Performance comparison between U.S. and South Korean electronics industries with the perspectives of inventory and R&D*

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Abstract

This article investigates the causal relationship between investments for inventory and research and development (R&D) and financial performance in the electronics industries of U.S. and South Korea. The results show that short-term R&D is negatively associated with the firm's financial performance while long-term R&D is positively associated with it in both countries. Regarding the effect of inventory investment, U.S. data shows positive relationship between appropriate level of inventory investment and firms' financial performance, while it turns out to be negative in Korea data. When the inventory investment is excessive, its effect is negative and significant in the U.S. data while it is not significant in Korea data. Our results imply that, to improve performance, firms need to maintain the reasonable level of

inventories and time gap between R&D investment and its materialization.

Key words: Electronics industries, Panel data, Inventory, R&D

I. Introduction

The proliferation of the information technology (IT) industry, including both hardware and software, has contributed to recent economic growth of economy of South Korea[1] significantly. Korea has become one of the leading countries in the electronics industry, competing with traditional leaders, such as U.S.. The electronics industry has been considered as the most prominent contributor to Korea economy and it still take a big portion of GDP. To become a competitive player, the electronics companies in Korea invested in research and development (R&D) to create and enhance the innovative technology, and secured the products which are accumulated in inventories before selling to the world market with agility. In this regard, we thought that understanding the electronics industry is important to understand the recent growth of Korean economy. So, we will investigate how R&D and inventory investment, taken as important in the industry development and performance lead to firms' performance in the electronics industry. We presume that these two different countries achieved success in boosting electronics industry and acquiring the positive outcomes in different ways.

Powel and Dent-Micallef (1997) found the increasing role of information technology in formulating and implementing strategy. They presented the hypotheses that human, business and technology resources of information technology firms affect firms' performance. Motivated by this idea, we suggest the similar propositions through substituting business resources and technology resources with inventory investment and R&D, respectively. We empirically examine the relationship with the following model:

Firm's financial performance = f(Inventory, R&D expenditure)   (1)

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1) In this paper, hereinafter, South Korea is abbreviated as Korea.

From (1), we investigate how firms' resources lead to their financial performance. To find the effective measure for R&D investment, we categorized R&D into short-term and long-term investment. Our result will provide key insights to determine whether R&D will be cost or benefit for firms. We also investigate whether there is any difference in the aforementioned relationship because of the required time until R&D effectiveness occurs. In case of inventory investment, we will check the trade-off whether making chance to sell products more and to avoid stock-out problem with increased holding cost or seeking for the lean management through less inventory level with bearing the customer's leaving.

Our research aims to contribute to the literature as follows. We compare the U.S. and Korea with a focus on the electronics industry and identify the similarities and differences in these two countries regarding the relationship between investments and performance. Practically, our findings have managerial and policy implications who want to effectively make the investment to maximize profit and social welfare, respectively.

Our paper is organized as follows. In the next section, data and variables are covered. Then, model and research methods are presented. Finally, concluding remarks follow.

Ⅱ. Data & Variables

We collected the U.S. data from the Compustat financial database through Wharton Research Data Services for U.S. companies and the Korea data from KIS Value which provides the corporate information service by NICE for Korean companies. The Compustat database have provided various business data for researchers and practitioners since 1993 and the variables mentioned herein can be covered in that data set.

The selection of the U.S. firms is based on the Standard Industry Classification (SIC) code assigned to each firm and the samples are restricted to the electronics companies and there are fewer companies in Korea Stock Market in the same category, so relatively small samples are available in Korea data (Table 1a, 1b, 1c, 1d). The collected data spreads from 1997 to 2009, but applied period will be 10 years

from 2000 to 2009 because some proxy variables use the past period data, so truncated data with strongly balanced form will be applied.

〈Table 1a〉 Classification of U.S. electronics industry

SIC codes	Industry Segment	SIC codes	Industry Segment
3570	Computer & office Equipment	3600	Electronic & Other Electrical Equipment (No Computer Equip)
3571	Electronic Computers	3661	Telephone & Telegraph Apparatus
3572	Computer Storage Devices	3663	Radio & TV Broadcasting & Communications Equipment
3575	Computer Terminals	3669	Communications Equipment, NEC
3576	Computer Communications Equipment	3670	Electronic Components & Accessories
3577	Computer Peripheral Equipment, NEC	3672	Printed Circuit Boards
3578	Calculating & Accounting Machines (No Electronic Computers)	3674	Semiconductors & Related Devices
3579	Office Machines, NEC	3677	Electronic Coils, Transformers & Other Inductors
3580	Refrigeration & Service Industry Machinery	3678	Electronic Connectors
3585	Air-Cond & Warm Air Heatg Equip & Comm & Indl Refrig Equip	3679	Electronic Components, NEC
3590	Misc Industrial & Commercial Machinery & Equipment		

〈Table 1b〉 Data description (U.S.)

