IT INVESTMENT AND ITS IMPACT ON FIRM PERFORMANCE: THE CASE OF KOREAN MANUFACTURING INDUSTRIES

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IT paradox debate

Many companies have invested time, money and their future in Information Technology (IT) to help cope with increasing domestic and global competition. According to the estimates of the Korean National Computer Agency, the enterprise sector's annual investment in IT grew to over 19 billion won in 1998. Yet they know little about IT's impact on the firm's performance. As pointed out by many researchers and practitioners, most investment decisions are still made based on "gut feelings" that benefits will ensue, despite the absence of specific scientific measurement techniques.

Many companies have invested time, money and their future in Information Technology (IT) to help cope with increasing domestic and global competition.

Up to date, a number of studies have investigated IT impact on performance. The evidence from the previous research, which mainly used North American data, has been contradictory with respect to the effects of IT on business performance. Some researchers have reported that there is no relationship between IT investment and improvement in organizational performance. On the other hand, some researchers have provided evidence that such a relationship does exist. The question of how IT creates value has been the subject of an ongoing debate ever since economists pointed out the IT paradox at the end of the last decade.

In Korean industries, the issue of evaluating the efficient use of IT and the factors related with IT efficiency is very important. This, however, is not an easy task, as there are problems such as faulty measurement of inputs and outputs, and lags between investments and benefits. To eliminate these difficulties, we apply the Data Envelopment Analysis (explained in the final section), which evaluates the efficiency of each firm by comparing it to a reference group of other firms that have the same set of inputs and outputs. In this research, we evaluate IT's impact on individual firm performance through the Data Envelopment Analysis (DEA) method.

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Data and methodology

In general, studies concerning the IT paradox use various levels of performance

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measures: the economy as a whole, the industry, the firm, and divisions within a firm and the individual information system. However, since it is known that firm-level performances provide more appropriate results, we focus our attention on the studies that measure firm-level performance.

We also focus our analysis on manufacturing firms so as to maintain sample homogeneity. Data for each firm was obtained from two sources. The survey data from Korea Information Society Development Institute was the source for hardware, software, networking, system maintenance & repair investment, and IT related labor cost as inputs. The KIS-LINE from Korea Investors Service was used to obtain firm performance data. Measurement of output (or performance) include sales volume and operating profit.

We limited our analysis to the 1996 period because there are many difficulties in collecting IT investment data and there is also a lack of data. To consider possible lags between IT investment and firm performance, total IT investment in 1996 is computed as below.

Total IT investment in 1996 = (IT investment in 1995×0.6) + (IT investment in 1996×0.4)

Because the length of this lag is not known and varies in reality, the lag constants such as 0.6 and 0.4 (=1-0.6) are determined by subjective judgement. And we used the input-oriented BCC model to distinguish between pure technical efficiencies and scale efficiencies.

Interpretative illustration of results

52 manufacturing firms were classified as relatively efficient, while the other 55 were classified as inefficient.

Table 1 shows the results of the DEA analysis. 52 manufacturing firms were classified as relatively efficient, while the other 55 were classified as inef ficient. Moreover, average technical efficiency and scale efficiency were 0.609 and 0.662, respectively. As can be seen in Table 1, basic metals, radio, television and communication equipment and apparatus industries have a greater proportion of efficient firms while the opposite is true for textiles, pulp, paper & paper products, motor vehicles, trailers and semi-trailers industries.

In addition, depending on the input target analysis, the amount of input resources that should be decreased for the firm to become efficient can be explained. Although it is not illustrated, 150,240 thousand won in hardware related investment, 77,300 thousand won software related investment, 58,800 thousand won in networking expenditure, 59,300 thousand won in system maintenance & repair investment, and 327,300 thousand won in IT related labor cost should be decreased to achieve best performance from average physical units. Apparently, this result shows that IT related labor cost and hardware related investment were not utilized effectively. Hence, more adequate management of these two investment factors is

Table 1. Distribution of Efficiencies across Industry

	No. of efficient sample	No. of inefficient sample	No. of total sample
Food & beverages	7	6	13
Textiles	3	7	10
Wearing apparel and fur articles	-	1	1
Leather, luggage handbags & footwear	1	-	1
Wood & wood products, except furniture	-	1	1
Pulp, paper & paper products	1	3	4
Publishing, printing & reproduction of recorded media	-	1	1
Coke, refined petroleum products	1	-	1
Chemicals & chemical products	10	11	21
Rubber and plastic products	2	1	3
Non-metallic mineral products	3	2	5
Basic metals	8	3	11
Fabricated metal products, except machinery and equipment	3	2	5
Machinery and equipment n.e.c	3	3	6
Office, accounting and computing machinery	-	-	-
Electrical machinery and apparatus	3	3	6
Radio, television and communication equipment and apparatus	6	3	9
Medical, precision and optical instruments, watches and clocks	-	2	2
Motor vehicles, trailers and semi-trailers	1	5	6
Other transport equipment	-	1	1
Furniture; manufacturing n.e.c	-	-	-
Recycling	-	-	-
Total	52	55	107

needed to lessen or eliminate these inefficiencies.

