MEASURING AND COMPARING PROFIT PATTERNS OF TRADITIONAL CONSTRUCTION COMPANIES EXTENDING TO HIGH-TECH CONSTRUCTION

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ABSTRACT: The need of constructing high-tech facilities is one of the important issues concerning the competitiveness by the high-tech companies. It, simultaneously, offers a magnificent opportunity for construction participants. Nevertheless, the high-tech construction is experience-based, resulting in little related construction knowledge that has been statistically analyzed and documented. This study measures and confers with the profit patterns causing the disparity between the traditional and high-tech construction. The database was the result of collecting detailed information of 65 construction projects from eight construction companies, including detailed records of over 20 main construction operations in each project. All of these were performed during the recent 10 years and encompassed in the project types of the high-tech construction, residential building, and commercial building. Rendering suggestions regarding profit management and expecting to economize cost of learning from inexperience while extending to the high-tech construction were both presented.

Key words: Project Management, Construction Engineering, Profit Patterns, High-Tech Construction

1. INTRODUCTION

The high-tech industry has gradually escalated its share of the national economy and becomes one of the main streams of industries in Taiwan, especially the electronic industry. During the last two decades, with the vigorous development of the high-tech industry, the number of construction projects has been increasing dramatically. Since the way of construction and specifications in erecting high-tech factory buildings has significant difference from traditional construction, most construction projects had to depend on foreign experienced companies. This resulted in, when a project of high-tech construction was finished, what left was merely technical documents such as system specifications, blueprints and operation manuals. The core knowledge of construction experience was seldom passed on concretely. Accordingly, few companies were willing to undertake the risks and enter the industry of building high-tech facilities entirely by their own capacity. However, fierce competition has made the profit margins of traditional construction projects meager. Construction companies have to explore new markets. With the economic boom in Mainland China the demand of high-tech construction surges. It is a trend for the construction industry to participate in building high-tech facilities. This study presents profit patterns of traditional construction companies extending to high-tech construction. Through the profit patterns and comparison, this study also offers the reference value of the profit margin between traditional construction projects and the initial stage of building high-tech facilities.

2. BASIC CONCEPTION OF THE HIGH-TECH FACILITY

There is no identical definition to high-tech industry among international standards. Nevertheless, concerning the characteristics of scientific inputs, there exist conceptual definitions. According to the definition of Sherman (1982), the scientific and technological enterprise conformed to the following three conditions:

(1) Invest a considerable amount of capital in research and development,
(2) Possess higher proportion of technical staff, and
(3) Produce innovation or invention as the chief aim.

In accordance with the definitions of Shanklin & Ryans (1984), the high-tech industry should match the following three criteria:

(1) Have strong scientific and technical foundations,
(2) The new technology can eliminate existing technologies rapidly, and
(3) The application of the new technology can create new markets and demand.

Scholars still have different definitions to high-tech industry. Some scholars focused on the input index of the hi-tech industry such as the expenditure on research and development in proportion to sales of products. They weighed the intensive degree of research in the industry and the number of technical personnel in proportion to the whole employees in the industry. Some countries prefer to adopt the indices to define their high-tech industry. When the proportion of both indices exceeds 10%, the industry is assumed to be a high-tech industry. For instance, the Bureau of Labor Statistics in U.S.A. uses the proportion of technical staff to the total number of employed workers and the proportion of expenditure to the sum of sales volume as its criteria. Once both indices are over 200% of the average values, the industry is claimed to be a high-tech industry. In Taiwan according to "Scientific and Technological White Paper" drawn up by the National Scientific Commission in 1997, the descriptions of the high-tech electronic industry were "having the features of dense funds, skill-intensiveness and advanced manpower intensiveness". Six criteria were utilized to measure if an industry belongs to the high-tech industry: great market potential, highly connected industry, high additional value, low degree of pollution, and low degree of energy dependence. For example, industries identified as high-tech are: communication, information software, consume electrons, integrated circuit (IC), precision instrument, automation, aviation advanced materials, special chemistry, pharmacy, medical treatment and health care, prevention and control of pollution (the Bureau of Industry in the Economic Department, 1994). One of the main economic lifelines relies on the electronic industry at present. Thus, the collected date used in this study focused on the facilities of the electronic industry.

