Critical External Factors Affecting Sales:
A Case of Korean Electronics Companies

Taeheung Kim, Jae Wook Kim, and Hoo-Gon Choi

Abstract—Firms strive to survive in tough markets by successfully launching new products and services. Measures such as sales volume, sales revenue, and sales costs are frequently used to evaluate success. Businesses require a more effective method of managing new product and service development, which many internal and external factors are hindering. This study focuses on the uncontrollable external factors that affect sales measures both positively and negatively in the Korean electronics industry. The linear regression model is used to determine the most critical external factors affecting 68 electronics companies registered on the KOSDAQ stock market. The top five critical factors are determined by comparing the models' largest coefficients. The study's results can be used to develop a profit model that includes the critical factors by which important decisions such as a "go/no go" for a project can be made.

Keywords—External factors, Korean electronics industry, linear regression, sales measures

I. INTRODUCTION

A firm strives to develop new products and services to enhance its competitiveness and survive in a tough market. Any improvement in quality, cost, or time generates profits. However, improving is made difficult by the uncertainties and risks, both internal and external that hinder project success. Project managers must efficiently and effectively control and respond to internal risks such as product complexity, resource tightness, schedule tightness, and team scope—known as "technical risks." These are largely controllable within a firm. Hwang et al. [1] presented a framework by which to measure the impact of technical risks on new product development (NPD) using a hierarchical scale. However, oil prices, exchange rates, inflation rates, stock prices, regulatory changes, climate changes, and other external risks are not under firm control. Miller [2] listed six different types of uncontrollable factors: politics and government regulations, macro-economic factors such as natural calamities, inflation and interest rates, industry competition factors, resources and industrial structures, product markets,

and demand patterns. These factors influence markets and industries both positively and negatively. Thus, project managers must constantly monitor them. The ISO 31000 risk management process provides guidance on risk management across extensive socio-technical systems, such as operations, processes, functions, projects, and human endeavors [3]. The process comprises risk identification, risk analysis, risk evaluation, risk treatment; and monitoring and review. Taking a bibliographic approach, Kim et al. [4] collected 114 risks identified in the core activities of NPD projects and classified them into four groups: endogenous (internal), exogenous (external), threats, and opportunities. Conducting a risk analysis and evaluation, Choi and Ahn [5] introduced a framework for measuring degrees of risk using fuzzy and stochastic processes and thereby determined integrated degrees of risk for the risks that had been identified for an NPD project. Park et al. [6] suggested a fuzzy method of determining the integrated degrees of forty external factors impacting NPD projects. In developing a risk treatment strategy, it should be remembered that risks can affect product and service development either positively or negatively [7]. The negative impacts of risk include project delays, high costs, and reduced profit, while positive impacts allow firms to maximize profits. Therefore, selecting risk-treatment options and preparing and implementing treatment plans should be done carefully when developing a risk management strategy.

Firms generally launch multiple projects while developing new products and services and then evaluate them before making "go/no go" decisions. The profit model, often used in such decisions, is composed of many parameters, such as sales volume, unit price, and cost. The model can estimate the expected profit from any project [8]. A project that generates higher than expected profits will be maintained until the next evaluation period. The model's parameter values fluctuate because of the uncertainties that affect the projects either positively or negatively. Both internal and external risks can arise randomly and hinder project success. Though external risks are beyond project managers' power to control, managers must respond carefully to their possible impacts.

Korea's electronics industry, one of the nation's most critical industrial domains, has seen its players enhance their competitive advantage greatly over the past 30 years. Korea's IT hardware-related technology has contributed to its transformation into a developed nation. Epoch-making developments in both hardware and software have been the key success factors in Korea's recent economic growth. Its electronics industry has also been one of the country's most active developers of new products and services. However, the industry has experienced adversity as well as prosperity

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despite its development efforts, due to both internal and external factors.

This study identifies the critical uncontrollable factors affecting sales volume, revenue, and costs—both positively and negatively—in Korea's electronics industry. Sales volume is the total amount of monetary returns from the sale of products and services during a given period. Sales revenue flows from a business's primary and incidental activities, such as interest on deposits, in a given period. Cost of sales (or cost of goods sold) is the carrying value of the goods and services sold during a given period. Costs include all costs of purchase and conversion as well as other costs incurred to bring the inventories to their current location and condition. Included in the costs of goods made by the business is material, labor, and allocated overhead. Together, these sales measures represent a company's total profits.

