Using simulation to evaluate investment projects

Utilizarea simulării pentru evaluarea proiectelor de investiţii

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Abstract

The goal of this paper is to show how the system dynamics simulation can be applied to incorporate in the evaluation process of various investment projects the interactions between market demand and financial health of the firm. Through simulation, a more accurate representation of the variability and uncertainty of business proposals or strategies can be obtained.

Keywords: *simulation, system dynamic, investment decision*

Rezumat

Scopul acestei lucrari este de a arăta modul în care simularea dinamicii sistemelor poate fi aplicată pentru a include în procesul de evaluare a diferitelor proiecte de investitii interactiunile dintre cererea de pe piată şi situatia financiară a firmei. Prin simulare poate fi obtinută o reprezentare mai realistă a variabilităţii şi incertitudinii asociate proiectelor sau strategiilor de afaceri.

Cuvinte-cheie: *simulare, dinamica sistemelor, decizia de investiţie*

JEL Classification: C15, C63, E22, E37, D81, D92

Introduction

An investment project represents a long-term allocation of funds to carry an investment idea through to its stable-income generation stage. A viable investment project aims at achieving a profitable return that ensures attractive return on the invested capital, and positive and consistent cash flows.

In general, there will be uncertainty about the size of the future cash flows and about the lifetime of each project. Thus, the approach would be more realistic if these uncertainties are incorporated into the analysis. The result would be a probability distribution, for the net present value, which would indicate the range within which it would be likely to lie and the probability of having particular values.

In (Luban, 1999, 2005) it is shown how Monte Carlo simulation can be used to extend the net present value approach so that it can explicitly take into account the uncertainty associated with an investment project.

Accelerating economic, technological, social, and environmental changes enhance the dynamic complexity of the economic systems, making difficult for managers to fully understand the behavior of such systems. Often, for the managers and marketing departments is difficult to foresee when the investment will be needed to meet future demand in the market. To remain competitive, small and medium enterprises must anticipate the situations in which demand will increase. In this paper it is shown how system dynamics simulation can be used for analysing the investment decisions in uncertain climates.

Senge (1994) considers that system dynamics models can facilitate the understanding of systems because they provide a method for comprehending how all the objects interact with one another. System dynamics asserts that these interactions, which are called causal relationships, form a complex underlying structure for any system. This structure may be discovered and described empirically or theoretically. Once discovered, we can learn about its impact on the behaviour of the individual objects and the entire system.

System dynamics was conceived at MIT in the late 1960s (Forrester, 1961). It has now grown into a major discipline (Rațiu-Suciu, 2000; Sterman, 2000, 2001) that is widely used in the private sector in, for example, oil, asset management, financial services, in health and social care, defence and consultancy. Its basis is learning to see patterns of behaviour in organisations and grounding these in the structure of organisations – their operational processes and policies. It uses software to map processes and policies at a strategic level, populate the map with data, and simulate the evolution of the processes under transparent assumptions, policies and scenarios. System dynamics is a versatile way of bringing whole-systems thinking to life in a rigorous, testable way.

In (Luban and Hîncu, 2009) there are presented several applications of system dynamics simulation analyse specific problems related to knowledge management processes. These applications include a dynamic management flight simulator (Sveiby, Linard and Dvorsky, 2002) which can help managers to understand better the dynamic interrelationships in organisation design and, in particular, the interrelationships between an organisation's profitability and investment in people competence, internal structure and relationship building measures with customers.

Appello, Hartman, and Martin-Vega (2000) present the application of the concept of system dynamics to a capacity expansion investment decision using semiconductor industry data.

Parker (1997) proposes a system dynamics model to simulate cash flow profiles for analysing investment opportunities with great accuracy and confidence in building strategies to support corporate growth.

Harvey (2002) illustrates the usefulness of Keynes' full-scale trade cycle model in modern crisis theory by modeling it using system dynamics.

Gupta and Kortzfleisch (1987) present a system dynamics model to analyze the consequences of investments in agriculture. The data is taken from the various case studies of agriculture in India. The paper describes in detail the system dynamics flow diagram of the agriculture system model, the factors which are important for investments to be profitable.