3. ENTERPRISE STRATEGY

It is often to discuss the similarities and dissimilarities of strategies between different enterprises through the taxonomies of tactics in practice. This simplifies researchers' and entrepreneurs' descriptions of tactics and is helpful to bring the structure of industrial competition into control. Traditional tactic scholars evaluated managing strategies chiefly by inspecting the category of products, geographical position, price, approaches and so forth. Every construction enterprise had to make a strategic decision on these aspects. Hence it can be inferred that each enterprise has its own principal concepts and further makes precise decisions based on these variables. Notwithstanding scholars including Ansoff (1965), Inkpen & Choudhury (1995), MacCrimmon (1993), and Burgelmen & Grove (1995) pointed out that enterprises may not have tactics or tactics are not necessary for enterprises. Taking the elasticity of management into consideration is prone to result in this phenomenon, especially in the highly fluctuating environment of the construction industry.

A enterprise usually makes decisions under reciprocal evaluations of many tactics (Pearce & Robinson, 2000). Enterprise tactics are indices that show the judgment and decision of managing strategies for a company in a specific stage. Pearce & Robinson firstly took account of the minimum costs and business risks. Supposing that this company uses rates of market growth and competitive position as its main shaft, 15 types of overall tactic models in detail were listed. These 15 types of tactics can be divided into four quadrants to further analyze how the enterprise managing tactics is accessed and chosen (Figure 1). The contents of these four quadrants are as follows: (I) the advantaged competitive position in a fast-growing market, (II) the disadvantaged competitive position in a slow-growing market, (III) the advantaged competitive position in a slow-growing market, and (IV) the disadvantaged competitive position in a slow-growing market. The contents of each quadrant include one set of overall strategy which has potential to develop. In terms of the present condition in Taiwan's construction companies, this study assumed that building the high-tech facilities belongs to the comprehensive tactic of market development, product development, and conversion.

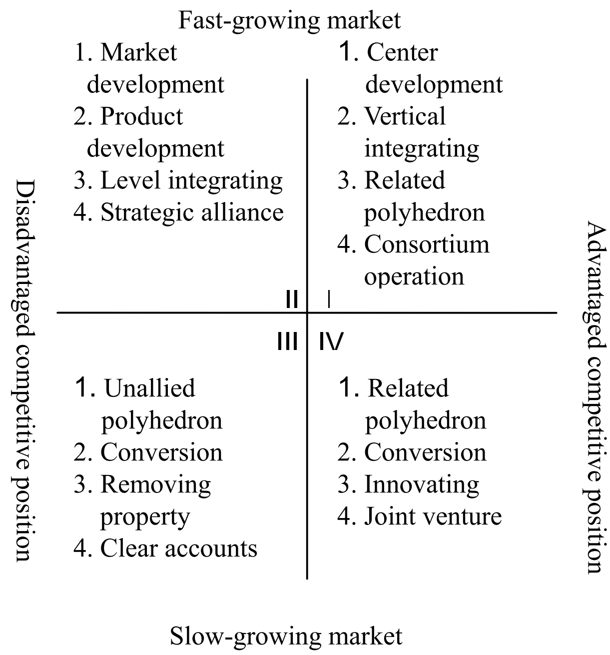

Figure1. Enterprise strategy swarming mode (Pearce II, J.A. and R.B.Robinson, 2000)

4. LEARNING CURVE MODEL

Learning effect is also named experience effect or learning phenomenon. It is defined that time or costs they need will diminish by degrees with the increasing number of times when people perform repeated works (Carlson, 1961;Yelle, 1979; Belkaoui, 1986; Thomas et al., 1986; Hijazi et al., 1992; Everett and Farghal, 1994; Lutz et al., 1994). The learning curve theory explains this phenomenon. It was first raised in 1936 by Wright who observed the aviation manufacturing and brought up the Straight-Line model.

