Decision Support System using Artificial Neural Network for Managing Product Innovation

Noppakorn Klintong, Ph.D. (Cand.)
Technopreneurship and Innovation Management Program
Graduate School, Chulalongkorn University
Bangkok, Thailand
noppakorn66@hotmail.com

Associate Professor Pakpachong Vadanasin, DBA.
Faculty of Commerce and Accountancy
Chulalongkorn University
Bangkok, Thailand
pakpachong@hotmail.com

Assistant Professor Natcha Thawesaengskulthai,
Faculty of Engineering
Chulalongkorn University
Bangkok, Thailand
natcha.t@chula.ac.th

Abstract

The firm's capability to develop product innovation and successfully launch new products has been regarded as crucial determinant in sustaining a firm's competitive advantage and increasing the value of the firm. Firms have been faced with a complicated problem in innovation development project selection decisions. From review of the related studies we found two groups of capability; firm's innovative capability and firm's new product development capability are the factors affect the successful development of product innovation By utilizing Decision support system using Artificial Intelligent Network (ANN) which is the mathematical models developed by the study of the organization and functioning of biological neurons, we believe it is possible that they will provide a superior predictive system for use in the product innovation development project.

Keywords: Artificial Neuron Networks - Innovation Management – New Product Development - Product Innovation – innovation capability

I. Introduction

Michael Porter [1] urged that succeeding in a competitive environment; firms must create and sustain a competitive advantage. Song and Parry [2] and Day and Fahey [3] pointed out that he firm's capability to develop product innovation and successfully launch new products has been regarded as a crucial determinant in sustaining a firm's competitive advantage and increasing the value of the firm. Product innovation providing superior value to customer is certainly increase market share and profits of the firm. Firms have been, for a long time, faced with a complicated problem in development project selection decisions, such as go/no-go choices and specific resource allocation decisions. Griffin [4] and Wind and Mahajan [5] found that despite a long list of high potential product innovation for management to choose, pledged support from product champions, and increased

attention from researchers on the development problem, there still is a relatively stable success rate near 59% for new products in the marketplace. Experienced product managers recognize patterns within projects consistent with previously successful and failed projects. Such practical knowledge enables them to guide projects to the development success or kill projects doomed for failure before valuable resources are wasted. This paper is aim to review the virtue of the Artificial Neuron Network in replacing the statistical analysis and the literature of factors affect the successful product innovation.

2. The Artificial Neural Network (ANN)

ANN is mathematical models developed by the study of the organization and functioning of biological neurons. Gluck and Bower [6] and Granger [7] has shown that there are numerous artificial neural network variations that are related to the nature of the task assigned to the network. There are also numerous variations in how the neuron is modelled. In some cases these models correspond closely to biological neurons

The study of ANN suggests several potential advantages that ANN has over statistical methods. Hornik [8] pointed out that ANN can be the good universal function approximators for even non-linear functions and also estimate piece-wise approximations of functions. ANN can be mathematically shown to be universal function approximators. This means that they can automatically approximate best characterizes the data for whatever functional form. From Connor [9] and Donaldson and Kim [10], ANN can also partially transform the input data automatically. ANN will be more valuable when it is used to extract more signals from complex functional forms.

Moreover, from Rumelhart and McClelland [11] and Wasserman [12], ANN is also inherently nonlinear [This means that they can estimate not only non-linear functions well, but they can also extract any residual non-linear elements from the data after linear terms are removed. DeGooijer and Kumar [13] recently have shown concerned on the limitations of using non-linear forecasting models. With ANN using one or more hidden layers, the networks can partition the sample space automatically and build different functions in different portions of that space. This means that ANN have a modest capability for building piece-wise non-linear models.