II. RELEVANT LITERATURE REVIEW

Many macroeconomic studies have examined how uncontrollable factors such as exchange rates, oil prices, and interest rates operate in various economic environments. For example, Ahn [9] investigated how exchange rate fluctuations affected 6,801 Korean manufacturing firms between 1989 and 2006. This empirical study showed that the firms' profitability declined when the Korean won/US dollar exchange rate rose and improved when the Japanese yen/US dollar rate rose. LG Economic Research Institute [10] reported that fluctuations in the dollar exchange rate of the Korean Won has affected Korean industries either positively or negatively depending on how well the firms managed their own exchange rate risk systems. Korea Institute for Industrial Economics and Trade [11] investigated the impact of the fluctuation of international energy prices on Korean manufacturing firms, finding that firms' economic performance declined because production costs rose when energy prices rose. Cho and Oh [12] argued that Korea is more vulnerable to international environmental factors like politics, economics, and financial changes than are other countries and that the most important external factor is the exchange rate, as Korea has been highly dependent on exports and has produced its goods with resources imported from overseas. Therefore, exchange rate fluctuations represent a significant variable that must be taken into account when making business decisions. This study explained the relationship between exchange rate fluctuations and earnings management by examining whether a company's exchange rate elasticity of sales affected its earnings management scale through an empirical analysis. The result showed that the average difference in the absolute values of discretional accruals between the group with an absolute value of exchange rate elasticity of sales of more than 1 and the group with an absolute value of less than 1 was meaningful; moreover, the bigger the company's exchange rate elasticity of sales, the greater the company's earnings management. Jeong and Yime [13] studied the impact of exchange rate fluctuations on Korea's tourism industry using VAR models for time series data; the relationship between the sales and the exchange rates was discovered to be strongly negative under stable conditions. In addition to these studies, similar results appear in research conducted by many economic institutes operating in many industries as well as by the Korean government.

Few studies have examined how multiple uncontrollable external factors collectively affect sales measures, perhaps because each factor's behavior is complex due to the confusedly interlaced economic situations in different countries. In this study, quarterly sales data covering 2002 to 2012 are collected for 68 Korean electronics companies registered in the KOSDAQ stock market (which plots fourteen typical external factors for small and medium-sized companies). A linear regression model is used to specify which external factors significantly affect sales volume, revenue, and costs, the dependent variables, either positively or negatively.

III. DATA COLLECTION AND ANALYSIS

Four major types of hardware produced by the Korean electronics industry are used to investigate the impacts of the external factors. All the companies selected for data collection are listed in the KOSDAQ stock market. Table I shows the number of companies whose quarterly data on sales volume, revenue, and costs are collected. Five different types of external factors are considered, as shown in Table II. The total number of companies analyzed is 68 and the total number of external factors 14. A total of 1,792 items of quarterly data are collected (which are standardized, since the selected companies' figures differ in their sizes and financial scales).

A linear regression model is used to find the relationship between sales and the external factors. The model is defined by 14 independent external factors and six independent time-related variables (such as year and quarters). Three dependent variables (quarterly sales volume, sales revenue, and cost of sales) are set and analyzed separately. Eq. (1) presents the linear regression model applied to 68 companies individually. Each company has its own coefficient values (i.e., β_0 through β_{18} for sale volume, sales revenue, and cost of sales respectively).

TABLE I
NUMBER OF ELECTRONICS COMPANIES

Typical hardware types	Number of companies
Integrated circuits	23
Semiconductor device	23
Flat panel display	16
PCB	6
Total	68

Each company has three regression models for sales volume, sales revenue, and cost of sales. After the coefficients of the linear regression model are determined for a company, they are tested for statistical significance with respect to other companies using ANOVA. The hypotheses for the test are as follows:

H0: The coefficient of each independent variable for a company is different from that of other companies

H1: No significant differences in independent variables exist between any two companies.

TABLE II
EXTERNAL FACTORS

External Factors	Data collection (variable name)
Interest rate	USA (int_rate_US)
	EU (int_rate_EU)
	Japan (int_rate_JP)
	Korea (int_rate_kr)
Commodity price	Producer price index(Produce)
	Consumer price index(Consumer)
	Raw material price index(Source)
Oil price	Dubai (Oil_DUB)
	Brent (Oil_Brant)
	WTI (Oil_WTI)
Stock price	KOSDAQ index(Kos)
Exchange rate[1]	Dollar (Exc_US)
	Euro (Exc_EU)
	Yen (Exc.JP)

[1] For Korean won

$$Y = \beta_0 + \beta_1(Year) + \beta_2(Q1) + \beta_3(Q2) + \beta_4(Q3)$$
$$+\beta_5 X_1 + \cdots + \beta_{18} X_{14} + \varepsilon \qquad (1)$$