After Wright introduced the Straight-line model, numerous learning curve models were extended by the follow-up major studies such as Stanford-B, DeJong, S-Curve, Cubic, Piecewise, Exponential, Pegels's Exponential, Levy's Adaptation, and Glover's learning formula. Among these models, Straight-line and Stanford-B models are relatively in wide-spreading use (Carlson, 1973; Belkaoui, 1986; Thomas et al., 1986; Everett and Farghal, 1994).

5. DATA COLLECTION AND DATA ANALYSIS

To measure the profit patterns, this study conducted data collection and analysis based on past construction projects. The use of a learning curve model to yield the profit patterns was one of the keys. Therefore, the collected data were the basis of this research. This section aims at articulating data collection and data analysis that show the original characteristics of materials in a distinct presentation.

5.1 Data collection

A pilot investigation was conducted. Hundreds of construction projects were investigated. Due to integrity of collectable data, the data collection followed the format and criteria demonstrated in Table 1. Data from seven construction companies made up the resource of data collection. These projects were the newly-built construction. The period of time these cases taken place is from 1995 to 2004, ten years in total. The residential buildings and high-tech facilities in northern Taiwan area are this research's main focus. The total floor areas of the projects range between 500m^2 and 100,000m^2. The contract prices vary from 20 million to 2 billion New Taiwan Dollars (NTD). The durations for the projects are all greater than six months but less than 30 months.

The durations of projects in this study consist with the reasonable term. Supposing that the construction duration may delay owing to the owner acknowledge change orders or some irresistible factors that cannot be controlled or predicted in bidding, these particular situations were not included in the scope of this research since the involving administrative procedures were complicated.

5.2 Data analysis

The number of total collected data is 65. They were divided into 44 projects of residential buildings, 15 projects of commercial buildings, and 6 projects of high-tech facilities in accordance with the types of construction.

The total contract price of these 65 construction projects is the sum of 25.8 billion NTD. The contract stated clearly the expenditure of administration and profits summed up to 1.5 billion NTD, producing the profit margin of 5.7% of the total contract price. Compared with the actual profits, the profit margins of residential projects do not stay constant. Instead, they fluctuate individually shown as Figure 2. However, correlation analysis using R-square illustrates irrelative connection between time and profit margin as Figure 3; the average of profit margin is 8.6%. The tendency line represents that the seven companies have reached the mature condition in the field of traditional construction: the average of the profit margin remains stable.

Table 1. Format and criteria of data collection

Project name	Project contract price	Project actual price
Temporary construction		
Retaining walls		
Structure		
Whitewashing		
Walls		
Doors and windows		
Elevator		
Steel and precast structure		
Landscaping		
Transportation fee and insurance		
Administration expense		
Profit margin		
Subtotal		
Electrical and Mechanical engineering		
Electrical and Mechanical administration expense		
Electrical and Mechanical profit margin		
Subtotal		
5% tax		
Total		
Management salary in field office		
Floor height		
Total floor square measure		
Construction location		
Construction duration		

