What distinguishes High Performance Manufacturing from the others - An Empirical Reassessment

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Abstract

This manuscript discusses the contemporary performance boundaries of High Performance Manufacturing comparing to the literature established on 1980's and 1990's. This global survey-based research explores current drivers of HPM. Counter-intuitively we found a minor influence of cost and location, even though we identify clear different strategies adopted at country level.

Keywords: High Performance Manufacturing, cluster analysis

INTRODUCTION

The performance frontier is moving forward faster than manufactures perceived due to the increasing dynamics of environment (Rosenzweig & Easton, 2010). New technologies and big data availability open unpredictable opportunities faster than manufacturers can identify and learn how to implement them. The velocity, volume, variety and sources of data compose a brand new landscape for decision making (McAfee & Brynjolfsson, 2012).

Moreover, recently researchers and practitioners awaken that the idea of over simplifying the process was improperly deployed and caused some hard-to-recover outcomes. Pisano & Shih (2009) shed light to this gap when manufacturers decided to outsource development and manufacturing work to specialists abroad in response of the high demand of focus on core competences and reduce low-value-added activities. Initially companies addressed relative simple projects to India, China, Brazil, East-Europe, and North African countries. But, as time goes by, immediate outcomes were attractive, suppliers were able to assume more complex challenges. Once organizations were still under competitive pressure, manufacturers decided to go further on

outsourcing process. By doing so, one did not realize that some competitive competences were hidden inside the "package outsourced". Important knowledge was transferred outside organizations and manufactures were not aware of its consequences. Short term gain, long term pain: in spite of decreasing competitiveness, they increased it at long range. Moreover, operational competences seems to be crucial for maintaining a firm´s competitive position.

In parallel, organizations from emerging economies grow. Additionally these organizations developed some peculiar competences due to their historical ability to manage uncertain and crisis environment. Guillén & Garcia-Canal (2009) argue that production subsidiaries from emerging MNE have been forced to deal with political, foreignness and competitive constrains. Consequently, they developed specific competences to handle uncertain in a better way comparing to American or European MNEs.

Based on this perspective, the main purpose of this manuscript is to discuss the contemporary performance boundaries of High Performance Manufacturing (HPM). In doing so, this study aims to: (i) categorize manufacturing plants by its competitive performance and (ii) identify process that distinguish HPM from the others.

In order to support this investigation, the present study adopts survey methodology. Survey method has been very successful for HPM studies by covering a wide range of manufacturing plants and different contexts and it seems to be a good approach either for the present study. Previous studies offer different perspectives of distinguishing manufacturing plants. For instance, Flynn et al (1999) stratified the sample on three plant types: world class reputation, traditional and Japanese-owned. Others focus on trade-offs paradigm to figure out manufacturing's taxonomies. For example, Safizadeh et al, (2000) concluded that there are trade-offs emergence when considering Cost/quality in job shops, cost/quality and cost/delivery in batch shops and cost/quality and quality/customization in continuous flows plants. However, they also noticed that some plants can have then both competences without being traded-off. Moreover, they advanced Miller and Roth (1994) research focusing on manufacturing plants instead of strategic business units and proposed 3 manufacturing clusters: *caretakers* (focus on low price), *innovators* (high average on one of the competitive priorities) and *marketers* (focus on product performance and reliability).

The present study intends to advance the previous efforts by distinguishing companies regarding their competitive performance, specifically looking for possible HPM antecedents. The database is framed by a sample of 338 manufacturing plants from 11 countries. Multivariate analysis techniques were used to test the hypothesis.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Taxonomies of manufacturing plants

World-Class Manufacturing[1] (WCM) was a term established in early 1980's by Hayes & Wheelwright (1984), followed by Schonberger (1986). It refers to outstanding performance in the

[1] Both terminology World-Class Manufacturing and High Performance Manufacturing are considered synonymous for the context of the present study.

industry the manufacturing belongs to. This concept was originally based on Asian experimentation of higher quality levels and the simplification of process. Schonberger (1986) states on the very first page of his book that WCM "*captures the breadth and essence of the fundamental changes taking place in industrial enterprises*". He emphasized the manufacturing were looking for robustness capabilities in order to be stronger, faster and to reach higher standards. According to these preliminary studies WCM was established based on 6 dimensions: (i) workforce skills and capabilities; (ii) workforce participation; (iii) management technical competence; (iv) quality; (v) unique resources and (vi) improvement practices.