Where,
Y= quarterly sales volume, sales revenue, or cost of sales
Q1, Q2, Q3 = 0 or 1 depending on corresponding quarter for Y
$X_1, \cdots, X_{14}$ = external factors

The analyses depend on the hypotheses' test results. If H0 is accepted, the external factors affecting the dependent variable most significantly would be identifiable by comparing the coefficients of a company with those of others (i.e., the largest coefficient for a company is compared to that of other companies). It should be noted that the absolute value of the largest coefficient is used in this comparison. On the other hand, the companies' average coefficient value for a given external factor would be compared to that of the other external factors if H1 is accepted: the external factor with the largest average coefficient value would affect the dependent variable most significantly. This comparison is made among companies classified as either semiconductor-related or electronics components manufacturing firms.

IV. RESULTS

Table III presents the linear regression results for the sale volume of a flat-display manufacturing company obtained by R package®. The positive coefficient value indicates that the sales volume increases if the corresponding external factor value increases. Furthermore, the external factors with a P-value of less than 0.05 are statistically significant. Thus, the significant external factors among the fourteen can be initially screened for each company. Fig. 1 shows the distribution of the residuals (ε) of the linear regression model for a semiconductor company. This distribution verifies the model's adequacy, as the randomness of the residuals allows for no pattern. The same conclusion applies to the regression models for the other companies.

Table I shows the companies grouped by four different product types: integrated circuit, semiconductor device, flat panel display, and PCB. The regression model reveals that some companies show no significance concerning any of the external factors and so are removed from further analysis. The companies with at least one significant external factor are

shown in Table IV.

The coefficients estimated for each company are compared with those of other companies to test the mean differences using ANOVA. The coefficients of the external factors affecting the companies are all significantly different; thus, hypothesis H0 must be accepted. Each company's largest coefficient in each regression model is compared with that of the other companies. The dependent variables are affected most strongly by the external factors with the largest coefficients. Table V presents the top five external factors—those with the largest coefficients of absolute values. For example, the US interest rate factor has the largest coefficients fifteen times for sales volume, revenue, and cost. These external factors are defined as the critical factors affecting the sales measures most significantly. As mentioned, external factors can affect sales either positively or negatively. A positive external factor with a positive coefficient can increase sales volume, revenue, or cost. Table VI summarizes the critical positive and negative factors in the Korean electronics industry. The analysis results can be described as follows:

❖ The US interest rate is a negative factor in sales volume and cost for flat panel display products and in sales revenue for integrated circuits. For other products, it is not critical. If the interest rate falls, the sales volume and revenue of the affected products increase while their sales cost decreases.

❖ The dollar exchange rate impacts sales volume negatively while reducing the sales cost for flat panel display products. However, it reduces the sales revenue of PCB products while increasing the cost of sales. The factor also increases the sales revenue of semiconductor devices.

❖ For flat panel display products, both sales volume and revenue increase when the WTI oil price increases, though the cost of sales also increases. The costs of sales for integrated circuits and PCB products fall when their price decreases. However, integrated circuit products' sales volume declines and the sales revenue of semiconductor devices increases when their prices increase.

❖ For PCB products, sales volume increases and sales cost decreases if the euro's exchange value falls. Furthermore, Dubai's oil prices affect the sales volume of PCB products positively, though their sales cost also increases.

❖ When the raw material price for integrated circuit products increases, their sales volume increases, though their sales cost also increases. The same factor affects both the sales volume and revenue of semiconductor devices positively despite the lack of a significant external factor for sales cost.

❖ The most complicated description is needed for the WTI oil price.

The explanations offered are somewhat ambiguous, except for those concerning the US interest rate, US dollar exchange rate, and euro exchange rate. Moreover, the results should be verified and validated through further research in this field. A tremendous amount of data on electronics companies is required to draw clearer results.

TABLE III
REGRESSION RESULT FOR THE SALES VOLUME OF A FLAT PANEL
DISPLAY MANUFACTURING COMPANY

Coefficients:				
	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	2.77E-15	9.17E-02	0	1
Year	-8.69E-01	1.30E+00	-0.671	0.50757
int_rate_KR	-9.41E-01	3.80E-01	-2.475	0.01962
int_rate_US	-1.09E+00	4.17E-01	-2.617	0.01414
int_rate_EU	1.10E+00	3.79E-01	2.891	0.00733
int_rate_JP	4.61E-0.2	1.88E-01	0.246	0.80732
Produce	-2.14E+00	1.64E+00	-1.308	0.20154
Consumer	2.53E+00	2.03E+00	1.246	0.22299
Source	5.24E+00	2.70E+00	1.942	0.00622
Oil_DUB	-2.58E+00	2.96E+00	-0.871	0.39133
Oil_Brent	-3.43E+00	2.48E+00	-1.382	0.17801
Oil_WTI	2.09E+00	9.43E-01	2.219	0.03480
Kos	2.81E-01	2.05E-01	1.367	0.18246
Exc_US	-8.71E-01	4.79E-01	-1.819	0.07968
Exc_JP	-7.20E-01	9.98E-01	-0.722	0.47631
Exc_EU	-3.87E-01	2.95E-01	-1.313	0.19999
Residual standard error: 0.6084 on 28 degrees of freedom				
Multiple R-squared: 0.7589				
F-statistic: 5.877 on 15 and 28 DF, p-value: 2.919e-05				

