DIFFERENCES IN STRATEGIC MANUFACTURING PRIORITIES AMONG CONTINENTS: AN EMPIRICAL STUDY

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Abstract

The empirical study presented in this paper is a foregoing international study in manufacturing strategy practices. The focus of our study is the examination of competitive priorities, strategic directions and concerns of manufacturers worldwide. Differences exist among continents in the way they implement manufacturing strategies, and these differences have been cited as consequences of cultural differences. Data on the levels of adoption and relative payoff of strategic manufacturing-related activities, strategy integration and company performance priorities were analyzed to test for differences. The results show strong contrasts among continents and are consistent with a difference in performance priorities among the regions.

Keywords

Manufacturing Strategies, Strategic Priorities, Empirical Studies, North America, South America, Europe, Australia, and Asia.

Introduction

There has been a growing interest of manufacturing strategy as a competitive factor for manufacturers worldwide. According to Avella et al. (1), the emphasis on certain manufacturing competitive priorities (or capabilities) and decisions or practices (on the key decision areas) and their internal coherence can be the base for achieving sustainable or lasting advantages over competitors, thus originating superior business performance. The importance of strategic manufacturing priorities is not in doubt, however, we must identify differences in priority assignations so that we can understand the best manufacturing strategy practices. We present differences among five different regions worldwide with a total sample size of 700 manufacturing companies from 23 different countries. A decade ago, manufacturing strategy research had been criticized for the lack of progress in such aspects as theory building, empirical studies and integration with other previous research, according to Leong et al. (2). In the present, there has been an increase in the development of new theories and the design of empirical studies in the area. However, the uniqueness of the present empirical study is that we could gather a large sample size in many countries around the world and therefore, we can reach to conclusions that can be statistically significant comparing results among continents. Our contribution to the manufacturing strategy research from this study is to identify the strategic manufacturing priorities among manufacturers worldwide, and to identify the degree of consistency between priorities and manufacturing action plans.

Data Collection

a) Survey instrument

A list of manufacturing strategy priorities and actions was compiled based on the existent literature. Once compiled, we refined the survey through a series of reviews by external judges. Operations and strategic management faculty were used as expert judges for content validation to determine how well the chosen items represented the defined constructs. Executive MBA students and plant managers at different manufacturing sites in the targeted industries were interviewed while they reviewed the questionnaire to identify any language ambiguities and perceived omissions of other manufacturing strategy priorities and actions used in manufacturing plants but not included in the survey. The discrepancies and comments were used to further refine the instrument.

b) Sample

The present study is based on the second iteration of the International Manufacturing Strategy Survey (IMSS II). The survey was distributed in 23 different countries worldwide in which we gathered a total sample size of 700 manufacturing companies. The sample is distributed as presented in Table 1.

(See table 1).

The SIC code, which identifies groups of common manufacturing processes and technologies, was used to identify the organizations. The actual SIC codes were selected from the companies in the 3400 to 3700 range of industries, which represents fabricated metal products, industrial machinery and equipment, electronic and other electric equipment, and transportation equipment.

We determined plant managers as the most appropriate respondents, since they are most familiar with their plant's operating practices and performance outcomes. Of the 5,000 mailed surveys, 700 completed surveys were returned, which corresponds to a 14% response rate.

According to the responses to the demographic question regarding plant size, South America, Australia and Europe present an average of smaller plant sizes (less than 800 employees) compared to North America and Asia (more than 3,000 employees). The average plant size for the whole sample is 1,884 employees. For further analyses, it would be recommended to examine differences between small and big/medium-sized companies. However, it is not within the scope of this paper.

Analysis and Results

We began the measurement analysis by first establishing the convergent validity and discriminant validity of the four key constructs –strategy integration, level of adoption of manufacturing-related activities, relative payoff of manufacturing-related activities and company performance priorities. We then proceeded to assess the instrument's reliability or the ability of its scales to consistently yield the same response. We assessed construct validity or extent to which the items in the scale measured one dominant dimension. Once the scales were determined to be reliable and valid, we started the comparison analysis.

