The Difference of Linkages between Manufacturing Strategy and Information Systems Activities

- An Empirical Comparison of U.S. and Korean Manufacturers -

Sang-Gun Lee, Choong Kwon Lee, and Yunchu Huang,

Department of Management College of Business Administration,
University of Nebraska-Lincoln, Lincoln. NE68588-0491
USA

1. Introduction

U.S. manufacturing industries have been one of the most profitable industries in the world business market for about 100 years. Although they had been outrun by Japanese companies in the 80's in some manufacturing fields like auto industry, US companies seemed to have quickly regained its leading position in the world market by conducting some structural and technical changes. On the other hand, Korean manufacturing industries have begun its start since Korean War and have experienced tremendous growth for the second half of the 20th century.

In the manufacturing field, different corporate strategies, thus different competitive priorities are related with different actions or programs. Particular competitive priorities would greatly enhance the payoff of certain programs/activities. The design of manufacturing systems should focus on developing competitive capabilities that satisfy customer needs and improve performance (Ward et al., 1994). Porter (1996) claims that a proper link between strategy and operations is a key to developing a sustainable competitive advantage. Upton (1994) states that firms must match their manufacturing systems capabilities with their strategic competitive priority in order to be successful.

The research focus is given to the numerous companies in the manufacturing field, because the primary purpose of this paper is to compare the general tendency in strategic priorities of manufacturing industries in the two countries. The manufacturing companies in the two countries showed a stable growth rate despite the trend of depression in manufacturing sector, and they also belong to two totally different cultural and environmental societies. Even though there are still some differences between US and Korean manufacturing industries in terms of scale, quality, structure, management style and other dimensions, these differences are out of the scope of this paper. This paper is interested in the difference in the competitive priorities

chosen by the manufacturing companies of the two countries, and in the relationship between the priorities and the computer-related manufacturing programs/activities.

Based on the data collected by MFP (Manufacturing Future Research Project), this paper is intended to find which programs/activities in regard to computer systems are more closely associated with some particular competitive priorities chosen by each of the two countries' manufacturing companies.

2. Construct Variables and Research Design

2.1 Independent variables---Competitive Priorities

In seminal work, Skinner (1969) developed a model for manufacturing strategy in which the contents of manufacturing strategy should be competitive priorities based on corporate or business strategy. The suggested competitive priorities were cost, flexibility, quality, and delivery. It is recommended that service be one of the competitive priorities. Therefore, in this paper independent variables in manufacturing strategy are defined as price, flexibility, quality, delivery, and service.

Price is defined as ability to profit in price competitive markets. Flexibility consists of five abilities such as abilities to make rapid design/volume and project mix changes, ability to introduce new products quickly, and ability to offer a broad product line. Quality consists of four abilities such as ability to offer consistent quality with low defects, ability to provide high-performance products, ability to provide reliable products, and ability to provide durable products. Delivery consists of two abilities such as ability to provide fast deliveries, and ability to provide dependable deliveries. Service consists of three abilities such as ability to provide effective after-sales service, ability to provide effective product support, and ability to customize products to individual customer's needs.

The sub-variables in competitive priorities are marked from 1 (Least important) to 7 (Most important) based on the importance of each sub-variable for the surveyed business unit to compete in the marketplace for the past 5 years.

2.2 Dependent variables---Programs/Activities

In order to extract essential corporate contents, we selected two different business aspects: Software-supported activities and IS-integrating activities. The data set contains three different activities for each of these two dependent variables. Software-supported activities consist of computer-aided manufacturing, computer-aided design, and computer integrated manufacturing. IS-integrating activities consist of integrating information systems within manufacturing, integrating information systems across functions within the business unit, and integrating information systems with suppliers and distributors. The programs/activities are marked from 1 (Little payoff) to 7 (Great payoff) based on the extent of payoff resulting from these programs or activities in the past two years.

