A Study of Risk and Performance Evaluation in Taiwanese Semiconductor Industry

Jau-shin Hon, Hui-ling Lin, and Ling-ya Su

Abstract This study discusses the relationship between risk and performance of the sampling of 12 Taiwanese semiconductor companies during the period of financial crisis. The purpose of this study is to survey the risk response capabilities of upstream and downstream of Taiwanese semiconductor firms. The methods of data envelopment analysis (DEA) and Malmquist index are applied to analyze the industry operating efficiency. From the viewpoint of efficiency, this study contributes to the company operation performance assessment before and after the period of financial crisis.

Keywords Data envelopment analysis • Malmquist productivity index • Risk and return

1 Introduction

Given the debate of whether only traditional evaluation methods remain appropriate for monitoring firms' performance, this study aimed to develop a new performance evaluation method to deal with this issue. We used Taiwanese semiconductor firms' financial profitability to justify the smile curve. Then, Data envelopment analysis (DEA) has been used to solve the changing situation of efficiency. DEA techniques were used by accommodating financial measures and time was considered as inputs/outputs variables providing a metric for industry and firm performance measurement [1, 2]. More specifically, several studies have used DEA techniques in order to measure industry performance.

J. Hon (✉) • H. Lin • L. Su
Department of Industrial Engineering and Enterprise Information,
Tunghai University, Taichung, Taiwan
e-mail: honjs@thu.edu.tw; ljoyce@teamail.ltu.edu.tw; amanda76902@gmail.com

E. Qi et al. (eds.), *Proceedings of 2013 4th International Asia Conference on Industrial Engineering and Management Innovation (IEMI2013)*,
DOI 10.1007/978-3-642-40060-5_45,

To solve some problems concerning performance evaluation, this study uses several methods other than DEA such as risk and return, and Malmquist productivity index [3, 4]. In contrast to prior studies, this paper for the first time uses several new models combining multiple performance measurements to evaluate the performance during the period of economy crisis. In such a way we provide an illustration of how financial indexes can be combined into a performance measure producing appropriate results. Using financial data the paper measures the performance of Taiwanese semiconductor sectors providing empirical evidences of the influence of performance evaluation.

2 Literature Review

2.1 Risk Evaluation

The traditionally accepted definition of risk is the potential for realization of unwanted, negative consequences of an event. For an event to be considered as a source of risk there must be a reasonable predictable loss associated which arises as a consequence of this chance event [5]. The scale of the loss referred to as the risk impact and attempts to place an acceptable value on this loss, often in monetary terms. For a firm the impact of the incidence of almost every risk event can be measured in financial terms as the effect upon turnover, market share, and profitability.

In order to investigate the effectiveness of these firms, we utilize Data Envelopment Analysis-window analysis models to evaluate the relative efficiencies of 12 semiconductor firms' financial data in 2008.

2.2 Efficiency Theory

Farrell [6] developed input-based indices of technical efficiency measured as the maximum equiproportionate reduction in all inputs consistent with equivalent production of observed output. As pointed out by Fare and Lovell [7], however, some slack may remain in some but not all inputs and/or outputs after Farrell efficiency is achieved. As a result, the Farrell measure may not measure Koopmans efficiency. Interest in this early theoretical work on technical inefficiency was renewed in the late 1970s with the development of Data Envelopment Analysis (DEA), a Farrell-based mathematical programming approach to frontier calculation pioneered in Charnes et al. [8]. DEA envelops the observed data to determine a best practice frontier. This technique has become popular in evaluating technical efficiency because it easily handles multiple outputs, is non-parametric, and does not require input price data.