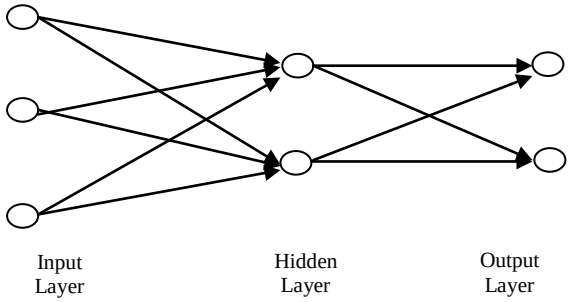

Figure 1 Artificial Neuron Network Model (ANN)

As in nature, many neurons combine to form an artificial neural network. The network consists of an input layer, an output layer. And perhaps one or more intervening layers; the latter are termed hidden layers. Each layer consists of multiple artificial neurons, these artificial neurons being connected to other neurons in adjacent layers. Since these networks contain many interacting non-linear neurons in multiple layers, the networks can capture relatively complex phenomena. Learning occurs in the same way as described above for an individual neuron; that is, the error is propagated backward and used to adjust the weights and biases in the network using the algorithm described earlier.

Rumelhart [14] has developed solution to the gradient descent problem accommodates this multi-layer back propagation. To begin estimating the network, the weights and biases are usually initialized with random values. The

observations are then input to the network and parameters are adjusted using one of the following two methods. In the first method, an observation is presented to the input layer and an output is generated. The difference between the network's output and the desired output provides the error that is backpropagated to adjust the weights. Then the next observation of the data is presented and more adjustments are made. In the second method, only after the entire data set has been presented is the adjustment made; the adjustment is based on the overall fit between the network outputs and the desired output values calculated across the entire data set. Usually, the first method is used to start the gradient descent process (since it leads to a fast descent of the error surface) and the second is used to close in on the minimum point.

The adjustment process is repeated until the error converges on a minimum point. However, it is not quite as simple as this, since the error surface may have both local minimums and a global minimum. To avoid the local minimums, a good starting point is required; a downhill simplex algorithm may be used to find such a starting point and also to hone in on the global minimum after backpropagation has ended. Marquez [15] used the methods developed by Nelder and Mead [16] to accomplish both of the above.

3. Product Innovation and its Key Success Factors

A review of literature in the study of factors affect the successful product innovation has shown numerous factors which can be grouped into three main factors: (1) The firm's innovation capability which consist of absorptive capability, R&D capability, marketing skill, project management capability, creativity management, culture of innovation, internal commitment, managerial control, and flexibility. (2) The new product development capability which consist of idea screening, opportunity analysis, design, testing, launching, cross function integration, team and product champion, customer involvement, supplier involvement. (3) the external competitive environment consists of competitive intensity, market potential and demand uncertainty, technical change, supplier availability and government support.

3.1 The Firm's Innovation Capability

A review of the new product success literature suggests that the firm's innovation capability is the necessity required to create product innovation.

Absorptive Capacity

Absorptive capability studied by Cohen and Levintal [17] is the firm ability to recognize the value of new information, assimilate it and apply it to commercial end. Study of Cooper [18] has found that adopting a transnational new product process is a critical success factor to the product innovation. Ar and Baki [19] pointed that organizational learning capability, regarded as the characteristic of absorptive capability of firm, has a significant and positive impact on process innovation.

R&D Capability

Maidique and Zirger [20] also pointed that "the R&D process of the successful product innovation is well planned and executed."

Marketing Capability

Maidique and Zirger [20] also conclude that new product success was more likely when "the developing organization is proficient in marketing and commits a significant amount of its resources to selling and promoting the product".

Project Management

From the study of Tatikonda and Rosenthal, [21] the successful project execution methods are positively associated with development project execution. Killen

[22] urged that new product success rates show a strong correlation with project portfolio management performance and the use of some Project Portfolio Management methods is correlated with specific Project Portfolio Management performance outcomes.

Creativity Management

Study of Ar and Baki [19] has shown that creative capability has significant impact on product innovation. While Prajogo and McDermott [23] found that creative problem solving processes shows a relationship with product innovation

Culture of Innovation

Valencia [24], and Prajogo and McDermott [23] studied culture of innovation of firm and found that Adhocratic cultures could enhance the development of new products or services. Firm culture shows a positive relationship with product innovation.

Internal Commitment

Ragatz [25] pointed that commitment from top management of companies in supporting new product development is a strategically critical issue impact a successful product innovation.