2.3 Data Collection

Data from Korean manufacturing companies were collected as a main activity of MFP-Korea by sending the questionnaire booklets to operation vice-presidents or directors who are relatively high-level managers in large manufacturing corporations. Data from U.S. manufacturing companies were collected by the MFP-USA located in Boston University. The MFP started in 1981 and quickly became a major force in the manufacturing research community by systematically collecting and

analyzing a rich set of data from about 200 large successful manufacturers every year. The trends and patterns identified from this survey data have been a useful resource in developing theories in regard to manufacturing strategy.

2.4 Research hypotheses

This empirical study examines the importance of different competitive priorities determined by manufacturing companies in both U.S. and Korea, as well as the relationship between competitive priorities and programs/activities in the manufacturing companies in the two countries. For these purposes, we test two hypotheses:

Hypothesis 1: There is a significant difference between U.S. and Korean manufacturing companies in setting the degree of importance of competitive priorities.

Hypothesis 2: There is a significant difference between U.S. and Korean manufacturing companies in linking competitive priorities with programs/ activities.

2.5 Analysis process

Data were analyzed by three-step statistical test: independent sample t-Test, factor analysis, and multivariate regression. First, the values of competitive priorities (independent variables) are conducted by independent sample t-test to see if there is a statistical difference in competitive priorities between U.S. and Korean manufacturing companies. Second, for each independent and dependent variable, factor analysis is applied to see if the grouped sub-variables are good representatives of each of the independent and dependent variable and can be treated as one factor. The sub-variable that has a factor loading value of more than 0.500 is selected and retained in that group, while that with factor loading value below 0.500 is discarded. Third, multivariate regression is applied to the five competitive priorities (independent variables) and the two main programs/activities (dependent variables) in order to analyze the relationship between each independent and dependent variable.

3. Results and Analyses

3.1 t-Tests of independent variables between USA and Korea

In order to determine whether or not there is a statistical difference in the competitive priorities between U.S. and Korea, independent sample t-Test is applied (see Table 1). Regarding price, the two countries showed a statistical difference at 90% confidence level in ability to make a profit in price competitive market. This significant difference ($p<0.08$) indicates that U.S. focused more on the variable than did Korea in the marketplace. In regard to flexibility, the two countries showed statistical difference at 90% confidence level in the four variables: ability to make rapid design changes ($p<0.0001$), ability to introduce new products quickly ($p<0.036$), ability to make rapid volume changes ($p<0.0001$), and ability to make rapid product mix changes ($p<0.001$). This result indicates that Korea focused more on flexibility than did U.S. in the marketplace. Also the two countries showed no statistical difference in the variable, ability to offer a broad product line.

Table 1. t-Test of independent variables between USA and Korea

Variables	USA	Korea	Mean Difference	Sig.
Price: Ability to profit in price competitive market	5.8647	5.5899	0.2748	*
Flexibility:				
Ability to make rapid design changes	4.9023	5.5000	-0.5977	***
Ability to introduce new products quickly	5.4427	5.7591	-0.3164	**
Ability to make rapid volume changes	4.7121	5.3261	-0.6140	***
Ability to make rapid product mix changes	4.9398	5.4493	-0.5095	***
Ability to offer a broad product line	5.1805	5.1324	0.0481	
Quality:				
Ability to offer consistent quality with low defects	6.3083	6.4710	-0.1627	*
Ability to provide high-performance products	5.5188	5.4963	0.0225	
Ability to provide reliable products	6.2030	6.0370	0.1660	
Ability to provide durable products	5.0992	4.7778	0.3214	*
Delivery:				
Ability to provide fast deliveries	5.7970	5.7986	-0.0016	
Ability to provide dependable deliveries	6.0602	5.9855	0.0747	
Service:				
Ability to provide effective after-sales service	5.0301	5.9348	-0.9047	***
Ability to provide effective product support	5.3485	5.4203	-0.0718	
Ability to customize products to individual customer's needs	5.2045	5.8261	-0.6216	*

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

In regard to quality, the two countries showed a statistical difference at 90% confidence level in the variables, ability to offer consistent quality with low defects ($p<0.10$) and ability to provide durable products ($p<0.075$). While Korea focused more on ability to offer consistent quality with low defects than did U.S. in the marketplace, U.S. focused more on ability to provide durable products ($p<0.075$) than did Korea in the marketplace. Also, the two countries showed no statistical difference in the variables, ability to provide high-performance products and ability to provide reliable products.