We are comparing the results from the four constructs among five different continents – North America, South America, Europe, Australia and Asia. This type of comparison is performed by using ANOVA. If any differences were identified, we performed another ANOVA for the variables within the significantly different constructs. And finally, we performed t-tests between the pair of continents that showed statistical differences in the corresponding variables of the constructs. This type of analysis is an approach from general to specific, which help us in exploring to the deepest level (items) what differences exist among continents.

a) Convergent and discriminant validity

A confirmatory factor analysis was conducted to address the convergent and discriminant validity of the constructs. We examined the convergent and discriminant validity of the key constructs -strategy integration with 4 indicators, level of adoption of manufacturing-related activities with 39 indicators and company performance priorities with 24 indicators. The construct relative payoff of manufacturing-related activities is directly affected by the analysis performed in level of adoption of manufacturing-related

activities, and therefore, the final indicators of the latter, are accepted to be the final indicators for the first one.

The criteria for dropping indicators from the analysis include eliminating those indicators that contained communalities lower than 0.5 and factor loadings less than 0.6. In case the communalities were higher than 0.5, then we followed the criteria for the statistical significance of factor loadings shown in Hair et al. (1998). Having a valid sample size greater than 350 in all tested items, we could consider statistically significant factor loadings higher than 0.30. However, most factor loadings presented values higher than 0.5.

From this first screening of the data, we dropped some indicators from further analysis. The corresponding deleted indicators for the different constructs are: 2 indicators from level of adoption of manufacturing-related activities and 2 indicators from company performance priorities. All those items that did not fit the criteria were subsequently dropped from further analysis.

b) Reliability and validity of scales

Then, our focus was turned to examine more closely the reliability and validity of the scales. We accepted the results of the confirmatory analysis and left out the 4 indicators that lacked convergent validity. We examined the internal consistency of all constructs first by a factor analysis, and second, by reliability testing of Cronbach's alpha. Our analysis hereafter was modeled after Flynn et al. (1994) who used largely exploratory analysis to examine the scales. Bagozzi et al. (1991) suggested that confirmatory analysis and exploratory analysis could supplement each other.

Each of the scales associated with the constructs was analyzed separately. All the indicators included within each of the individual constructs were thought to load together as one factor, so no varimax rotation was needed during the factor analysis. From the factor analysis, 2 indicators from company performance priorities and 1 indicator from level of adoption of manufacturing-related activities were dropped from further analysis. Table 2 identifies the number of respondents, alpha score, and the number of items that loaded onto each scale. An alpha of 0.5 may be acceptable (Hair et al., 1995). According to this criterion, all the items that reached this point are accepted based on the previous analyses.

c) Research Questions

The research questions that will guide us through this paper are:

- Are there differences among continents in the level of adoption of strategic manufacturing-related activities (LAMRA)?
- Are there differences among continents in the relative payoff of strategic manufacturing-related activities (REPAMRA)?
- Are there differences among continents in the strategy integration level (SI)?

- Are there differences among continents in the company performance priorities (COPER)?

In case we find differences among continents in any of the four constructs, we will perform ANOVA for the different variables in those constructs and finally, t-tests on the item level until we find real causes of the differences. The results from this study will show us the effect of cultural issues in the manufacturing strategy practices and priorities. And also, will help us determining in future analyses, best practices for manufacturing strategy in a global perspective.

d) Results

Strategy Integration (SI)

We defined strategy integration (SI) with four items where respondents were asked to indicate on a 5-point Likert scale: a) the extent to which the organization translates corporate/business goals into a manufacturing strategy, b) the extent to which the organization translates marketing goals into a manufacturing strategy, c) the extent to which manufacturing influence the development of corporate/business strategies and goals and d) the extent to which manufacturing influence the development of marketing strategies and goals.

From our findings, we can see a strong pattern that confirms that Asia presents higher scores than the rest of the continents in all items for SI. We also see a significantly higher score in all items in North America when compared to Europe. Finally, Europe is significantly lower than Australia in the extent to which manufacturing influence both in the development of corporate/business strategies and goals and in the development of marketing strategies and goals. These country specific differences in SI that lead to higher scores for Asia, can be due to the enormous pressure from Asia to respond to today's volatile and highly diversified market demands that are creating more and more competitive environments where only agile, flexible, cost efficient and high quality producers can survive. Those who define their strategies in a unified way, from marketing to manufacturing to corporate goals and strategies, are the companies seeking for world-class manufacturing practices. We can see a window for opportunity in European companies, since they scored less in this construct. European companies should focus more in integrating their strategy definition and in consolidating their goal definitions and translating them into corporate strategies.

