Defining World Class Manufacturing: Examination of "America's Best" Plants

Track: Operations Strategy

Abstract: This paper examines the fundamental dimensions underlying best practices in manufacturing plants. The study uses data from a survey of past winners of the "America's Best" competition held each year by *Industry Week*. We explore plant profiles as well as relationships among eight major practices identified. The results of the analysis suggest that plants progress through a series of capability developments to achieve higher and broader levels of performance.

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Introduction

The study of world-class manufacturing (WCM) has evolved, reflecting an increasing scope. Early researchers proposed fundamental areas of WCM that have been augmented and refined (Hayes and Wheelwright, 1984; Giffi et al., 1990; Schonberger, 1986, 1990, 1996). Our study continues this trend in investigating WCM practices by broadening the perspective further to include supply chain considerations. There are a number of other studies that have examined salient aspects of world-class manufacturing within the context of operations strategy (see for example, Flynn et al. 1999, Miller and Roth, 1994, Schroeder et al. 1986). The manufacturing practices examined in these studies and their conclusions are relevant to the objectives pursued in our study.

In examining the progression of research in this area, two principal inferences can be made. First, the underlying dimensions that constitute world-class manufacturing continue to evolve, reflecting changes in competitive requirements placed on manufacturing firms. Consequently, it is imperative that manufacturing practices in leading edge firms be examined periodically to reflect the *current state* of world-class manufacturing practices. Second, the evolution of these manufacturing practices is suggestive of a *dynamic progression* of manufacturing capabilities needed to appropriately respond to competitive challenges.

Building upon these two basic inferences, this paper reports our efforts toward achieving the following objectives:

1) Carry out a study to identify an updated set of core world-class manufacturing practices. This objective examines how practices have evolved.
2) Investigate whether the best plants are similarly positioned in the space of these core world-class manufacturing practices; and if they are not, understand the differences in their positioning.
3) Investigate the relationships between manufacturing practices and performance in these clusters to develop insights into the hypothesized progression of manufacturing capabilities.

We accomplish these objectives via an empirical study of "America's Best" plants (i.e., winners and finalists the America's Best competition held by *Industry Week*). In doing so, we extend the theoretical underpinnings of the WCM paradigm, and derive prescriptive managerial implications regarding competitive manufacturing strategy.

Empirical Study

Our objective was not only to be comprehensive in the inclusion of the constructs and dimensions addressed in prior research, but also to include key initiatives and practices representative of today's manufacturing plants. We adapted measures from previous research where possible (e.g., Flynn, et al., 1999), and developed measures from construct descriptions in case-oriented studies when needed (Hayes and Wheelwright, 1984; Giffi, et al., 1990; Schonberger, 1986, 1990, 1996). In addition, we adapted and included measures from the *Industry Week* survey. Our questionnaire contained a total of 93 items addressing WCM practices, and 20 items addressing manufacturing performance. The questionnaire presented the measures under ten major category headings: *Labor Force Management, Customer Orientation, Operations Flow, Supply Chain Management, Technology Management, Quality Management Programs, New Product Development, Strategy Formulation and Measurement, Manufacturing Performance, Plant Characteristics*. Most measures were formatted using a 5-point, Likert-type scales. In addition, respondents were asked to provide the average annual change over the last two years for the following measures: labor productivity, profitability, sales, and market share. Respondents also provided their average market share for the last two years.

Because our research focuses on the practices and performance associated with WCM, it was important to identify a representative set of the world's best manufacturing plants. Accordingly, we chose the past winners and finalists in the "America's Best" competition, 1990-1999, as the targeted population for our study. This list contained 150 unique plants. We obtained 58 completed questionnaires.

Results and Discussion

The data were analyzed using exploratory factor analysis, in order to extract factors from the items comprising world class manufacturing practices. Eight factors were identified and labeled as follows: *Advanced Manufacturing Technology and Integrated Development* (AMT/ID*), Strategic Supply Management* (SSM), *Statistical Process Control* (SPC*), Supplier Relationship Management* (SRM), *Empowerment, Teaming, and Employee Development* (ETED), *Optimized Processes* (OP), *Just In Time Operations* (JIT), and *Customer Oriented Manufacturing* (COM). These factors present a broadened perspective of world class manufacturing practices. Though they are consistent with discussions of WCM in prior research, the factors, integrated product development, supply chain management, and customer oriented manufacturing, were not explicitly included in previous studies. This points to the evolutionary nature of the underlying dimensions of world class manufacturing practices.