In regard to delivery, the two countries showed no statistical differences at 90% confidence level in the variables, ability to provide fast deliveries and ability to provide dependable deliveries.

In regard to service, the two countries showed statistical difference at 90% confidence level in the variables, ability to provide effective after-sales service ($p<0.0001$) and ability to customize products to individual customer's needs ($p<0.0001$). Korea focused more on these variables than did USA in the marketplace. Also the two countries showed no statistical differences in the variable, ability to provide effective product support.

Because the mean differences are significant as shown in Table 1, hypothesis 1 is partially or fully supported by such variables as price, flexibility, quality, and service. For example, quality has four sub-variables, and two of them, ability to offer consistent quality with low defects and ability to provide durable products, showed statistical differences. So hypothesis 1 is partially supported. However, because delivery has two sub-variables and none of them showed statistical differences, hypothesis 1 is rejected.

3.2 t-Tests of dependent variables between U.S. and Korea

As shown in Table 2, Korea focused more on the two dependent variables, software-supported activities and IS-integrating activities, than did U.S. Moreover, the differences are quite significant especially in IS-integrating activities at 90% confidence level ($p<0.01$). This result leads us to estimate that Korean manufacturers have put more emphases on computer-related activities than have their U.S. counterparts.

As shown in Table 2, all of 6 sub-variables that are tested for hypothesis 2 showed statistical difference at 90% confidence level between U.S. and Korean manufacturing companies. Accordingly, Hypothesis 2 is fully supported by such variables as price, flexibility, quality, and service. Most importantly, Korean manufacturing companies put more emphasis on these two

Table 2. t-Test of dependent variables between USA and Korea

Variables	USA	Korea	Mean Difference	Sig.
Software-supported activities				
Computer-aided manufacturing	4.0485	4.4054	-0.3569	*
CAD/or computer-aided engineering	4.3866	4.7264	-0.3398	*
Computer integrated manufacturing	3.7742	3.9891	-0.2149	***
IS-integraing activities				
Integrating IS within manufacturing	3.9492	4.6589	-0.7097	***
Integrating IS across functions within the business unit	3.7155	4.5954	-0.8799	***
Integrating IS with suppliers and distributors	3.4592	4.1818	-0.7226	***

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 3. Factor Analysis of competitive priority in USA

Factor	Variable	Factor loading		Eigen Value		Percent of Variance		Chronbach α	
		U.S.	Korea	U.S.	Korea	U.S.	Korea	U.S.	Korea
Price	Ability to profit in price competitive market	N/A		N/A		N/A		N/A	
Flexibility	Ability to make rapid design changes	0.657	0.591	2.093	2.458	41.864	49.164	0.6481	0.7365
	Ability to introduce new products quickly	0.633	0.692						
	Ability to make rapid volume changes	0.675	0.746						
	Ability to make rapid product mix changes	0.740	0.718						
	Ability to offer a broad product line	0.508	0.748						
Quality	Ability to offer consistent quality with low defects	0.766	0.571	2.065	1.957	51.624	48.921	0.6335	0.6422
	Ability to provide high-performance products	0.576	0.779						
	Ability to provide reliable products	0.768	0.707						
	Ability to provide durable products	0.8							

computer related activities than U.S. manufacturing companies does. Further, we might assume that Korea put more money in IT (information technologies) than U.S. do.

3.3 Factor analysis of competitive priority in U.S. and Korea

In order to test whether the sub-variables we selected are good representatives of each competitive priority, factor analysis is applied to each of the four following competitive priorities: Flexibility, Quality, Delivery, and Service (see Table 2). Factor analysis is commonly used to reduce a set of variables into underlying factors that are generally linear combinations of the original variables. Because the price has only one sub-variable, ability to profit in price competitive markets, it is defined as one factor.