Organizations are continuously challenged to translate competitive priorities to operational capabilities. However, competitive priorities are critical, but not sufficient in the process of implementing a successful operations strategy (Boyer & Lewis, 2002). Voss (1995) consolidated three paradigms behind operations strategy: (i) Competing Through Manufacturing – stage 4 of Hayes and Wheelwright - exploitation of competitive capabilities. However according to the author, no matter how good the focus and commitment to reach an specific goal, it will fail if there is an inappropriate process or infrastructure; (ii) Strategic choices in manufacturing - the correct choices will lead to superior performance. The main limitation behind this approach, is that no matter what choices it has taken, it is necessary to have good practices. Further, (iii) Best practices - best practice will lead to superior performance, increasing its competitiveness. If the strategy fails to catch industry, best practice can remove the competing edge from manufacturing. Voss concluded that an HPM needs to focus on the loop of all three paradigms instead of each one separately.

These paradigms seem to be aligned to the concept of performance frontier, which is defined by the "*maximum performance that can be achieved by a manufacturing unit given a set of operations choices*" (Schmenner & Swink, 1998, p. 108). Operations choices, according to the authors, can be addressed by organizations considering design and investment (asset frontier) or plant operations (operating frontier). A fully operational plant should face trade-offs among operational competitive capabilities. Considering that technology is available for everybody, competing manufacturing units using similar technologies should have similar performance frontiers. If all plants are close to both performance boundaries, it is possible that organizations face trade-offs. However, in a sector that all plants are far from asset frontier, if one plant can simultaneously reach lower costs and higher above-average performance on quality, flexibility, and delivery. It is possible due to the lack of opportunities at operational level to be explored through continuous improvements.

Robustness on capability building means little performance penalties as time goes by. Every organization should fall in a specific capability due a short period of time, but in a long range HPM's have clear definition of the capabilities to forefront most of the time. (Hayes & Pisano, 1994). Focus on pure continuous improvement exercises instead of observing what kind of capability building is demanded for the future.

Based on it, this manuscript aims to reassess if the original dimensions of WCM are still contemporary after two decades. More precisely, this study will: (i) verify if there is an HPM indeed and, (ii) evaluate what dimensions distinguish HPM from the others currently. For doing so, the objects of the study are three mature industries that are closed to performance frontier. The assumption is that HPM would be the one that reach superior results through both frontiers.

What does distinguish an HPM from the others ?

HPM original concept was established based on 6 dimensions: (i) workforce skills and capabilities; (ii) workforce participation; (iii) management technical competence; (iv) quality; (v) unique resources and (vi) improvement practices (Hayes & Wheelwright, 1984; Schonberger, 1986). Maskell (1991) distinguish WCM from the others pointing out some key characteristics:

a) New approach to product quality **-** For Maskell (1991) the primary emphasis placed on problem solving instead of merely problem detection is the main difference between WCM and traditional manufacturing approaches to quality. Maskell argues that WCM is anger to achieve Zero Defect due to the systematical focus on root causes of problems. The idea of pure problem solving is also criticized by (Hayes & Pisano, 1994).
b) Faster production techniques - new approach for quality echoed in other areas of organization once products must be designed for quality (e.g. Process and Product Engineering), products must be produced with more complex or expensive raw materials/components (e.g. impacts on Sourcing strategy) or infrastructure (e.g. changes on shop floor layout, building new areas, equipment's refurbish or retrofit)
c) Flexible approach to customer requirements **-** refers to two kind of flexibilities: production flexibility (short lead times, variation of mix from day to day, multi task employees) and design flexibility (ability to introduce new products and modifications to current products).

Maskell's elements are closed linked to the concept of operational competences. Increasingly researchers have been investigating operational competences because the manner they evolve provide a firm with competitive advantage (Größler & Grübner, 2006; Peng, Schroeder, & Shah, 2008; Swink & Hegarty, 1998; Wu, Melnyk, & Flynn, 2010; Wu, Melnyk, & Swink, 2012). Thus, the development of operational competences should be one of the most important aims pursued by operations strategy (Wu et al., 2012).