Managerial Control

Prajogo and McDermott, [23] found that decentralization shows a positive relationship with product innovation.

Flexibility

Study of Prajogo and McDermott [23] and Tatikonda and Rosenthal [21] has shown that flexibility shows a positive relationship with product innovation. Effective product development execution requires organizational flexibility within a structure.

3.2 The New Product Development Capability

Many studies have pointed to various new product development activities as important determinants of new product success. After examining 143 new product projects from Europe and 21 from Japan by Cooper [26] reports positive and significant correlations between new product success and development proficiency, which include measures of proficiency in *idea development and screening, business and market opportunity analysis, product design, testing, launching and commercialization.* A follow-up study by Cooper and Kleinschmidt [27] reports similar results, as does later studies of Australian firms by Dwyer and Mellor [28], Chinese firms by Parry and Song [29], and Japanese firms by Song and Parry [30].

Cross-functional Integration

Study of Griffin and Hauser [31] and Song and Parry [30] has shown that cross-functional integration has also been identified as an important determinant of new product success. Maidique and Zirger [20] conclude that the probability of new product success rises when the creation, make, and market functions are well interfaced and coordinated.

Teams and Champion

Chakrabarti [32] pointed that product champion is important in the success of product innovation While Hoegl and Gemuenden [33] found that teamwork is important for the success of innovative projects.

Customer Involvement

From study of Lau, [34], customer involvement can lead to better new product performance. Moreoreover, Gruner and Homburg [35] pointed that customer interaction during certain stages of the new product development process has a positive impact on new product success.

Suppliers Involvement

Ragatz [25] in his study found that supplier involvement in new product development is a strategically critical issue. While Ar and Baki [19] and Lau, [34]

confirmeded that supplier relationship has significantly impact upon product innovation Supplier involvement leads to better new product performance

3.3 The External Competitive Environment Factors

Balachandra and Friar, [35] pointed that a new product development cannot succeed if the environment in which it is introduced is not supportive.

Competitive Intensity

Many studies of new product success directly link the level of competition in the marketplace to the level of new product success. In a recent study of the electronics industry, Zirger and Maidique [37] report that failures were more likely for products introduced into highly competitive markets. More recently, Parry and Song [38] found strong negative correlations between competitive intensity and new product success ratings in both China and Japan.

Market Potential and Demand Uncertainty

Study of Cao [39] has shown that market uncertainties is reduced during the front end, the higher is the effectiveness of new product development projects product. Moreover, Balachandra and Friar,[36] pointed that the expected growth rate of the market for the product is an important successful factor for the decision to pursue the new

Technological Change & Uncertainty

Cao [39] urged that technical uncertainties is reduced during the front end, the higher is the effectiveness of NPD projects.

Supplier Availability and Capacity

Vega-Jurado [40] studied supplier-dominated firms and large-scale producers and found that cooperation with industrial agents is very important for the development of new products.

Government Support

Li [41] pointed that Government public R&D subsidies and disembodied technology imports positively and significantly impact on firms' private R&D investment. Study of Hardie and Newell [42] found that the role of government regulators in either inhibiting or driving innovation is regarded as critical by successful innovators

From the review of the related study, the Factors affect the successful product development can be summarized as the table below:

Table 1
Summary of Factors affect successful product innovation

The firm's innovation capability
1. Absorptive capacity 2. R & D capability 3. Marketing capability 4. Project Management 5. Creativity Management 6. Culture of innovation 7. Internal commitment 8. Managerial control 9. Flexibility
New product development Capability
1. Idea development and screening proficiency 2. Business and market opportunity analysis proficiency 3. Product conceptual design and detailed design proficiency 4. Product testing proficiency 5. Product launching and commercialization proficiency 6. Cross-functional integration 7. Teams and champion 8. Customer involvement 9. Suppliers involvement
The external competitive environment
1. Competition intensity 2. Market potential and demand uncertainty 3. Technological change & uncertainty 4. Supplier availability and capacity 5. Government support

5. Concluding Remarks

Properly constructed for generalizability, artificial neural networks are particularly useful for modelling underlying patterns in data through a learning process. They can be quite useful in pattern recognition problems, such as the modelling of product innovation project. Artificial neural network decision support systems will use learning algorithms to approximate this practical experience. Because of the highly connected, non- linear structure of artificial neural networks and their impressive performance in other applications, we believe it is possible that they will provide a superior predictive system for use in the product innovation project. Thus, we believe that artificial neural networks provide cutting edge scientific tools for reducing risks in product innovation project.

