P_{23} & 0 & 0 & 0 \\ 0 & P_{38} & 0 & 0 & 0 & P_{34} & 0 & 0 \\ 0 & P_{48} & 0 & 0 & 0 & 0 & P_{45} & 0 \\ 0 & P_{58} & 0 & 0 & 0 & 0 & 0 & P_{56} \\ P_{67} & P_{68} & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \Rightarrow p^* = \left[\begin{array}{cc|cccccc} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & .32 & 0 & .68 & 0 & 0 & 0 & 0 \\ 0 & .31 & 0 & 0 & .69 & 0 & 0 & 0 \\ 0 & .3 & 0 & 0 & 0 & .7 & 0 & 0 \\ 0 & .16 & 0 & 0 & 0 & 0 & .84 & 0 \\ 0 & .15 & 0 & 0 & 0 & 0 & 0 & .85 \\ .58 & .42 & 0 & 0 & 0 & 0 & 0 & 0 \end{array}\right]$$

At the first step, by converting the matric into a fundamental matrix, we can answer the question how likely it is that the system will be in non-absorbing states in the long run. In fact, the fundamental matrix shows the chances of the system's being in the non- absorbing states before moving to one of the absorbing states. The non-absorbing state in the innovation process, from idea generation to commercialization and absorbing states, refers to the success or failure of the product in each of the stages. Considering relation 1 used for calculating the fundamental matrix, the fundamental matrix is shown in Table 2:

Table 2. Fundamental matrix

State	1	2	3	4	5	6
1	1	0.68	0.469	0.328	0.275	0.234
2	0	1	0.69	0.483	0.405	0.344
3	0	0	1	0.7	0.588	0.499
4	0	0	0	1	0.84	0.714
5	0	0	0	0	1	0.85
6	0	0	0	0	0	1

As the fundamental matrix represents the number of chances that the system may be in a non-absorbing state before it moves to an absorbing state, so, as an example, if the process is in the first stage (idea generation), the chances of reaching the commercialization stage is merely 23%. However, if a new product design reaches the testing state, it will reach commercialization with 85% probability. As the fundamental matrix shows in Table 2, the more the system approaches the final states of development, the more likely that it reaches commercialization.

Also, as an example, if the system is in the first stage (idea generation), the probabilities of the idea's reaching the ideas screening state, the development state, and the testing state are 68%, 32%, and 27%, respectively. This situation suggests the ideas are less likely to reach a more advanced state. Now, by multiplying the fundamental matrix by matrix R, the final probabilities matrix is resulted. Thus, considering relation 2, the final probabilities matrix, for solving the problem of idea success or failure, would be calculated as in Table 3.

Table 3 shows the probability of success and failure of an idea in each state. So, if the system is in the first state (idea generation), there is a 13% possibility that the new idea achieves success, whereas there is an 86% possibility that the idea end in failure. Still, if the process is in the ideas screening state, the idea can become successful with 20% possibility. The same percentage would be 29% for an idea in economic analyses state, and 41% for a product that has reached the development state. Products reaching the testing state can achieve success with 49% probability. The percentage of product success increases in each stage, implying that the more the process approaches final stages, the more likely that the project will be successful. Thus, it can be concluded that companies can be more optimistic about the success of the product, if they expand their investment in the final stages.

Table 3. The final probabilities matrix for success or failure of ideas in each stage

π	Success	Failure
Idea generation	0.136	0.863
Ideas screening	0.2	0.799
Economic analyses	0.289	0.7101
Development	0.414	0.585
Testing	0.493	0.507
Commercialization	0.58	0.42

4.2. Evaluating the idea for a new product

At this stage, considering the issues addressed in section 3 above as well as the results observed in 4.1, we propose a method for idea evaluation. To evaluate the idea behind a new product, the process is normally assumed to be in the first step of the 6 states which is idea generation. Calculated through relation 2, matrix A reveals that the idea will be successful with $a_{1,7}$ probability. This value is the risk parameter or the likelihood of success of the idea at this stage. The first column of fundamental matrix F shows the probabilities of reaching any of the 6 states, if the process is currently in the first state. By estimating vectors Q and C for each idea in each of the states, decision-making about ideas screening and idea selection can be conducted through the following procedure:

- Step 1: fundamental matrix F and absorbing matrix A should be calculated to determine the probability of transition among different states of the process.
- Step 2: vectors Q and C should be estimated for the idea in question in the current state.
- Step 3: vectors of total costs and total quality should be calculated by multiplying vectors C and Q by the transpose of the row related to the current state by matrix F (the process is assumed to be in the first stage):

$$Q^k(T) = \begin{bmatrix} q_1 & q_2 & q_3 & q_4 & q_5 & q_6 \end{bmatrix} \times \begin{bmatrix} 1 \\ x_{1,2} \\ x_{1,3} \\ x_{1,4} \\ x_{1,5} \\ x_{1,6} \end{bmatrix} \quad (3)$$

$$C^k(T) = \begin{bmatrix} c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \end{bmatrix} \times \begin{bmatrix} 1 \\ x_{1,2} \\ x_{1,3} \\ x_{1,4} \\ x_{1,5} \\ x_{1,6} \end{bmatrix} \quad (4)$$

where $C^k(T)$ is the expected value of costs for transferring an idea from the current stage to commercialization, and $Q^k(T)$ is the expected value of idea quality from the current stage to commercialization. c_i is the costs of each state and q_i is the quality of each state. Also, $x_{i,j}$ is the probability of reaching state j when the current state is state i. These values refer to the transpose of the i row of the fundamental matrix.