Level of Adoption of Manufacturing-Related Activities (LAMRA)

We gathered data from 37 items that were grouped into nine different factors concerning manufacturing-related activities. We asked the respondents to answer in a 5-point Liker scale the degree of use of manufacturing-related activities. The factors that came out from the factor analysis are: process automation, production organization, management

practices, lean manufacturing, IT applications, green programs, new product development, process control and IT infrastructure. The construct in general, presented significantly higher results for Asia and North America than for South America, Australia and Europe. We used Turkey tests to find out that no significant differences are present between the following pairs of continents: North America and Asia, South America and Europe, South America and Australia and finally, Australia and Europe. For simplicity, we formed 2 groups for further analyses in this construct: group 1 (North America and Asia) and group 2 (South America, Australia and Europe). Using these groups, we performed t-tests to find out in which variables and items are significantly different. The results are presented in the following paragraphs.

Process automation is related to those activities such as single minute exchange of dies (SMED), robotics, automated tool changes, automated parts loading/unloading, automated storage/retrieval systems (AS/RS) and automated guided vehicles (AGV's). In these activities, the respondents showed that group 1 is implementing them more frequently than group 2. However, the mean values are not high (2.52 to 3.23), therefore, we could conclude that the degree of use of process automation activities is relatively low in all continents, even more for the three continents that correspond to group 2.

Production organization is a variable that contains items such as materials requirement planning (MRP), manufacturing resource planning (MRP II), pull scheduling (i.e. Kanban), design for assembly/manufacturability (DFA/DFM), value analyses/redesign of products, reorganize to "plant within a plant" and business process reengineering (BPR). As expected, these activities have been very popular in the development of the competitive manufacturers in group 1; most of them are highly implemented in these continents when compared to group 2.

Management practices are represented by the following activities: benchmarking, simultaneous/concurrent engineering, defining a manufacturing strategy, implementing team approach (work groups) and total preventive maintenance (TPM). The t-tests showed that group 1 is significantly higher than group 2 in implementing the mentioned activities, except for defining a manufacturing strategy in which the difference is not significant.

Lean Manufacturing contains activities such as total quality management (TQM), statistical process control (SPC), zero defects programs, continuous improvement (Kaizen), just-in-time manufacturing/lean production and just-in-time (frequent) deliveries to customers. Most of these activities have their origins in Asia and North America and it is well known that these two continents (group 1) are the pioneers in these activities, both in philosophy and implementation. Therefore, the results are expected, since group 1 present significantly higher levels of adoption of lean manufacturing activities than group 2.

IT applications are defined by the use of computer-aided manufacturing (CAM), FMC, FAS and computer-integrated manufacturing (CIM). The implementation of these activities is very expensive and it is expected that their degree of use is conservative

(means range from 1.73 to 2.68). In both activities, group 1 is higher than group 2, since it the economic power of Asia and North America is higher than the rest.

Green programs are activities that deal with the environment care and conservation. These activities include energy conservation programs, environmental protection programs and health and safety programs. All of these activities are significantly higher in group 1 than in group 2. And also, within this construct, the item that is implemented the most is health and safety programs, followed by environmental protection programs.

New product development activities are briefly analyzed by quality function deployment and quality policy deployment. Again, we see a superior implementation in group 1. There are so much improvement opportunities for South America, Europe and Australia in all of these activities. Interesting future research can be to perform individual comparisons between pairs of continents so that the total variance is not affected.

Process control is the only construct in which there are no significant differences between the two groups of continents. This variable includes activities such as computer-aided engineering (CAE) and computer-aided design (CAD).

IT infrastructure is defined with activities as local area networks (LAN), wide area networks (WAN) and shared databases. Information technology is growing fast and it is expected that those continents with higher economic resources are implementing them the most. The results show that group 1 is the pair of continents that implement more these technologies.

Relative Payoff of Manufacturing-Related Activities (REPAMRA)

The same 49 items for the level of adoption of manufacturing-related activities grouped in 9 variables are used for relative payoff of manufacturing-related activities (REPAMRA). However, as we will see, the results differ from level of adoption to relative payoff. This can be explained by a non-linear relationship between these two variables, which is not in the scope of this paper. However, it can be considered analysis for further research.