References

[1] M. E. Porter (1985), *Competitive Advantage: Creating and Sustaining Superior Performance,* New York, The Free Press.

[2] X. M .Song and M. E. Parry (1997), "The Determinants of Japanese New Product Successes," *Journal of Marketing Research, Vol. 34*, pp. 64-76.

[3] G. Day and L. Fahey (1998), "Valuing Market Strategies," *Journal of Marketing, Vol. 52*, July, pp. 45-57.

[4] A. Griffin (1997), "PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices," *Journal of Product Innovation Management, Vol. 14*, November, pp. 429-58.

[5] J. Wind and V. Mahajan (1997), "Issues and Opportunities in New Product Development: An Introduction to the Special Issue," *Journal of Marketing Research, Vol. 34*, pp.1-12.

[6] M. A. Gluck and G. H. Bower (1988), "Evaluating an Adaptive Model of Human Learning," *Journal of Memory and Language, Vol. 27*, pp. 166-195.

[7] R. Granger, et al. (1989), "Memorial Operation of Multiple, Interacting Simulated Brain Structures", in: M. Cluck and D. Rumelhart, eds., *Neuroscience and Connectionist Theory*, pp. 95-129. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc, xiv, 405 pp.

[8] K.Hornik et al. (1989), "Multilayer Feedforward Networks are Universal Approximators," *Neural Networks, Vol. 2*, pp. 359-366.

[9] D. Connor (1988), "Data Transformation Explains the Basics of Neural Networks", *EDN*, 12 May, pp. 138-144.

[10] R. G. Donaldson and K.H.Y.Kim (1993), *Evaluating Alternative Models for Conditional Stock Volatility: Evidence from International Data*, Working Paper (University of British Columbia).

[11] D. Rumelhart and J.McClelland (1986), *Parallel Distributed Processing*, MIT Press, Cambridge.

[12] P. D. Wasserman (1989), *Neural Computing: Theory and Practice*, Van Nostrand Reinhold, New York.

[13] J. G. DeGooijer and K.Kumar (1992), "Some Recent Developments in Non-linear Modeling, Testing. and Forecasting," *International Journal of Forecasting, Vol. 8*, pp. 135-156.

[14] D. E. Rumelhart et al. (1986), "Learning Representations by Back-Propagating Errors," *Nature, Vol. 323*, pp. 533-536.

[15] L. Marquez et al. (1992), "Neural Network Models for Forecast a Review," *IEEE Proceedings of the 25th Hawaii International Conference on System Sciences, Vol. 4*, pp. 494–498.

[16] J. Nelder and R. Mead (1965), "A Simplex Method for Function Minimization," *Computer Journal, Vol. 7*, pp. 308-313.

[17] W. M. Cohen and D. A. Levinthal (1990), "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly, Vol. 35,* pp. 128-152.

[18] R. G. Cooper (1999) "From Experience: The Invisible Success Factors in Product Innovation," *Journal of Product Innovation Management, Vol. 16,* pp. 115-133.

[19] I. M. Ar and B. Baki (2011), "Antecedents and Performance Impacts of Product Versus Process Innovation: Empirical Evidence from SMEs Located in Turkish Science and TechnologyP," *European Journal of Innovation Management, Vol. 14,* pp. 172-206.

[20] M. A. Maidique and B. J. Zirger (1984), "A Study of Success and Failure in Product Innovation: The Case of the U.S. Electronics Industry," *IEEE Transactions in Engineering Management, Vol. 4,* pp. 192-203.

[21] M. V. Tatikonda and S. R. Rosenthal (2000), "Successful Execution of Product Development Projects: Balancing Firmness and Flexibility in Innovation Process," *Journal of Operations Management, Vol. 18,* pp. 401-425.