Operational competences are specific skills, processes, and routines developed within operations strategy for the best use of resources in order to achieve its objectives (Wu et al., 2010, 2012). It involves both explicit elements (resources and practices) and implicit elements (know-how, skills, leadership etc.). Explicit elements are easily transferable across companies because resources can be bought in factory markets and practices can be learned through benchmarking (Wu et al., 2010). In this sense, competitive advantage arises when explicit and implicit elements are combined in building operational competences (Wu et al., 2010). It is very difficult to imitate, transfer, or substitute them, because they are developed within the firm, are time and path dependent (Größler & Grübner, 2006; Peng et al., 2008; Wu et al., 2010). In the literature there are four basic competences that a plant should pursue, they are: quality, delivery, flexibility and cost (Boyer & Lewis, 2002; Größler & Grübner, 2006; Peng et al., 2008; Ward, Peter T.; McCreery, Jhon K.; Ritzman, Larry P.; Sharma, 1998; Wheelwright, 1984). Some studies recognize that some plants will face trade-offs which means that the choice of developing a competence, for instance producing with high quality is concurrent with producing with low cost (Wheelwright, 1984). Therefore, in order to compete in the market a plant must chose only one competence, because it is not possible to perform well in more than one dimension. On the other hand, some scholars have highlighted that a company can not only perform in more than one competence simultaneously, but this is also critical to gain competitive advantage (Meyer, 1990; Noble, 1995; Schroeder, Shah, & Xiaosong Peng, 2011). In doing so, a company that focuses on more than one competence outperforms those ones that do only one.

A possible explanation is the fact that competences are complimentary which means that when they are combined there is a synergistic effect that otherwise would be impossible and it makes competences a source of competitive advantage. The resource based view of the firm theorizes that competitive advantage are created when a firm has resources that are difficult to imitate, non-substitutable, rare, and therefore are valuable (Barney, 1991). In this sense, the synergy between competences makes a company more competitive because its competitors cannot easily identify the sources of competitive advantage due to the complexity of joint competences. Furthermore, a company that is able to provide its customers with high-quality products and also delivery in the right time, for example, is more likely to outperform a company that has only the former competence.

When competences are developed simultaneously a firm can get out the most of its structure and infrastructure. Since competences are composed of skills, process, and routines a company attempts to develop as many competences as possible leverages its intangible and tangible elements because different competences can share same resources and leadership, for example. Therefore, we consider a High Performance Manufacturing plants that score great levels of performance in quality, delivery, flexibility and cost at the same time. From this reflection emerges the following hypothesis:

> *Hypothesis 1: High Performance Manufacturing can be distinguished from traditional manufacturing by superior performance in operational practices*.

The Role of People on HPM

There is a traditional discourse that people involvement is key for organizational success. In continuous improvement studies, for instance, there is a congruence in recognizing that "(…) *without the active involvement of everyone in the organization, and the required resources and support from top management, continuous improvement in any organization cannot be successful.*" (Bhuiyan & Baghel, 2005, p. 769). It is possible to notice two elements in that statement: (i) people self-interest and; (ii) top management superior efforts. Manufacturers can arouse people's interest to achieve superior results by tangible and intangible incentives. (Dur, Non, & Roelfsema, 2010) They emphasize that bonus pay for workers weakens the incentives for his superior to provides attention. In sum, "*with motivated agents there is less need for incentive pay*" (Besley & Ghatak, 2005, p. 630).

Regarding top management efforts, Maskell (1991) argues that to achieve HPM standard each plant must have at least one top manager fully engaged to deploy it. On the other hand, Schonberger (1986) noticed an emerging gap on relying manufacturing outcomes on top management style only. According to him, HPM is not based on top-down management or bottom-up management. It applies a bidirectional management effort. In other words, it seems to have a synchronization between top management strong leadership for high performance and employees willingness to collaborate.