The DEA is a mathematical programming approach which assesses the comparative efficiency of a set of decision making units (DMU), where the presence of multiple inputs and outputs makes comparison difficult. The DEA is a non-parametric approach which allows efficiency to be measured without any assumptions regarding the functional form of the production function or the weights for the different inputs and outputs chosen. The DEA defines a best practice efficiency frontier that can be used. In economic study, DEA is also a powerful tool when studying boundary productions which have multiple inputs and multiple outputs. Therefore, it can be used to research the problems which are relevant with multilateral production function, such as the rate of technological progress, the productivity index, scale, the minimum cost problem and maximum benefits, etc. Since the DEA method does not need to estimate parameters in advance, it has underestimated superiority in avoiding subjective factors, simplifying operations and reducing error, etc. Compared with other methods, the biggest advantage of DEA method is that it is pure technical, need not given an advance known production function with the parameters.

Three main DEA models have been developed according to the nature of returns to scale: the CCR model, the BCC model, and Malmquist indexes. The CCR model, named for Charnes et al. [8], was developed under the assumption of constant returns to scale (CRS). The second model, the BCC model, introduced by Banker et al. [9] as an extension of the CCR model, was developed under the assumption of variable returns to scale (VRS). VRS implies disproportionate variation in outputs when inputs are increased. This model is able to measure pure technical efficiency, while scale efficiency can be determined by overall performance efficiency divided by pure technical efficiency. This enables the decision makers to determine whether the inefficiency comes from a technical problem or from a scale problem.

Malmquist indexes can be used to describe the production technology efficiency which is intertemporal with multiple inputs and outputs variables and determine the changes of total factor productivity. Malmquist index analysis has the following three advantages: First, it is suitable for multiplt countries or regions across the stage to analyze sample. Second, it can be further decomposed into Technical Efficiency Change and Efficiency Change index. Third, it does not need relative price information of factors. So this paper also adopts the Malmquist index method. The analysis equation is as follows.

3 Methodology

3.1 Sample

High-tech industries can be defined as those that normally invest at least 10 % of their sales in R&D [10]. This study examines the semiconductor industry in Taiwan. This industry can be classified as a high-tech industry. The semiconductor

Table 1 Taiwanese semiconductor industry productivity (2006–2010)

	Effch	Techch	Pech	Sech	Tfpch
2006–2007	1.089	1.139	0.988	1.102	1.240
2007–2008	0.874	0.438	0.906	0.965	0.383
2008–2009	0.988	0.979	0.967	1.021	0.967
2009–2010	1.217	0.991	1.197	1.017	1.206
Mean	1.034	0.834	1.009	1.025	0.862

Note: the index > 1 means progression; otherwise, regression

industry is selected as the empirical sample because it exhibits typical features of high-tech industries, including steep price erosion and stress due to the rapid progress of technology. The Standard Industry Classification (SIC) code of firms that produce semiconductors and related devices is 3675. The industry classification system is based on the US-based SIC, which was created by the US government (1994).

The original observations of 12 firms were matched with firm-level data from the Taiwan Economic Journal, which annually compiles a list of firms' financial reports. These lists are well received in the professional economic and financial communities and various indexes of these surveys have been used to support numerous research projects [11, 12]. The 12 firms ranked by company assets were extracted from 2006 to 2010 [13]. This final dataset consisted of 12 valid firms from the following semiconductor sub-families: Integrated- Circuit (IC) design firms, IC fabrication firms, IC packaging firms, and IC testing firms.

3.2 Data

The data selected for this paper is related to the input and output of the industrial enterprises' operation expense. The inputs of operation overhand are primarily R&D expenditure, fixed assets, operational expenditure and R&D personnel which are four core indexes in science and technology activities. The outputs of operation activities of semiconductor firms are selected from many indexes including operation revenues and operation gross profit.

3.3 Malmquist Productivity Index

This study decomposed the Malmquist productivity (**tfpch**) index into four sources of productivity change: technical efficiency change (**effch**), technical change (**techch**), pure efficiency change (**pech**) and scale efficiency change (**sech**). Table 1 shows every pair of adjacent year's values for each variable such as **effch**, **techch**, **pech**, **sech** and **tfpch** (total factor productivity change).