TABLE IV
NUMBER OF COMPANIES WITH SIGNIFICANT EXTERNAL
FACTORS

Typical products	Sales measures	Number of companies
Integrated circuits	Sales volume	10
	Sales revenue	6
	Cost of sales	8
Semiconductor devices	Sales volume	9
	Sales revenue	10
	Cost of sales	7
Flat panel display	Sales volume	8
	Sales revenue	10
	Cost of sales	7
PCB	Sales volume	3
	Sales revenue	1
	Cost of sales	3

V. CONCLUSION AND DISCUSSION

This study determines the critical external factors in Korean electronics manufacturing that affect sales volume, revenue, and cost. A linear regression model examines fourteen external factors applied to 68 companies. The top five critical factors are selected by comparing the model's largest coefficients and performing significance tests using ANOVA; they are then classified into positive and negative factors affecting the sales measures.
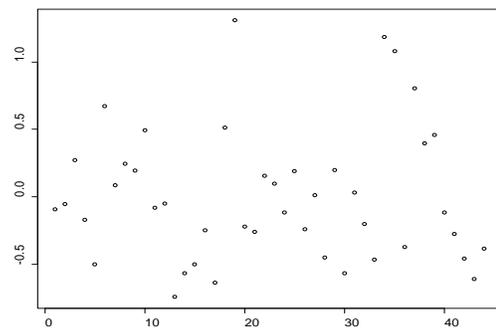

Fig. 1 Distribution of residuals for a flat display manufacturing company

TABLE V
TOP FIVE CRITICAL EXTERNAL FACTORS AFFECTING SALES

External factors	Frequency
US interest rate	15
Dollar exchange rate[1]	13
WTI oil price	10
Euro exchange rate[1]	8
Raw material price index	7
Dubai oil price	7

A firm deploys its best resources (e.g., budget, time, people) to develop new products and services. However, only a few projects will enjoy sustained support until the launch date by displaying a high success probability. Most firms use an evaluation system to decide whether to support a project (i.e., a go/no go decision). As this evaluation is usually made on the basis of the expected profit, firms must develop a profit model that is highly accurate and reliable by considering the appropriate parameters such as sales volume, unit price, and cost, variables that will be conditioned by time and by internal and external factors. This study provides guidelines for developing such a profit model by suggesting the relevant critical external factors.

This study has limitations that affect the generalizability of its results:

❖ The manufacturing and technological characteristics of the companies examined have not been studied, prohibiting closer analysis of the impacts of the external factors.

❖ Only companies registered on the KOSDAQ stock market have been selected, thus excluding the many manufacturing companies listed on the KOSPI stock market. This limitation should be addressed in order to extract more detailed and comprehensive results. Further study will lead to a better understanding of the impact of the external factors this paper discusses:

❖ More external factors (e.g., inflation rates, the commodity prices of foreign countries, weather changes) should be considered.

❖ More sampling periods should be used.

❖ Better methods, such as the decision tree or support vector machine (SVM), should be applied to the data, along with appropriate data modification. For example, all real value data could be converted into binary values (i.e., 0 or 1) to classify the external factors into groups.

TABLE VI
CRITICAL POSITIVE AND NEGATIVE EXTERNAL FACTORS FOR TYPICAL PRODUCTS

Typical product	Sales Volume		Sales Revenue		Cost of Sales	
	P	N	P	N	P	N
Integrated circuits	Raw material price	WTI oil price	N/A	US interest rate	Raw material price	WTI oil price
Semiconductor devices	Raw material price	N/A	WTI oil price, Raw material price, dollar exchange rate	N/A	N/A	N/A
Flat panel display	WTI oil price	US interest rate, dollar exchange rate	WTI oil price	N/A	WTI oil price	US interest rate, dollar, exchange rate
PCB	Dubai oil price	Euro exchange rate	N/A	Dollar exchange rate	Dollar exchange rate, Dubai oil price	Raw material price, WTI oil price, euro exchange rate

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