Previous studies about the effects of human resources management influence on operations management focus on selective hiring, use of teams and decentralization, incentives to performance, extensive training, status difference and sharing information (e.g., Corbett & Harrison, 1992; Ahmad & Schroeder, 2003). However these two remaining perspectives (*human*

virtue and *top management direct influence*) were not deeply embraced by OM literature. The following hypothesis is built upon this argument:

> *Hypothesis 2a: High Performance Manufacturing can be distinguished from the others by using tangible incentive to the employees.*
>
> *Hypothesis 2b: High Performance Manufacturing is distinguished from the others by individual superior effort of its employees (humane virtue).*

METHODS

Manufacturing plant is the unit of analysis. The sample is composed by manufacturing plants with more than 100 employees in electronics, metal-mechanics and auto parts industries. Data were collected in USA, Brazil, Germany, Italy, Spain, Finland, Sweden, Austria, Japan, China and Korea, as presented on table 1, and it is balanced between all three industries.

Table 1: Number of plants by country and sector

Country	Electronic		Metal mechanic		Transport	
	n	%	N	%	n	%
Austria	10	47,6%	7	33,3%	4	19,0%
Brazil	5	22,7%	8	36,4%	9	40,9%
China	21	41,2%	16	31,4%	14	27,5%
Finland	14	46,7%	6	20,0%	10	33,3%
Germany	9	22,0%	13	31,7%	19	46,3%
Italy	10	37,0%	10	37,0%	7	25,9%
Japan	10	28,6%	12	34,3%	13	37,1%
Korea	10	32,3%	10	32,3%	11	35,5%
Spain	9	33,3%	8	29,6%	10	37,0%
Sweden	7	29,2%	10	41,7%	7	29,2%
USA	9	31,0%	11	37,9%	9	31,0%
	114	33,7%	111	32,8%	113	33,4%

Survey questionnaires and instructions for administering the research instrument were equally distributed for the global research team. Questionnaires were translated from English to the mother tongues. In order to assure its reliability, questionnaires were careful back translated to English by different researchers. A total of 13 different questionnaires were applied in each plant to compose the database.

DATA ANALYSIS

We analyze data through three different statistical techniques: initially, once it is critical to develop the study upon a robust construct base, we conduct confirmatory (CFA) for set of variables to test the hypothesis of the study.

Further, we adopt cluster analysis for building the manufacturing classification. Cluster analysis allow us to consider multiple variables as source of configuration definition and then

support the creation of a rich description of clusters (Ketchen & Shook, 1996). Finally, we conduct ANOVA tests in order to identify which set of variables are more feasible to distinguish the manufacturing plants one from another.

Cluster Analysis

The cluster solution was created by the average score of competitive performance constructs. Upon the empirical data we aim to build a coherent taxonomy in order to further test hypothesis of the present study.

In doing so, we follow Hair (2009) and we combine hierarchical approach followed by a non-hierarchical method. We consider Ward hierarchical method through Euclidean squared distance as a measure of clusters distance and characterize centroids for building the initial seeds for the non-hierarchical solution. Dendogram shows 4 and 5 clusters solutions. We adopt dendogram 5-clusters solution, which presents a best solution. Through the canonical function it is possible to forecast the belonging to the groups: 86,1% of original cases are correctly classified.

Further, we adopt the non-hierarchical method of kmeans clusters combining all observations in order to allocate them more precisely. For purpose of interpretation and characterization of the groupings we follow Hair (2009) using as reference the centroid of the grouping which is more adequate for this process. All clusters are significant different considering the set of variables (ANOVA).

Table 2: Cluster analysis

	Clusters				
Competences	**1-Runners**	**2-Savers**	**3-Laggards**	**4-HPM**	**5-Customizers**
Cost	2,67	4,33	1,33	4,67	2,67
Delivery	5,00	3,50	3,00	5,00	2,50
Flexibility	3,67	2,33	2,33	5,00	4,33
Quality	3,50	3,50	2,50	5,00	4,00

Based on this construction, we are able to categorize and label each cluster as follows:

Cluster 1 – Runners: It is composed by organizations with focus on delivery, flexibility, and quality . Although the importance of flexibility and quality, such organizations are totally committed to fast deliveries. In doing so, this group faces a trade-off because its focus on delivery is concurrent with its costs.