There are no significant differences between North America and Asia, South America and Australia and South America and Europe. We can analyze it again using the previous code, such as group 1 (North America and Asia) and group 2 (South America, Australia and Europe). However, we will specify the internal differences that exist in group 2 between Australia and Europe. In general, group 1 present higher scores than group 2 in relative payoff of manufacturing-related activities. The results from LAMRA support the previous findings. It is expected that those continents that have higher levels of adoption of the manufacturing-related activities, are those continents that will collect higher benefits from them (higher payoffs). Therefore, Asia and North America have higher LAMRA and also have higher REPAMRA. Again, the relationship between these two constructs is subject for further research. In the case of Australia and Europe that don't

have any evidence of significant differences in LAMRA, present significantly higher scores for Europe in REPAMRA. This means that the users of manufacturing-related activities in Australia haven't received as much feedback and success as those in Europe.

Company Performance Priorities (COPER)

This construct is defined by 17 items related to company performance priorities grouped in 5 variables. By this construct, we wanted to measure how important it is to measure some performance indexes in the organization. An explanation of the 9 variables is given below.

Lean manufacturing is a variable composed by average unit manufacturing costs, materials and overhead total costs, manufacturing lead time, delivery lead time, supplier quality and worker/direct labor productivity. Green performance is formed by items that concern with environment protection such as energy consumption, product recyclability and waste/by-product recyclability. New product development contains aspects such as product variety, speed of product development and number of new products developed. Company-wide performance refers to return on investment, equipment changeover time and inventory turnover (sales/inventory). Finally, the last variable under company performance priorities is customer satisfaction measured by the customer service (after sales and/or technical support) and customer satisfaction. All of these measures were obtained using a 5-point Likert scale.

There are no significant differences found in those traditional performance measures, however, we found enough evidence to reject the hypotheses of equal means in two non-traditional performance measures (green performance and new product development).

No significant differences were found in green performance measures between Asia and South America. However, we found that these two continents are above the rest in assigning priorities to energy consumption, product recyclability and waste/by-product recyclability. Europe is found significantly higher than Australia in all three items for green performance.

Similar results are found for new product development. Asia presents the highest scores for the variable new product development. Australia and North America present significant differences only in speed of product development, where North America is faster than Australia in this process. South America and Europe present significantly higher scores than Australia in product variety and speed of product development, however, there are no significant differences in number of new products developed.

Conclusions

This study set out to explore differences in strategic manufacturing priorities among North America, South America, Asia, Australia and Europe. The findings show that both North America and Asia lead in their focus on manufacturing strategy. Those continents (predominantly Asia) show higher SI, LAMRA, REPAMRA and COPER constructs. It is well known that North America and Asia have been leaders in developing quality and manufacturing philosophies and procedures to improve their performance. However, we can also present a hint for future research in testing the same differences but counting for the factor "company size", since both North America and Asia have a larger company size than the rest of the continents.

We can conclude from the results of this empirical study, that Europe, Australia and South America have a wide range of opportunities for improvement in assigning priorities to their manufacturing strategy. Europe, followed by Australia, should emphasize in assigning higher priorities to SI, since integration in strategy definition and implementation is crucial for achieving goals and objectives. We found out that Asia and North America are implementing more manufacturing-related activities, since they show higher LAMRA, except in Process Control in which all continents are using this kind of technology into their manufacturing processes. As expected, the continents that use higher LAMRA, present higher REPAMRA (relative payoff of manufacturing-related activities). The only exception is Europe that presents significantly lower results than Australia even though these continents don't present significant differences in LAMRA. And finally, most continents assign similar priorities to company performance (COPER), except for two constructs that are relatively new, green performance (related to environment protection and safety) and new product development (related to number of products developed and speed of product development). In these two constructs, Asia shows higher priorities assigned to them, and therefore, we can perceive the interest in Asian companies for preserving our planet, even though it costs a little more money for their budgets.

In general, we could conclude that Asia and North America are an example to follow and we could perceive which are their priorities in manufacturing strategy in order to provide improvement opportunities for those continents that don't show the same interest in important constructs such as strategy integration, level of adoption and relative payoff of manufacturing related activities and non-traditional company performance priorities. Future studies must support these findings and must provide further research questions so that we can broaden our knowledge in best practices in manufacturing strategy.

Table 1. Sample Distribution by Continent.