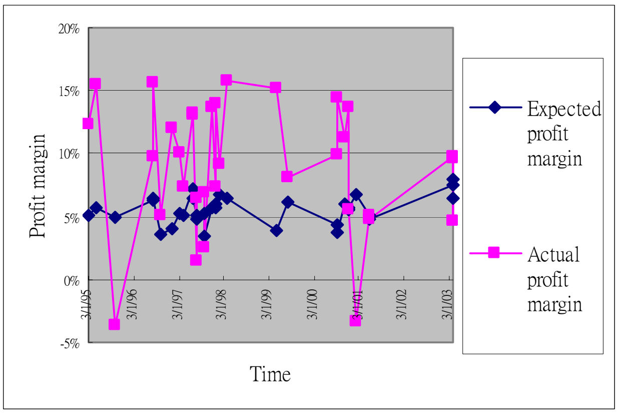

Figure 2. Expected profit margins compared with actual profit margins

Next data of high-tech facilities were analyzed. Six projects of high-tech construction were included in collected data, due to availability where these 7 firms recently entered the high-tech industry. By drafting and carrying out linear regression analysis, the tendency was found that -19.7% of profit margin by initially entering the industry with a stable growth on account of repetitive learning, and that the R^2 value yields 0.8161 standing for high correlation illustrated as Figure 4. Although for the time being there are merely six samples included in the database, the tendency of the profit margin increase is yet conspicuous and therefore can approximately present the profit tendency of high-tech construction in the preliminary research stage.

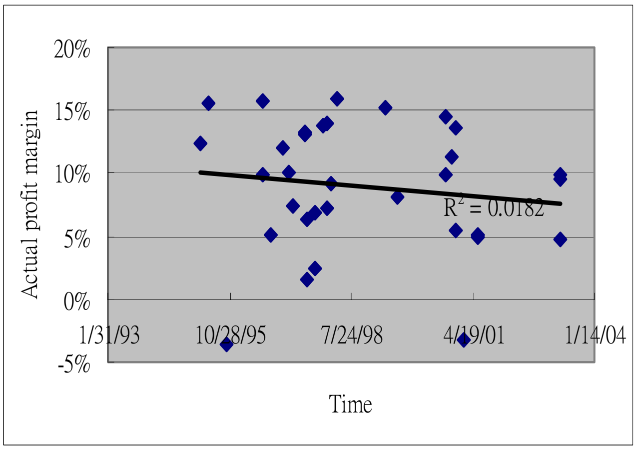

Figure 3. Actual profit margins analyzed by linear regression

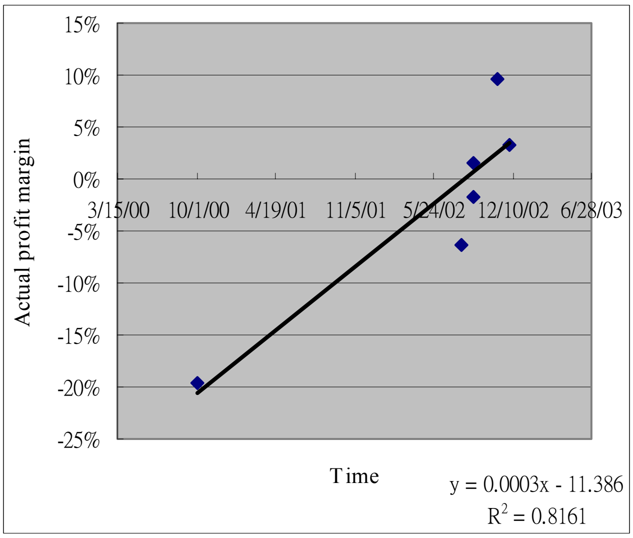

Figure 4. Profit margins of high-tech industry projects

6. PFOFIT PATTERN OF HIGH-TECH FACILITIES

By referring back to Section 4, there are dozens of learning curve models. Seven of these, Straight-line, Stanford-B, Dejong, S-Curve, Cubic, Piecewise, and Exponential, are adopted frequently. Among these seven models, Cubic, Piecewise, and Exponential have a particular assumption that needs to have the third set of estimated values to establish the models. This causes difficulty on account of project features in the construction industry. Dejong and S-Curve models require the consideration of applying equipment into productivity by accurate estimates of the proportion of equipment use. It also experiences difficulty due to the nature of collected data. Using the Straight-line model has a basic condition, that is, do not consider the influence of past experience. This is against ordinary concepts while engaging in construction projects. Therefore, only one out of the seven models whose assumptions and features fit the scope of this research: Stanford-B model.