As the next step in our analysis, we performed a cluster analysis in order to establish and examine differences across groups of plants contained in our sample. Using the scores for the eight WCM practice factors identified, a 4-cluster solution offered maximum interpretability, defining a readily apparent WCM typology. Table 1 shows the results of ANOVA and the Duncan multiple range tests on the four WCM types with their respective mean scores on the WCM practices and their relative rankings within each cluster. These WCM types are labeled "*Starters*", "*Internal/Process Focusers*", "*External/SCM Focusers*", and "*Stars*" respectively. These labels are based on our interpretations of the significant differences across the cluster means of the WCM practices, and on the relative rankings of the importance of WCM practices within each cluster.

See Table 1

The existence of these four WCM types (clusters) in our study sample lends credence to our speculation that not all world-class manufacturers are similarly positioned with respect to the eight WCM practices. Although the average firms in each group engage in all of these practices at levels that are near or above their industry standards, there are clear differences among the firms belonging to the different clusters. In order to examine the notion of *strategic capability progression*, pair-wise comparisons across the WCM types were carried out on WCM practices and performance measures using independent t-tests (Tables 2 and 3). The t-tests offer the dual benefits of directly contrasting one WCM position with another, and increasing the statistical power over that of multiple comparison tests.

See Tables 2 and 3

The comparison of *Starters* and *Internal/Process Focusers* indicates that the scores for WCM practices SPC, SRM, and JIT are significantly higher for *Internal/Process Focusers* than for *Starters*. SPC, SRM, and JIT typify the representative capabilities pursued by *Internal/Process Focus* group. The comparisons between *Starters* and *External/SCM Focusers*, and between *External/SCM Focusers* and *Internal/Process Focusers* indicate that AMT, SSM, SRM, and COM receive significantly higher emphasis in *External/SCM Focusers*, than in *Starters* or *Internal/Process Focusers*. Among these four WCM practices, the *Internal/Process Focus* group emphasizes SRM to a greater degree than *Starters* do. Thus AMT, SSM, and COM can be recognized as the capability improvements required to move from either a *Starters* or *Internal/Process Focus* position to become a member of the *External/SCM Focus* group. In addition, further improvement in AMT, SSM, SPC, and OP is required to move from the *External/SCM Focus* group to *Stars* status.

Similarly, the comparison between *External/Process Focusers* and *Stars* shows that superior implementations of ETED and OP characterize the *Stars.* The pair-wise comparisons imply that, when the locus of WCM practices transitions from *Starters* through *Internal/Process Focusers* and *External/Process Focusers* to *Stars*, a higher level of competence is acquired in all WCM practices systematically. This assertion is supported in particular by a comparison of *Starters* and *Stars*, which indicates that the scores of all of WCM practices are significantly higher for *Stars* compared to *Starters*.

Next, we analyzed the *performance gains* associated with the evolutionary transitions from *Starters* to *Stars*. *External/SCM Focusers* have significantly higher scores in the composite performance measures, new product development (NPD) and flexibility (FLX), as compared to *Internal/Process Focusers*. This suggests that the performance dimensions NPD and FLX can be improved by moving to an *External/SCM Focus*. The comparison between *External/SCM Focusers* and *Stars* suggests that the magnitude of MBP is markedly higher in *Stars* compared to *External/SCM Focusers*, suggesting a gain in MBP by a transition from *External/SCM Focusers* to *Stars*. Comparisons show that the transition from *Internal/Process Focusers* to *Stars* results in performance gains in NPD, FLX and MBP. Thus, the results imply that performance gains might also be cumulative depending on the stepwise shift of WCM strategic focus from one group to another group. Regarding productivity improvement, (LPI) *Internal/Process Focusers* group has a significantly higher mean compared to *Starters*. This suggests that LPI is the performance gain when transitioning to *Internal/Process Focus* group from *Starters*.

An interesting aspect of the results is that there is no statistically significant difference in Cost performance among the cluster means, suggesting that cost is not a performance gain

achieved from the progression of WCM practices. Rather, cost efficiency may be viewed as foundational beyond which other performance gains are accumulated.

The results of our study suggest that world-class manufacturing practices do evolve over time. Our speculation was fueled by the results of prior studies on WCM practices that over time alluded to differing sets of WCM practices. Although, the foregoing research of WCM has been substantial, the differences and evolutionary growth of practices that constitute WCM have not received adequate attention. Our results suggest that it is possible for firms to be world-class manufacturers in different stages of evolution. That is, not all WCM plants need be engaged in all the WCM practices to the same degree at any given time. This important insight bears on several views relating to world-class manufacturing.