In light of statistical measures such as eigen value, percent of variance, and Cronbach α, all sub-variables are good representatives of each competitive priority, and the four priorities are considered as one factor. For example, flexibility consists of five sub-variables: ability to make rapid design changes, ability to introduce new products quickly, ability to make rapid volume changes, ability to make rapid product mix changes, and ability to offer a broad product line. The factor analysis about U.S. shows eigen-value of 2.093 that is bigger than 1.0, and percent of variance explained of 41.864%. Also the five sub-variables have factor loading values of more than 0.500, and a Cronbach α value of more than 0.6. So, the five sub-variables are considered as reasonable representatives of flexibility, and are grouped as one factor.

3.4 Factor analysis of Programs/Activities in USA and Korea

Among 36 different programs/activities, we grouped some programs/activities together according to its inner resemblance, and constructed two groups. To test whether the sub-variables we selected are good representatives of each group, factor analysis is applied to each of the two following groups: software-supported activities and IS-integrating activities (see table 3).

The sub-variables we selected are good representatives of each group, and the two groups, Software-supported activities and IS-integrating activities, are considered as one factor. For example, software-supported activities consist of three sub-variables: Computer-aided manufacturing, Computer-aided design and/or computer-aided engineering, and Computer integrated manufacturing. The factor analysis about Korea shows eigen-value of 1.914, and percent of variance explained of 63.810%. Also the three sub-variables have factor loading values of more than 0.500, and a Cronbach α value of more than 0.6. So, the three sub-variables are considered as

Table 3. Factor analysis of Program/Activities in USA and Korea

Factor	Variables	Factor loading		Eigen Value		Per. of Variance		Chronbach α	
		U.S.	Korea	U.S.	Korea	U.S.	Korea	U.S.	Korea
Software-Supported Activities	Computer-aided manufacturing	0.830	0.798	2.150	1.914	71.669	63.810	0.802	0.7115
	Computer-aided design	0.846	0.808						
	Computer integrated manufacturing	0.864	0.791						
IS-Integrating Activities	Integrating IS within manufacturing	0.901	0.888	2.181	2.151	72.708	71.687	0.808	0.7901
	Integrating IS across functions within the business unit	0.877	0.893						
	Integrating IS with suppliers and distributors	0.774	0.751						

reasonable representatives of Software-supported activities, and are grouped as one factor.

3.5 Regression analysis between strategy and activities in U.S. and Korea

For hypothesis 2, multivariate regression is conducted to find the relationship between competitive priorities and programs/activities in the two countries' manufacturing companies. Regression analysis is first conducted for USA companies. The five competitive priorities composed of different sub-variables are treated as independent variables, and the two groups composed of different programs/activities are treated as dependent variables (see Figure 1).

At 95% confidence level, the regression for the Software-supported activities in U.S. shows that this dependent variable is positively related with two independent variables: price (Beta=0.218) and quality (Beta=0.419). Similarly, the regression for IS-integrating activities shows that this dependent variable is related with three independent variables: flexibility, delivery, and service. Here, flexibility (Beta=0.407) and service (Beta=0.365) are all positively related with IS-integrating activities, while delivery (Beta=-0.378) is negatively related. In sum, the four independent variables except delivery are positively related with a dependent variable, either software-supported activities or IS-integrating activities.

Figure 1. The linkages between Manufacturing Strategy and Programs/Activities in USA