In this paper, we introduce an example of system dynamics application, such as to evaluate different types of investment decisions for developing an copany whose existing production capacity is not sufficient to cover current demand and it is expected a growth in demand for company products in the future.

The necessity of system dynamics approach for investment analysis

In a world characterized by uncertainty arising from rapidly changing technologies and global competition, it seems particularly important to identify new sources of competitive advantages for companies and regions. Studies on cognitive science and innovation recognize knowledge as the main strategic resource to be developed or purchased in order to create new products and processes. So, firms, especially those operating in industries based on knowledge, should invest in technologies for creating new knowledge and learn to establish competitive advantage.

Traditional cash flow analyses for justification of budgeting for a capital investment project lack the ability to incorporate external factors, which include competition, timing, emotions and their interactions. To make significant changes in such complex adaptive situations it is necessary to think differently and test ideas before use, as effective solutions may often seem to be counter-intuitive and even defy logic. System dynamics provides a method of testing solutions and it provides a set of thinking skills and a set of modelling tools (Richmond, 1998).

Thinking skills include:

- dynamic thinking – conceptualising how organisations behave over time and how we would like them to behave;
- system as cause thinking – determining plausible explanations for the behaviour of the organisation over time in terms of past actions;
- forest thinking – seeing the big picture and transcending organisational boundaries;
- operational thinking – analysing the contribution which different operational factors make to overall behaviour;
- closed-loop thinking – analysing feedback loops, including the way that results can influence causes;
- quantitative thinking – determining the mathematical relationships needed to model cause and effect;
- scientific thinking – using models to construct and test hypotheses.

Modelling tools include as key elements of system dynamics: causal loop diagrams and stocks and flows.

Causal loop diagram allows describing a set of variables, linked by arrows, showing the causal influences between couples of them.

Stock and flow structures are utilized to describe variables that can be accumulated (stocks) and their rates (flows) of increasing and/or decreasing. Stocks represent the state of the system, and generate the information upon which decisions and actions are based. Stocks give systems inertia and create delays by accumulating the difference between the inflow to a process and its outflow. These accumulations can be tangible stocks, such as plant, cash, equipment, and intangible ones, such as employee skills, customer loyalty, knowledge etc. A system dynamics model involves and auxiliary variables, which can be linked to stocks and flows and are used to better describe the system behaviour.

In this paper, a system dynamics model will be used attempting to incorporate the techniques of cash flow analysis for a capital investment project with the external factors such as those related to current market conditions and the organisation culture and emotions related to previous investments.

Description of investment model

In this application, it is considered that the market drives the demand for the product. The purpose of the model is to investigate the feasibility and the profitability of the following capacity investment options to meet forecasted demand:

O1. Investment for building a new factory with the same number of productive facilities as the existing factory

O2. Investment for expansion the present factory with a new productive facility

O3. Investment for modernization of a part or of the all existing productive facilities by introducing new technologies

O4. No investment.

The simulation model will allows the analyst to determine investments at each point in time over the established horizon, which maximize the profit of the firm, given current demand and condition of the market at the time of decision. The diagram of system dynamics simulation model for this investment process is presented in Figure 1.

Investment allowed, total productive capacity and forecasted demand drive the investment decisions looking to determine where and when money should be allocated for development. If one invest in the new factory, then it will be necessary to invest in productive facilities. Only productive facilities allow one to increase output. If the forecasted demands surpass the productive capacity and the net present value (NPV) is positive, then money will be allocated to the investment option that has the greatest NPV and an investment that is less than the amount of money available for investment in the period. The amount founding allowed in a particular period is based on the minimum acceptable rate of return established by the company, in conjunction with the NPV for forecasted demand, external founding and total productive capacity.

In the model presented in Figure 1, there are two stock variables (productive capacity of the company and number of productive facilities), six flow variable (company productive capacity growth rate, company productive capacity decay rate, productive facility growth rate, productive facility decay rate, market share of the company and forecasted product demand).and many auxiliary variables. By allowing for the manipulation of the demand and the market share, the impact of investment decision on the profitability of the company can be identified through the use of what-if scenarios that can be easily modified and analysed.