From the BCC analysis, we also illustrate scale efficiencies and economies of scale as shown in Table 2. The results from Table 2 show that non-metallic mineral products and basic metals industries have a greater proportion of scale on efficient firms. In the viewpoint of returns to scale, basic metals, machinery and equipment n.e.c, radio, television and communication equipment and apparatus are providing higher increasing outputs to proportionate inputs while the opposite is true for textiles. electrical machinery and apparatus, motor vehicles, trailers and semi-trailers.

Non-metallic mineral products and basic metals industries have a greater proportion of scale on efficient firms.

Further, in order to explore the factors associated with the efficiencies, a series of parametric (T-Tests) tests were performed on the efficient and inefficient firms. First, we investigated the statistical mean difference between efficient firms and inefficient firms from the point of sales volume. According to the results, although

Table 2. Distribution of Scale Efficiencies and Economies of Scale

	No. of Total Samples	No. of Scale Efficient Sample	No. of Returns to Scale		
			Decreasing	Constant	Increasing
Food & beverages	13	3	5	2	6
Textiles	10	2	5	2	3
Wearing apparel and fur articles	1	-	1	-	-
Leather, luggage handbags & footwear	1	-	-	-	1
Wood & wood products, except furniture	1	-	1	-	-
Pulp, paper & paper products	4	-	2	-	2
Publishing, printing & reproduction of recorded media	1	-	-	-	1
Coke, refined petroleum products	1	-	-	-	1
Chemicals & chemical products	21	6	8	7	6
Rubber and plastic products	3	-	1	-	2
Non-metallic mineral products	5	2	1	1	3
Basic metals	11	4	2	4	5
Fabricated metal products, except machinery and equipment	5	-	2	-	3
Machinery and equipment n.e.c	6	-	2	-	4
Office, accounting and computing machinery	-	-	-	-	-
Electrical machinery and apparatus	6	2	3	3	-
Radio, television and communication equipment and apparatus	9	-	3	-	6
Medical, precision and optical instruments, watches and clocks	2	-	1	-	1
Motor vehicles, trailers and semi-trailers	6	-	4	-	2
Other transport equipment	1	-	1	-	
Furniture; manufacturing n.e.c	-	-	-	-	-
Recycling	-	-	-	-	-

the average sales volume of efficient firms (54,900 thousand won) was much greather than that of inefficient firms (23,020 thousand won), it was not a statistically significant result with a significant level 0.05. Also, it was similar for the operating profit.

We were not able to show clear evidence of a connection between firm size and the efficiency of IT.

Consequently, we were not able to show clear evidence of a connection between firm size and the efficiency of IT. However, since we included only one year data to the DEA model, it should be noted that there are some limitations in generalizing such paradoxical characteristics. To broaden our analysis, a review on normalization

and validation of data, longitudinal pattern analysis like a Malmquist index, intermediation role of IT, and qualitative factors should be further studied in detail.

For example, gross income to sales, gross value added to total assets (or productivity of capital- the measurement of value added created from capital invested in a business), and sales per employee have statistically significant results. This fact implies that there are some possibilities for explaining additional relationships between IT and performance. VIP

Table 3. Data Envelopment Analysis

Data Envelopment Analysis(DEA) computes the efficiency of a Decision Making Unit (DMU) in transforming inputs into outputs in relation to its peer group. Charnes et al.(1978) first developed the DEA approach based on the concept of technical efficiency of Farrel(1957).

The DEA model generalized the single-output/input ratio measure of efficiency for a single firm (or DMU) in terms of a fractional linear programming formulation transforming the mulitple output/input characterization of each DMU to that of a single virtual output and virtual input.

The relative efficiency of any DMU is calculated by forming the ratio of a weighted sum of outputs to a weighted sum of inputs, where the weights (or mulipliers) for both outputs and inputs are to be selected in a manner that calculates the Pareto efficiency measure of each DMU subject to the constraint that no DMU can have a relative efficiency score greater than unity.

In contrast to econometric approaches, DEA analysis:

1. focuses on individual observations in contrast to population averages.
2. produces a single aggregate measure for each DMUs in terms of its utilization of input factors to produce desired outputs.
3. can simultaeously utilize multiple outputs and multiple inputs with each being stated in different units of measurement.
4. is value free and do not require specification or knowledge of a priori weights or prices for the inputs or outputs.
5. places no restriction on the functional form of the production relationship (production function).
6. produces specific estimates for desired changes in inputs and/or outputs for projecting DMUs below the efficient frontier onto the efficient frontier.
7. focuses on revealed best-practice frontiers rather than on central tendency properties of frontiers.