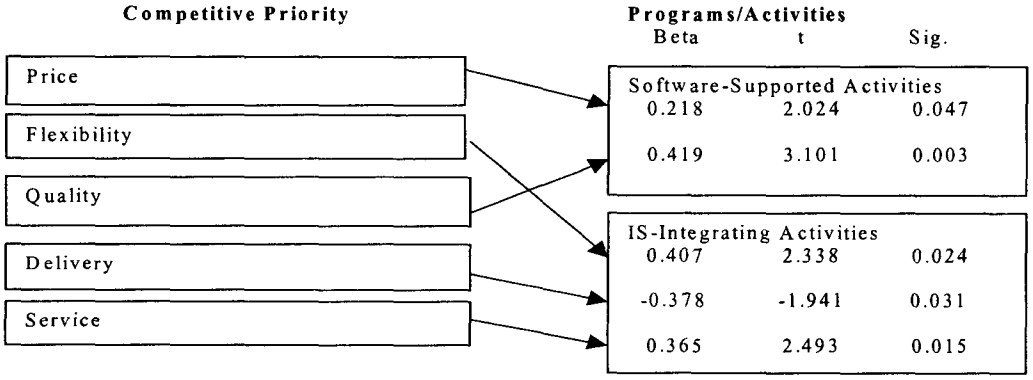
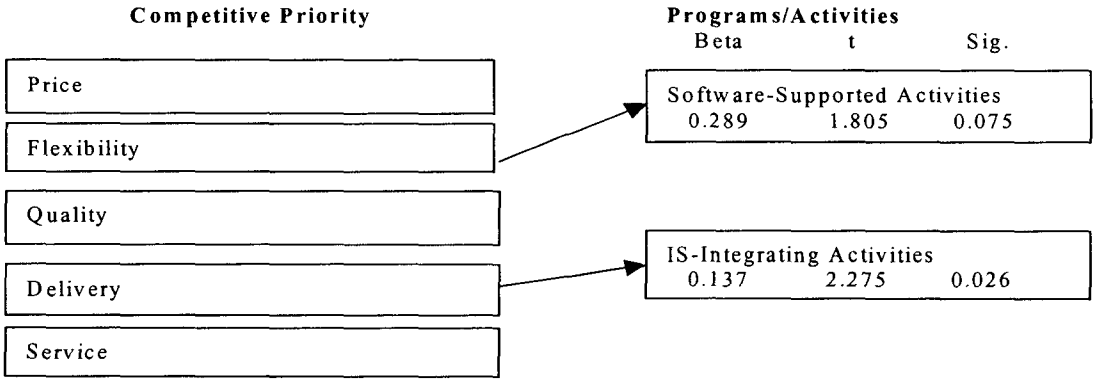


Figure 2. The linkages between Manufacturing Strategy and Programs/Activities in Korea



In U.S., as the importance of price and quality is increased, the payoff from Software-supported activities is increased. As

the importance of flexibility and service is increased, the payoff from IS-integrating activities is increased. However, when the importance of delivery is increased, the payoff from IS-integrating activities is decreased.

In Korea, as shown in Figure 2, the regression for software-supported activities in Korea shows that this dependent variable is positively related with only one independent variable, flexibility, at 90% confidence level. At 95% confidence level, the regression for IS-integrating shows that this dependent variable is positively related with delivery. When the importance of flexibility is increased, the payoff from Software-supported activities is increased. When the importance of delivery is increased, the payoff from IS integrating activities is also increased.

Comparing Figure 1 with Figure 2, we can reach to a conclusion that there is a significant difference between U.S. and Korean manufacturing companies in linking competitive priorities with programs/activities. In other words, hypothesis 2 is supported. While U.S. manufacturers seem to have a good strategic focus by establishing links between competitive priorities and IT, Korean manufacturers do not. In other words, Koreans manufacturers do not seem to have IT action plans that would achieve their strategic purposes in competition.

4. Conclusion

U.S. and Korean manufacturing companies showed a significant difference in regard to the importance of sub-variables that are part of the 5 competitive priorities. In general, 15 sub-variables are tested for hypothesis 1, and 9 of them showed statistical difference at 90% confidence level between U.S. and Korean manufacturing companies. Hypothesis 1 is partially or fully supported by price, flexibility, quality and service, and is not supported by delivery.

In U.S., competitive priorities and programs/activities are well correlated. The increase in the importance of price and quality would result in the increase of the payoff from Software-supported activities. The increase in the importance of flexibility and service would result in the increase of the payoff from IS-integrating activities, while the increase in the importance of delivery would result in the decrease of the payoff from IS-integrating activities.

In Korea, the increase in the importance of flexibility would enhance the payoff from Software-supported activities. Also, the increase in the importance of delivery would enhance the payoff from IS integrating activities.

The study finding shows that (1) there is a significant difference in the importance of competitive priorities between US manufacturing companies and Korean manufacturing companies, and (2) the relationship between competitive priorities and programs/activities in US manufacturing companies is different from the relationship in Korean manufacturing companies.

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