SIC codes	No. of Firms with full data	No. of Firms searched	SIC codes	No. of Firms with full data	No. of Firms searched
3570	2	9	3600	3	8
3571	6	40	3661	15	126
3572	8	51	3663	45	165
3575	1	10	3669	11	59
3576	17	97	3670	3	25
3577	17	89	3672	2	33
3578	4	21	3674	78	298
3579	1	12	3677	1	3
3580	3	31	3678	4	14
3585	3	26	3679	21	68
3590	1	18	Total	246	1203

⟨Table 1c⟩ Classification of Korean electronics industry

Industry Segment in English	
Semiconductors & Related Devices Manufacturer	Communications & TV Broadcasting
Electronic Components & Accessories	Video & Sound Equipments
Computer & Related Equipments	

⟨Table 1d⟩ Data description (Korea)

Industry Segment in English	No. of Firms with full data	No. of Firms searched	Industry Segment in English	No. of Firms with full data	No. of Firms searched
Semiconductors & Related Devices Manufacturer	4	9	Communications & TV Broadcasting	5	9
Electronic Components & Accessories	7	19	Video & Sound Equipments	2	4
Computer & Related Equipments	1	3	Total	19	44

The sample size of Korea data is just 190 observations during 2000 ~ 2009 (number of firms with full data for Korea are 19), so interpretation of the result may be burdensome. The subscripts are used similarly following the existing studies. t is time-specific, i is company-specific and s is country-specific ones, so variables with subscripts are as follows.

⟨Table 2⟩ Variable description

Variable	Description
RD_{its}	End-of-year R&D expenditure
INV_{its}	End of year inventory level
$(INV_{its})^2$	End-of-year squared inventory level
GM_{its}	End-of-year gross margin

As proxies used in the model, the expression (2) scaled by sales are added. We adopt the definitions used by Capkun et al. (2009) for the performance and inventory, so

$INVS_{its}$ will be the indicator for inventory level and GMS_{its} will be used for representing the measure of financial performance in our model. The short-term R&D of one year-lagged period is from Yoon (2002) and the long-term R&D period is based on the usual time gap between the very first development and massive production in the usual cases of the semiconductor industry. As the period of the long-term R&D effectiveness occurrence depends upon the industry environment, the research based on the specific data reflecting industry characteristics will be done in the future. Although the long-term period proxy in this article is from the specific industry, the general applications are acceptable due to the widespread characteristics of this domain.

$$GMS_{its} = \frac{Sales_{its} - COGS_{its}}{Sales_{its}}, INVS_{its} = \frac{avg\left(INV_{i(t-1)s} + INV_{its}\right)}{Sales_{its}}$$

$$RDS_{its} = \frac{avg\left(RD_{its} + RD_{i(t-1)s}\right)}{Sales_{its}},$$

$$RDL_{its} = \frac{avg\left(RD_{i(t-2)s} + RD_{i(t-3)s}\right)}{Sales_{its}}$$

(2)

Ⅲ. Theory and Hypotheses

In this section, we develop hypotheses that relate inventory level and R&D expenditure to financial performance. An important and meaningful approach used in this paper is division of effects of inventory and R&D into the following categories: 'Appropriate level of inventory vs. Excessive level of inventory' and 'Short-term R&D expenditure vs. Long-term R&D expenditure'.

R&D used in article is R&D expenditure if speaking precisely and means all investments spent for developing or carrying out new and particular technologies. Tsai and Wang (2004) investigated the R&D impact on firm's productivity and value-added output and found that R&D was the significant factor for enhancing outcomes and firm's competitive advantage. Griffith et al. (2006) also found the linkage between R&D and productivity. The productivity will be replaced with the financial perform-

ance hereafter for inducing the unified result. Because a firm's capability improves through R&D, we hypothesize that R&D will impact on the firm's financial performance.

Hypothesis 1: R&D is correlated with the firm's financial performance.

Bushee (1998) investigated the short-term focus of US executives and investors, and found myopic R&D behavior of the managers to secure their portions when the institutional ownership is low. However, it seems reasonable that there is some lag between the investment and its materialization, since the effect from R&D cannot be realized at once. Thus, we presume that the short-term effect of R&D before realization is cost rather than benefit, which is reflected in Hypothesis 1a.

Hypothesis 1a: Short-term R&D is negatively correlated with the firm's financial performance.