The major objective is to find out the key influencing index; furthermore, it leads to improve the productivity. The empirical results summarized in Table 1. The total factor productivity change index exhibits the regression trend during the period of research. The major reason is the technical change less than one. It means the Taiwanese semiconductor industry is in maturity stage and does not create new technology. Although at different levels of financial crisis, the relationship of productivity change and technical change is positive. It means that the technical development of Taiwanese semiconductor industry is weak. This result suggests that the high-tech firms need consistent investing the new productivity equipment, R&D resource, and new patent to maintain the competitive advantage.

4 Results

In the analysis of performance measurement there is a practical limitation to the number of ratios which can be included. Increasing the number of ratios for predictive purposes introduces redundancies in the analysis and makes the interpretation of the results increasingly difficult. We utilize DEA and Malmquist index to implement performance evaluations in semiconductor industry for Taiwanese 12 firms based on Taiwan Economic Journal. We employ four inputs and two outputs in our analysis.

IC design industry has a higher proportion of research and development (R&D) costs and lower operating costs; IC manufacturing, packaging and testing industries have a higher proportion of permanent assets and operating costs. IC manufacturing, packaging and testing industries burden higher operating and financial risks, and the operating profit of the manufacturers is significantly influenced by the economy cycle.

IC design industry has less risk during the period of financial crisis in the 2008, but they invest lots of R&D to improve their performance. Comparing to IC design firms, IC manufacturing firms only invest the IC equipment before the financial crisis coming. It occur the idle capacity and the investment becomes a major burden, so it decreases the operating efficiency; meanwhile, IC packaging and testing industries since the operating income decreasing, it results increasing operating costs. Therefore, the decreasing of operating profits makes them to be relatively inefficient units during the economy crisis.

Most IC design firms are in the low risk-high reward region which is the best position in the smile curve. However, only a small number of IC manufacturing, packaging and testing firms are in this best region. It shows the risk can be circumvented by management.

The productivity of Taiwan's semiconductor industry is mainly reasoned from the growth rate of technological progress. In order to maintain the advantage in this competitive field, the semiconductor firms should actively develop the new technology and strengthen the patent blueprint.

References

1. Destefanis S, Sena V (2007) Patterns of corporate governance and technical efficiency in Italian manufacturing. Manage Decis Econ 28:27–40
2. Sun CC (2011) Evaluating and benchmarking productive performances of six industries in Taiwan Hsin Chu Industrial Science Park. Expert Syst Appl 38:2195–2205
3. Pastor JT, Lovell CAK (2005) A global Malmquist productivity index. Econ Lett 88:266–271
4. Wang YM, Lan YX (2011) Measuring Malmquist productivity index: a new approach based on double frontiers data envelopment analysis. Math Comput Model 54:2760–2771
5. Halkos GE, Tzeremes NG (2012) Industry performance evaluation with the use of financial ratios: an application of bootstrapped DEA. Expert Syst Appl 39:5872–5880
6. Farrell MJ (1957) The measurement of productive efficiency. J R Stat Soc 120(3):253–281
7. Fare R, Lovell CAK (1978) Measuring the technical efficiency of production. J Econ Theory 19:150–162
8. Charnes A, Cooper WW, Rhodes E (1978) Measuring the efficiency of decision making units. Eur J Oper Res 2:429–444
9. Banker RD, Charnes A, Cooper WW (1984) Some models for estimating technical and scale inefficiencies in data envelopment analysis. Manage Sci 30(9):1078–1092
10. U.S. Department of Commerce (1996) Transportation annual survey: 1996. BiblioGov, Washington, DC
11. Liu DY, Tseng KA, Yen SW (2009) The incremental impact of intellectual capital on value creation. J Intellect Cap 10:260–276
12. Peng YS, Fang CP (2010) Acquisition experience, board characteristics, and acquisition behavior. J Bus Res 63:502–509
13. Golany B, Roll Y (1989) An application procedure for DEA. OMEGA 17(3):237–250