The Stanford-B model is the learning curve model developed by Stanford Research Institute in 1949. Researchers found that the Straight-line model was not suitable for projects during WWII. Stanford-B model made an improvement on Straight-line model by taking the existing experience into consideration where the definition of existing experience is that workers have practiced similar operations or made resembling products (Garg, 1961; Carlson, 1973; Yelle, 1979; Belkaoui, 1986; Thomas et al., 1986). Stanford-B model selected in the study has its own particularity: Similar experience can accelerate learning ability in entering a new construction field. This research used data of traditional and high-tech construction. The choice of Stanford-B model to carry out fitting yielded the profit pattern. The formula of Stanford B model is described as below:

$$Y=a(X+b)^n \ ; \ n=\mathrm{Log}_2 L \qquad (1)$$

where

Y：the time costs when producing X unit
X：repeated frequency of production
a：the time costs when producing the first unit
b：the degree of existing experiences
n：slope of logarithm curve
L：learning rate

Parameter b of this model lies between 1 and 10($1 \leqq b \leqq 10$). The higher the b value is, the greater the value of existing experience is. The regular b value is set to 4. If workers have no existing experience, b is equal to 0 and Stanford-B model is completely equal to Straight-line model (Grag, 1961).

Depending on collected data, the technologies of these enterprises in residential projects were quite mature. However, the average profit margins of residential projects have slightly decreased. Cooperating with the enterprise strategies simultaneously, the entrepreneurs will eventually decide to enter a new field such as construction of high-tech facilities as to seek future development. In investing a new field, there must involve a high degree of uncertain risks.

Building high-tech facilities appears to be a relatively new field for construction companies in Taiwan. There are still familiar procedures for high-tech facilities based on the technologies of constructing residential and commercial buildings. The Stanford-B model explained this in the following paragraphs.

This study took advantage of use of OriginPro7.0 software to proceed with curve fitting to set up a mathematical model via limited samples followed by further analysis. The sample points were data of high-tech construction projects collected in this research. Assume b=4 in Equation 1 and carry out fitting with these six samples of high-tech construction shown as Figure 5, Equation 2 can be derived from Equation 1:

$$Y=-0.13695(X+4)^{-0.36184} \qquad (2)$$

a=-0.13695
n=-0.36184
L= 79%

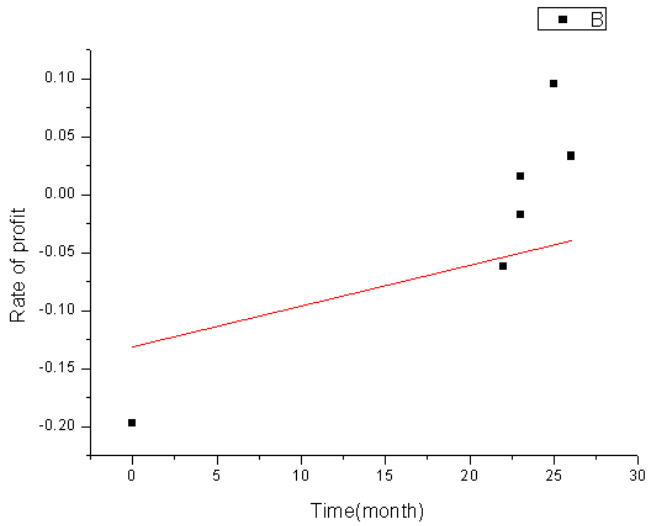

Figure 5. Profit pattern by learning curve model

This result presents that the profit margin of the first investment in constructing high-tech facilities is -13.695%. With the learning rate of 79%, the exponential formula shown as Equation 2 is the profit pattern of newly entering high-tech construction.

7. DISCUSSION AND CONCLUSION

The profit pattern of constructing high-tech facilities in this study was found and able to apply to other construction companies which attempt to enter this field yet may encounter risks.

The following are a list of contributions that this study brought about:

(1) Displaying the possible risks of profit difference as engaging in high-tech construction.
(2) Setting up both the profit patterns of entering high-tech facilities and traditional construction.
(3) Rudimentarily presenting that the learning rate of profit margin for constructing high-tech facilities is 79%.