Cluster 2 – Savers: In opposite of cluster 1, we find cluster 2 which we label "Low costers". This organizations grasp its attention on reducing costs. Both clusters present clearly the "trade-off" paradigm. This cluster is similar to Miller and Roth (1996) "Caretakers" classification because of cost appears to be the most important competitive priority. However, in authors study the manufacturing analyses "*low relative emphasis on the development of competitive capabilities appears to prepare them for the minimum standards for competition*" (p.290). The present cluster demonstrate an incipient attention to other competences even if at lower level for the time being.

Cluster 3 – Laggards: This cluster is composed by organizations which score low levels in all competences. We induct that those organizations are not fast enough on competitive priorities development. This group as pointed by Roth (1996) is characterized by companies which bases their strategies on old management styles backing to Ford and Sloan. In doing so, they are the least competitive in the market.

Cluster 4 – High Performers: This cluster is composed by organizations that achieve superior performance in all four dimensions. Such organizations are believed to generate more competitive advantage than the others by the fact that they provide their customers with more value because they are able to produce with quality, delivery at the right time, introduce flexibility, and with lower costs.

Cluster 5 – Customizers: Cluster 5 is composed by organizations that focus on flexibility and quality. This group, as cluster 1, faces a trade-off since its priority is the consolidation of flexible production system with quality, such organizations should incur in higher costs.

ANOVA

In the next step we aim to identify which set of variables are more feasible to distinguish the manufacturing plants one from another. Upon the five clusters solution proposed by previous cluster analysis, we conducted ANOVA testing. Results are presented in table 3.

Table 3: Anova Analysis

	1-Runners	2-Savers	3-Laggards	4-High Performers	5-Customizers	F Statistics
Factors	n=59 Mean (S.D)	n=50 Mean (S.D)	n=49 Mean (S.D)	n=67 Mean (S.D)	n=67 Mean (S.D)	
Continuous improvement	5.75 (0.58) [3]	5.53 (0.54) [4]	5.34 (0.76) [1,4]	6.02 (0.54) [2,3,5]	5.62 (0.57) [4]	4.12*
Financial Incentives	4.52 (0.86)	4.58 (0.92)	4.14 (1.10)	4.66 (1.19)	4.28 (0.93)	2.62*
Humane virtue	5.68 (0.61)	5.78 (0.54)	5.53 (0.56) [4]	5.92 (0.48) [3]	5.7 (0.50)	10.60*

Notes:

* $p < 0.05$

The numbers in parentheses are sample standard deviations.

The number in brackets indicate the group means from which this group is significantly different at the 0.05 significance level as indicated by the Tukey's pairwise comparison test.

The results show that continuous improvement is a characteristic of the High Performance Manufacturing group. This finding confirms the literature. A superior performance presents antecedent efforts like TQM, quality certification and kaizen approach. All these practices are

able to improve cost, quality and flexibility simultaneously. Therefore the hypothesis 1 was confirmed.

Regarding human resources practices we found contradictory results. Companies with higher performance in all the competitive criteria presented financial incentives as a HR policy. Possibly these policies are connected to continuous improvement processes. Relevant and feasible suggestions may allow the employees to receive part of the gains in many companies that adopt continuous improvement. Therefore hypothesis 2 was confirmed.

Surprisingly we did not find any evidence that human virtue is a specific characteristic of the high performers companies. Even that, the results show that companies in the HPM group have a difference statistically significant when compared to the Laggards group. Thus the hypothesis 3 was not confirmed.

FINAL REMARKS

This manuscript is part of a more complex study and unfortunately, due space limitation we were not able to present our data analysis deeply. Preliminary results suggest the cluster construction seems to represent accordingly the current scenario of manufacturing landscape. Once cluster analysis has a strong influence of researchers appraisal, we assure an underlying theoretical rationale by triangulating data analysis through different statistical methods. This strategy avoids the possibility of imposing groups that non exist.

In spite of "holds more of the same", this study aims to provoke the advance of this discussion for fields unexplored like HRM significance in Operations Management. While our analysis has focused on operational competences it opens some opportunities for future research. This study can motivate practitioners and researchers to dig deeper and evaluate why practitioners speech consider the human (individual) intention as a competitive advantage while there is not significant evidences to prove it? Is that a myth or myopia? Should some manufacturing organizations spend a huge amount of money on it for nothing?

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