Although the effect of R&D activities is not instantaneous, R&D investments have significant consequences in the corporate performance. Franko (1989) concluded that corporate R&D intensity is not only an important driving force and forecaster of the firm's growth but it plays a principal role of gaining market share in a competitive global market. A decision on the important activity such as investing the firm's capital in R&D expenditure is usually influenced by the executives and these people are exposed to the condition that goals, viewpoints of their departments could be the base of selections (Dearbon and Simon, 1958). Barker and Mueller (2002) specified how CEO's career experiences influenced the R&D spending through showing that 'A firm whose CEO has career experience in the R&D/engineering and marketing/sales function will spend more on R&D than a firm whose CEO does not have R&D/engineering and marketing/sales experience.' and 'A firm whose CEO has career experience in the legal and production/operations function will spend less on R&D than a firm whose CEO does not have legal and production/operations experience'. The difference between the former and the latter seems natural because the primary objectives and

purposes of respective functions are different across firms. Thus, the CEOs with R&D /engineering and marketing/sales experience are inclined to show an interest in the long-term and fundamental improvement. In this regard, we set up Hypothesis 1b.

Hypothesis 1b: Long-term R&D is positively correlated with the firm's financial performance.

There have been diverse and controversial studies about the relationship between the firms' inventory holdings and financial performances. Koumanakos (2008) conducted an investigation of negative correlation between the inventory level and firm's profitability. On the other hands, Rumyantsev et al. (2007) hypothesized that aggregate inventory level is positively associated with aggregate product margins and found empirical evidence to support their theory. Although inventory holding costs amount more in higher inventories, it is more important for firms not to make stockouts, which are more sensitive to firms' financial results. Capkun et al. (2009) showed the inventory level is positively correlated with the financial performance by considering the different types of inventories such as raw material, work-in-process and final goods. Under the above literature streams, we presume that the inventory performance is positively associated with the financial performance because the manufacturers of the electronic devices will lose the market share (in other words, firm's financial gains) if the required inventory is not available as reflected in Nokia case (Gallen, 2011). But the unconditionally high inventory level will not have a good effect on the performance. This idea is similar with the example on page 10 of Greene's book (2008). The following set of hypotheses reflects these ideas.

Hypothesis 2: Inventory investment is correlated with the firm's financial performance.
Hypothesis 2a: Appropriate inventory investment is positively correlated with the firm's financial performance.
Hypothesis 2b: Excessive inventory investment is negatively correlated with the firm's financial performance.

Ⅳ. Research Methods

There are many indicators for financial performances. EBITDA is used in Capkun et al. (2009), ROA and ROE are used in Maditinos et al. (2011), and gross margin is used in Rumyantsev et al. (2007). The most suitable one for this article is gross margin because the base data used in this one is not assets, equities but COGS, revenue. The following expression is the tentative model of this article.

$$GMS_{its} = a_i + b_{s1}RDS_{its} + b_{s2}RDL_{its} + b_{s3}INVS_{its} + b_{s4}\left(INVS\right)^2_{its} + \varepsilon_{its} \tag{3}$$

Firm-specific fixed effects, denoted with a_i, is considered in the model because the specific cultures, characteristics and management style from the sample firms matter. Whether modeling the above one is based on Fixed effects or Random effects will be evaluated in the next section.

4.1 Hausman test

Correlation between independent variables and a_i is important to consider in choosing Random effects model and Fixed effects model (Wooldridge, 2002; Min and Choi, 2009, 2010a, 2010b). We compare Fixed effect model and Random effect model with Hausman test, which is often used to evaluate the significance of an estimator versus an alternative one. Table 3 summarizes the results from the Hausman test.

Random effects model (RE) is selected for consistency and efficiency if the null hypothesis is not rejected and fixed effect model (FE) is preferred for consistency if the alternative hypothesis is accepted under Hausman test. The null hypothesis states that differences in coefficients are not systematic. The results on Table 3 show the chi-square values and p-values, as based on these numbers, Fixed effects model is recommendable for the U.S. & Korea case and the U.S. case. Meanwhile, Random effect model is suitable for the Korea case.