Since data collected in this study were projects from well-running companies, companies with mature technologies in traditional construction can use its profits to compensate the learning costs when entering high-tech construction and constantly sustaining the companies' normal operation. This concludes that companies engaged in the new field successfully when profits gained in the competitive traditional construction were not totally offset. Thus, this study suggests that each company needs to prepare thoroughly by understanding the profit patterns achieved in this research before investing in the markets of high rates of demand.

This research was based on finished construction projects in the latest decade. It is advised to record each project efficiently with an aim of follow-up research. Now that computers are widely used, it is proposed to computerize the systems of construction companies so as to reduce the space of data storage, avoid data loss, and save data completely. It will be more convenient if the recording format can be unified. In addition, because most materials are still deemed as confidential information, it is difficult to have complete sets of data in hand. The degree of accuracy is suspicious owing to the limited samples of high-tech construction; however, the results showed the real condition of the construction companies that just entered into this field. In the sequential procedures, if the sample size is enlarged, the profit patterns will be more accurate.

Lastly this research utilized a statistical regression model to construct the profit pattern. It inevitably involved with certain degree of inaccuracy in the interpretation of the findings. The follow-up researchers are recommended to make use of other approaches such as artificial neural networks and neurofuzzy models to verify the statements.

REFERENCES

[1] Sherman, B., "Successful Marketing Strategy for High Tech Firms," *Journal of Retailing*, 58: 25-43, 1982.
[2] Shanklin, W. L.. & Ryans, Jr., "Marketing High Technology," *Strategy Management Journal*, 3: 35-52, 1984.
[3] U.S. Department of Labor, http://www.dol.gov/, 2005.
[4] The Bureau of Industry in the Economic Department in Taiwan, http://www.chemnet.com.tw/sctp/, 1994.
[5] Ansoff, H.I., *Corporate strategy*, New York: McGraw-Hill, 1965.
[6] Inkpen, A. and Choudhury, N., "The Seeking of Strategy Where it is Not: Towards a Theory of Strategy Absence", *Strategic Management Journa*l, Vol. 16, No.4, pp.313-23, 1995.
[7] MacCrimmon, K.R. "Do firm strategies exist?", *Strategic Management Journal*, 14, pp.113-130, 1993.
[8] Pearce, J. A. & Robinson, R. B., *Formulation, implementation, and control of competitive strategy*, Homewood, IL: Irwin/McGraw-Hill, 2000.
[9] Carlson, J. G., "How management can use the improvement phenomenon." *California Mgmt. Rev.*, 3(2), 83-94, 1961.

[10] Yelle, L. E., "The learning Curve: historical review and comprehensive survey." *Decision Sci*., 10(2), 302-328, 1979.
[11] Belkaoui, A., *The learning curve*, Quorum Books, Westport, CT, 1986.
[12] Thomas, H. R., Mathews, C. T., and Ward, J. G. "Learning curve models of construction productivity." *J. Constr. Engrg. and Mgmt*., 112(2), 245-258, 1986.
[13] Hijazi, A. M., AbouRizk, M., and Halpin, D. W., "Modeling and simulating learning development in construction." *J. Constr. Engrg. and Mgmt*., 118(4), 685-700, 1992.
[14] Everett, J. G., and Farghal, S., "Learning curve predictors for construction field operations." *J. Constr. Engrg. and Mgmt*., 120(3), 603-616, 1994.
[15] Lutz, J. D., Halpin, D. W., and Wilson, J. R. "Simulation of learning development in repetitive construction." *J. Constr. Engrg. and Mgmt*., 120(4), 753-773, 1994.
[16] Carlson, J. G. H. "Cubic learning curves: precision tool for labor estimating." *Manufacturing Engrg. and mgmt*., 67(11), 22-25, 1973.
[17] Everett, J. G., and Farghal, S. H. "Data representation for predicting performance with learning curves." *J. Constr. Engrg. and Mgmt.*, 123(1), 46-52, 1997.
[18] Garg, A. and Milliman, P., "The aircraft progress curve modified for design changes." *Journal of Industrial Engineering*, 12(1), 23-28, 1961.