Country	*Sample Size*	*Continent*	*Continent Sample Size*
China	30	Asia	123
South Korea	50		
Japan	29		
Hong Kong	14		
Denmark	27	Europe	304
Italy	71		
Netherland	29		
Norway	13		
Sweden	27		
Spain	33		
UK	24		
Finland	14		
Hungary	38		
Germany	28		
USA	41	North America	110
Mexico	29		
Canada	40		
New Zealand	32	Australia	87
Australia	55		
Argentina	31	South America	76
Brazil	27		
Peru	8		
Chile	10		

Table 2. Overall Internal Consistency of Scales.

Scale Title	Number of Respondents	Cronbach's alpha	Number of items in scale	Number of items deleted
Strategy Integration	684	0.7602	4	0
Level of Adoption of Manufacturing-Related Activities				
Process Automation	503	0.8164	6	0
Production Organization	479	0.8011	7	0
Management Practices	502	0.7733	5	0
Lean Manufacturing	548	0.8093	6	0
IT Applications	532	0.8124	2	1
Green Programs	589	0.7946	3	0
New Product Development	579	0.7704	2	0
Process Control	562	0.6968	2	1
IT Infrastructure	538	0.7706	3	0
Relative Payoff of Manufacturing-Related Activities				
Process Automation	371	0.8283	6	0
Production Organization	356	0.8031	7	0
Management Practices	404	0.7758	5	0
Lean Manufacturing	429	0.8271	6	0
IT Applications	440	0.8096	2	0
Green Programs	524	0.7275	3	0
New Product Development	494	0.7749	2	0
Process Control	493	0.7647	2	0
IT Infrastructure	443	0.7179	3	0
Company Performance Priorities				
Lean Manufacturing	512	0.7421	6	0
Green Performance	466	0.7079	3	1
New Product Development	479	0.7560	3	1
Company Wide Performance	501	0.5871	3	3
Customer Satisfaction	560	0.6100	2	0
Timeliness	606	1.0000	1	1

Table 3. ANOVA results for construct differences among continents.

Construct	*Continent*	*N*	*Mean*	*Std. Deviation*	*North America*	*South America*	*Asia*	*Australia*	*Europe*
Strategy Integration *	North America	103	3.44	0.786	-	0.924	0.000*	1.000	0.008*
	South America	73	3.35	0.903	0.924	-	0.000*	0.933	0.286
	Asia	122	3.93	0.744	0.000*	0.000*	-	0.000*	0.000*
	Australia	86	3.44	0.770	1.000	0.933	0.000*	-	0.016*
	Europe	300	3.15	0.720	0.008*	0.286	0.000*	0.016*	-
	Total	684	3.39	0.809	-	-	-	-	-
Level of Adoption of Manufacturing-Related Activities *	North America	101	3.00	0.816	-	0.001*	0.189	0.001*	0.001*
	South America	71	2.52	0.822	0.001*	-	0.000*	0.999	0.769
	Asia	121	3.23	0.759	0.189	0.000*	-	0.000*	0.000*
	Australia	85	2.55	0.835	0.001*	0.999	0.000*	-	0.883
	Europe	299	2.64	0.752	0.001*	0.769	0.000*	0.883	-
	Total	677	2.77	0.820	-	-	-	-	-
Relative Payoff of Manufacturing-Related Activities *	North America	99	3.25	0.838	-	0.000*	0.930	0.000*	0.016*
	South America	68	2.67	0.889	0.000*	-	0.000*	0.974	0.050
	Asia	120	3.33	0.760	0.930	0.000*	-	0.000*	0.000*
	Australia	83	2.60	0.765	0.000*	0.974	0.000*	-	0.002*
	Europe	290	2.96	0.751	0.016*	0.050	0.000*	0.002*	-
	Total	660	3.00	0.819	-	-	-	-	-
Company Performance Priorities *	North America	104	3.78	0.633	-	0.933	0.023*	0.006*	1.000
	South America	64	3.85	0.558	0.933	-	0.382	0.002*	0.860
	Asia	119	4.01	0.613	0.023*	0.382	-	0.000*	0.002*
	Australia	81	3.49	0.491	0.006*	0.002*	0.000*	-	0.001*
	Europe	285	3.78	0.550	1.000	0.860	0.002*	0.001*	-
	Total	653	3.79	0.586	-	-	-	-	-

* Significant at 0.05.

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