- Step 4: the value of B^k should be calculated for idea k.

$$B^k = \sum_{m=1}^{4} e_m^k . w_m^k$$
$$\Rightarrow B^k = \left\{e_1^k . w_1^k\right\} + \left\{Q^k(T) . w_2^k\right\} + \left\{e_3^k . w_3^k\right\} + \left\{a_{i,7} . w_4^k\right\} \tag{5}$$

where k is idea and m is the parameter: e_1 is the costs parameter which is calculated as the normalized value of costs based on $C^k(T)$'s; e_2 is the quality parameter represented as $Q^k(T)$; e_3 is the parameter of time which refers to the normalized values of project time; and e_4 is the parameter of risk. W is the weight of each parameter. i is the stage or any of the 6 states.

As a result, any idea in any of the states is compared to other ideas, and the idea with a greater B values is selected.

5. Conclusion

This studied was concerned with different stages of a new product development from idea generation to commercialization and to idea success or failure. The innovation process was then broken into 6 stages including idea generation, ideas screening, economic analyses, development, testing, commercialization. The probability of success or failure of each of the stages of the innovation process was modeled based on the transition process and Markov chains. The results of the Markov analysis revealed that the more the process approaches the final stages, the more likely that the product will be successful in market. Furthermore, considering the results of Markov analysis, a product's likelihood of success and its reaching to commercialization and ultimately success in market is 13% only. Following the analysis, a method was proposed to compare ideas based on Markov chains. In this method, four criteria were proposed for ideas screening: project risk, costs, quality, and time. Further studies can address product life cycle stages through Markov analysis.

References

1. Basiri, M. (2007). Application of data mining in costumer relations management. 4th Conference on National E-Commerce, Tehran, Iran. [In Persian]
2. C.-J. Cheng, S.W. Chiu, C.-B. Cheng, J.-Y. Wu, (2011) , "Customer lifetime value prediction by a Markov chain based data mining model: Application to an auto repair and maintenance company in Taiwan", Sharif University of Technology.
3. Cooper, R. G. (2000). "Doing it right". Ivey Business Journal, 64(6), 54–60
4. Holt K. "The role of the user in product innovation, in R Rothwell and J Bessant (Eds) Innovation", adaptation and growth, (1987) , pp. 1-12, Elsevier, Amsterdam
5. Jimenez-Jimenez,D. & Sanz-Valle, R.(2011).Innovation, Organizational learning, and Performance.Journal of Business Research,64.408-417.
6. Liu, X., Zhang, W. J., & Jiang, R. (2008). An analytical approach to customer requirement satisfaction in design specification development. IEEE Transactions on Engineering Management, 35(1), 94–102.
7. Marquez, A. C., & Blanchar, C. (2006). A decision support system for evaluating operations investments in high-technology business. Decision Support Systems, 41(2), 472–487.
8. Melissa, A. S. (2005). "Strategic management of technological innovation (Internationaled.)". New York: McGraw-Hill.
9. Modaress-Yazdi, M. Zero theory. (1991). Tehran: University Press Center. [In Persian]
10. Pfeifer, P. E., & Carraway, R. L. (2000). Modeling customer relationships as Markov chains. Journal of Interactive Marketing, 14(2), 43–45.
11. Razmi, J., & Ghanbari, A. (2008). Proposing a new model for customer lifetime value prediction. Information Technology Management, 2, 35-50. [In Persian]
12. Rezvani, H.R., & Gerailinazhad, R. (2011). Proposing a model for innovation taxonomy. Technological Growth, 28. [In Persian]
13. Rosenthal, S. R. (1992). Effective product design and development – How to cut lead time and increase customer satisfaction. Business One Irwin, 21–30.
14. S.L. Chan , W.H. Ip, V. Cho, (2010), "A model for predicting customer value from perspectives of product attractiveness and marketing strategy" , Expert Systems with Applications , vol 37 , P 1207–1215.

15. Schumpeter, J. A. (1934). The theory of economic development: An inquiry in to profits, capital credit, Interest and the business cycle. Cambridge: Harvard Business Press
16. Sohrabi, B., Khanlari, A., & Ajorloo, N. (2011). A model for determining customer lifetime value prediction in the banking industry. Iranian Management Research, 15, 1. [In Persian]
17. Swink, M., & Song, M. (2007). Effects of marketing-manufacturing integration on new product development time and competitive advantage. Journal of Operations Management, 25(1), 203–217.
18. Swink, M., Talluri, S., & Pandejpong, T. (2006). Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs. Journal of Operations Management, 24(5), 542–562.
19. Tushman, L. M., & O'Reilly, C, A. (1997). Winning Through Innovation: A practical guide to leading organizational change and renewal. Harward: Harvard Business Review Press.
20. Urabe, K. "Innovation and the Japanese management system. In K. Urabe, J. Child, & T. Kagono (Eds.)", Innovation and management international comparisons. (1988). Berlin: Walter de Gruyter.