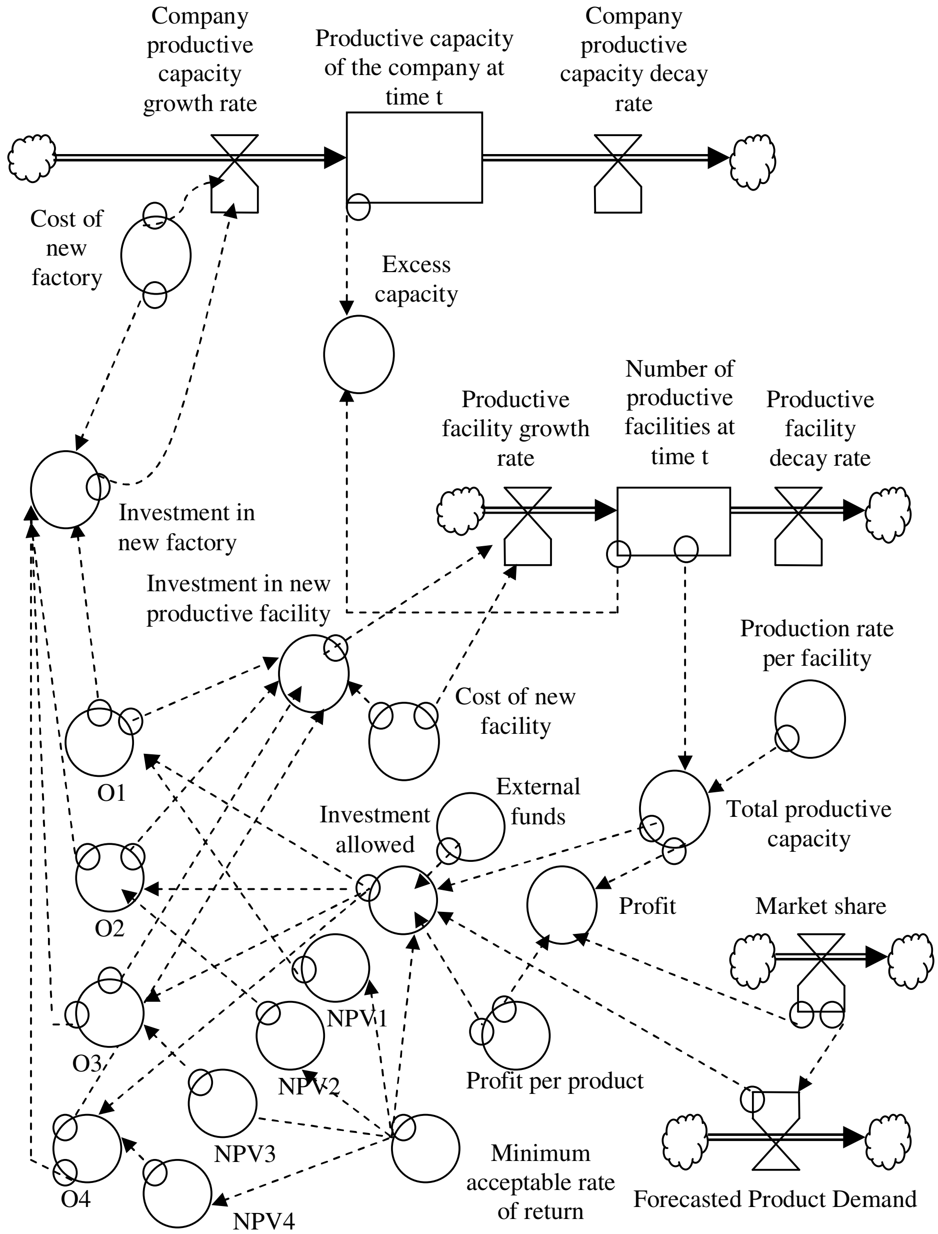

Figure 1 Diagram of system dynamics model for investment process

Conclusion

System dynamics model provide a way to allow for insight into the potential gains posed by various investment options. This will allow the acceptance/rejection of proposals to become more predictable. System dynamics is a way of thinking about the future which focuses on stocks and flows within processes and the relationships between them. It is a risk-free way of refining plans before implementation using computer simulation and can facilitate ideas for both specific solutions and generic new world rules.

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