[22] C. P. Killen et al. (2008), "Project Portfolio Management for Product Innovation," *International Journal of Quality & Reliability Management, Vol. 25,* pp. 24-38.

[23] D. I. Prajogo and C. M. McDermott (2011), "The Relationship Between Multidimensional Organizational Culture and Performance," *International Journal of Operations & Production Management, Vol. 31,* pp.712-735.

[24] J. C. N. Valencia et al. (2010), "Organizational Culture as Determinant of Product Innovation," *European Journal of Innovation Management, Vol. 13,* pp.466 – 480.

[25] G. L. Ragatz et al. (1997), "Success Factors for Integrating Suppliers into New Product Development," *Journal of Product Innovation Management, Vol. 14,* pp. 190-202.

[26] R. G. Cooper (1979) "Identifying Industrial New Product Success: Project," *Industrial Marketing Management, Vol. 8,* pp. 124-135.

[27] R. G. Cooper and E.J.Kleinschmidt (1987), "Success Factors in Product Innovation," *Industrial Marketing Management, Vol. 16,* pp. 215-33.

[28] L. Dwyer and R. Mellor (1991), "Organizational Environment, New Product Process Activities, and Project Outcomes," *Journal of Product Innovation & Management, Vol. 8,* pp. 39-48.

[29] X. M. Song and M. E. Parry (1994), "The Dimensions of Industrial New Product Success and Failure in State Enterprises in the People's Republic of China," *Journal of Product Innovation Management, Vol. 11,* pp. 105-18.

[30] X. M. Song and M. E. Parry (1996), "What Separates Japanese New Product Winners from Losers," *Journal of Product Innovation Management, Vol. 13,* pp. 422-439.

[31] A. Griffin and J. R. Hauser (1992), "Patterns of Communication among Marketing, Engineering and Manufacturing - A Comparison between Two New Product Teams," *Management Science, Vol. 38,* pp. 360-373.

[32] A. K. Chakrabarti (1974), "The Role of Champion in Product Innovation," *California Management Review,* pp. 58-62.

[33] M. Hoegl and H. G. Gemuenden (2001), "Teamwork Quality and the Success of Innovation Projects: A Theoretical Concept and Empirical Evidence," *Organization Science, Vol. 12,* pp. 435-449.

[34] A. K. W. Lau (2011), "Supplier and Customer Involvement on New Product

Performance: Contextual Factors and An Empirical Test from Manufacturer Perspective," *Industrial Management & Data Systems, Vol. 11,* pp. 910-942.

[35] K. E. Gruner and C. Homburg (2000), "Does Customer Interaction Enhance New Product Success," *Journal of Business Research, Vol. 49,* pp. 1-14.

[36] R. Balachandra and J. H. Friar (1997), "Factors for Success in R&D Projects and New Product Innovation: A Contextual Framework," *IEEE Transactions on Engineering Management,* Vol. 44, pp. 276-287.

[37] B.J.Zirger and M.Maidique (1990), "A Model of New Product Development: An Empirical Test," *Management Science, Vol. 36,* pp. 867-883.

[38] M. E. Parry and X. M. Song (1994), "Identifying New Product Success in China," *Journal of Product Innovation Management, Vol. 11,* pp. 15-30.

[39] Y. Cao, et al. (2011), "The Impact of Front End Innovation in New Product Development in Japanese Manufacturing Companies," *Nankai Business Review International, Vol. 2,* pp. 98-113.

[40] J. Vega-Jurado et al. (2008), "The Effect of External and Internal Factors on Firms' Product Innovation," *Research Policy, Vol. 37,* pp. 616-632.

[41] Z. Li et al. (2011), "Government Support, International Trade and Firm's R&D Investment: Evidence from Chinese High-Tech Industries," *Journal of Science and Technology Policy in China, Vol. 2,* pp. 146-158.

[42] M. Hardie and G. Newell (2011), "Factors Influencing Technical Innovation in Construction SMEs: An Australian Perspective," *Engineering, Construction and Architectural Management, Vol. 18,* pp. 618-636.