〈Table 3〉 Coefficients and standard errors

	U.S. & KOREA		U.S.		KOREA	
	FE	RE	FE	RE	FE	RE
	coef/se	coef/se	coef/se	coef/se	coef/se	coef/se
Inventory	1.630***	2.295***	1.496**	2.482***	−0.481***	−0.438***
	(0.583)	(0.474)	(0.634)	(0.508)	(0.153)	(0.153)
Squared Inventory	−2.761***	−3.156***	−3.338***	−3.825***	0.192	0.134
	(0.317)	(0.279)	(0.342)	(0.301)	(0.209)	(0.209)
Long-term R&D	0.337***	0.354***	0.353***	0.372***	0.670***	0.703***
	(0.019)	(0.018)	(0.020)	(0.019)	(0.223)	(0.224)
Short-term R&D	−2.007***	−2.035***	−2.001***	−2.033***	−0.882***	−0.866***
	(0.028)	(0.026)	(0.029)	(0.027)	(0.222)	(0.223)
Constant	0.531***	0.446***	0.599***	0.470***	0.270***	0.265***
	(0.082)	(0.084)	(0.090)	(0.089)	(0.020)	(0.047)
Chi2(4)	35.76		28.58		3.05	
Prob>chi2	0.0000		0.0000		0.5492	

note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.2 Results

Both U.S. and Korea data support Hypothesis 1a, implying that the short-term R&D expenditure plays a role of the cost component, negatively influencing short-term firm performance. The negative effect is caused by the lag between R&D investment and its realization. Both U.S. and Korea data support Hypothesis 1b which implies that the long-term effect of R&D expenditure is positive and significant. In the sample data, the lag turns out to be about 2～3 years. The results provide managerial insight ensuring that managers should select R&D levels to maximize long-term benefit rather than to meet short-term earning. According to a comparison of coefficients between U.S. and Korea data, Korean firms show better outputs than U.S. firms in both long-run and short-run operations in their R&D expenditure. In other words, under the all factors fixed equally, one unit increase of Long-term R&D shows higher gross margin and one unit increase of short-term R&D shows lower loss in Korea than the U.S. This is supposed that Korean companies' pursuing fast follower spirit leads to culture appreciating short-term outcomes.

The U.S. data supports Hypothesis 2a which implies that the economies of scale in the inventory management affect the financial performance positively. But Hypothesis 2a is not supported in the Korea data, indicating that the strategy to reduce the inventory level such as JIT (Just-in-time) may still be valid. On the other hand, for the U.S. firms, the excessive inventory quantities would be viewed as loss to firms. However, the coefficient of Korea is not valid and further the positive coefficient for the excessive inventory shows the unreasonable result when considering the negative coefficient for the appropriate inventory. In this regard, the hypothesis 2b is not significant in Korea from both quantitative result and reasoning.

Hong and Yoo (1999) showed the contribution of IT industry to the economy of the U.S. and Korea (e.g., labor productivity). Unfortunately, this study did not reflect Korea's recent astonishing progress in the IT industry for the last decade or so. To improve the existing model, we collect recent data, presuming that Korea has caught up with the U.S. in terms of its progress in the IT industry, and thus the difference between these two countries is insignificant. However, the structural difference between countries can be noticed according to the results of Table 3. From the view of both long-run and short-run investments in their R&D expenditure, Korea shows better R&D operations than U.S., however, from the inventory view, Korea are in the situation that positive effects of inventory assets as the business resources are not appreciated. It is supposed that the U.S. firms enjoy the positive effect of inventory assets for their financial output. Further, mixed data set of both U.S. and Korea don't represent in-between results of U.S. and Korea, because data heterogeneity for two countries exists.

V. Conclusion

The purpose of this study is finding the causal relationship between investments for inventory and research and development (R&D) and financial performance for U.S. and Korea manufacturing companies in the electronics industries. We found that the U.S. data fully supports all hypotheses while Korea data partially supports them.

Future study may want to identify the reasons for the difference and investigate whether the partial acceptance originates from the Korean firms' industrial characteristics. Our results underscore the reasonable level of inventories and time gap that is required for realizing the R&D investments. Although the model is simple, comparing with the trendy industries will provide some insights with managers about their business plans.

The main limitation of this study is that only four independent variables are available. The result may be more interesting if control variables such as firm size and previous performance are included. In case of the lagged financial performance, we expect the past performance affects the present performance. Sine et al. (2003) showed the universities' past licensing performance influences the new licensing and they called this effect as 'halo effect'. However the assertion that the present poor status can spur the company was also available (Cyert et al, 1963). The former suggestion would be acceptable due to the latest study's suitability for capturing and reflecting the recent trends.

As mentioned in the introduction, the missing variable from Powel and Dent-Micallef (1997) is human resources. The tendency, that firms do not uncover to the database firm in the U.S. case how much their employees are paid, ended in failure in making the corresponding variable for human resources. If data for individual firm become available, our findings would be required for re-analysis. The future research will have the following deviations from this article. First, it is possible to change the performance measure into new proxies such as EBITDA instead of gross margin. Because interests are taxes are not main concern in the operations management. Second, different modeling such as the dynamic panel analysis will adopted. Because the earlier performance affects the present results as described above, then a different nature would be observed with a new approach.

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