The eight factors that characterize world class manufacturing practices suggest that a *broadened perspective* regarding WCM is needed. In particular, *strategic sourcing management, supplier relations management, integrated product development, optimized processes,* and *customer oriented manufacturing* have not received explicit recognition in prior work. While this list of WCM practices is consistent with the themes of prior research, the differences included strengthen the notion of evolution in WCM practices. The practices identified by this study provide a current snapshot of WCM practices, helping to define the dimensionality of world-class manufacturing. This latter point is significant in that it facilitates research debates concerning WCM practices by providing a common framework, for the time being. Also, from a practitioner perspective, individual firms (i.e., world class manufacturers) can see how they are positioned relative to others in the "space of these WCM practices," allowing for meaningful comparisons of practices and performance.

The results of this study suggest that if a firm is targeting specific performance gains, then it must emphasize specific WCM practices. A firm could follow different transition paths, each representing a *strategy* (i.e., dynamic positioning of a firm's capabilities). Further, the results suggest that capabilities are cumulative in that the S*tars* engage in all the WCM practices and they are the same or better than the other groups in implementing and using these practices. This observation has implications for operations strategy. Although a firm can choose to move from *Starters* to *Stars* in one move, such a strategy would entail simultaneous improvement in all WCM practices. The cost of implementing such a strategy as well as the challenge of managing the attendant changes would make this strategy a risky one. In contrast, the move from *Starters* to *Internal/Process Focuser* is more manageable in that there is a single performance gain objective that is being pursued and the progression along the practice dimension calls for emphasis on a related and cohesive set of practices – SPC, JIT and SRM. Likewise, the move from *Internal/Process Focuser to External/SCM focuser* has a manageable set of objectives coupled with a cohesive set of practices. Strategically, it may be more efficacious to transition from one typology to the next to ensure the success of practices progression and performance gains.

References

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Table 1 : ANOVA and Duncan multiple range tests on WCM practices

	Starters *(N = 10)*	Internal Process Focus (N = 8)	External SCM Focus *(N = 11)*	Stars (N = 28)	F (Sig.)
SPC					
Cluster Mean	2.53 (2,4)	**4.41** (1,3)	2.27 (2,4)	**3.94** (1,3)	24.276
Rank	7	1	8	5	(.000)
Standard Error	.8371	.4419	.7862	.7115	
SRM					
Cluster Mean	3.04 (2,3,4)	**3.56** (1)	**4.06** (1)	**3.97** (1)	7.782
Rank	4	5	2	4	(.000)
Standard Error	.3578	.6232	.5516	.6317	
JIT					
Cluster Mean	2.75 (2,3,4)	**3.21** (1)	**3.26** (1)	**3.48** (1)	4.555
Rank	5	6	6	8	(.007)
Standard Error	.4142	.3240	.6572	.5728	
AMT/ ID					
Cluster Mean	2.23 (3,4)	2.42 (3,4)	**3.24** (1,2)	**3.67** (1,2)	22.496
Rank	8	8	7	7	(.000)
Standard Error	.2080	.5384	.6192	.5978	
SSM					
Cluster Mean	2.59 (3,4)	2.85 (3,4)	**3.43** (1,2)	**3.76** (1,2)	19.926
Rank	6	7	5	6	(.000)
Standard Error	.4076	.3678	.4295	.5052	
COM					
Cluster Mean	3.76 (3)	3.88 (3)	**4.46** (1,2)	4.13	2.884
Rank	1	3	1	3	(.044)
Standard Error	.5141	.7559	.4279	.6148	
OP					
Cluster Mean	3.53 (2,4)	**4.03** (1,3)	3.55 (2,4)	**4.31** (1,3)	7.394
Rank	2	2	4	1	(.000)
Standard Error	.7873	.4713	.7891	.3702	
ETED					
Cluster Mean	3.53 (1)	3.69 (1)	3.86 (1)	**4.27** (2,3,4)	7.586
Rank	2	4	3	2	(.000)
Standard Error	.5769	.5480	.4960	.4165	

SPC = Statistical Process Control
SRM = Supplier Relationship Management
JIT = Just In Time Operations
AMT/ID = Advanced Manufacturing Technology and Integrated Development
SSM = Strategic Supply Management
COM = Customer Oriented Manufacturing
OP = Optimized Processes
ETED = Empowerment, Teaming, and Employee Development

Table 2: Independent T-Tests on WCM practices

	1 vs. 2	*1 vs. 3*	*1 vs. 4*	*2 vs. 3*	*2 vs. 4*	*3 vs. 4*
SPC						
T value	**-5.727**	.712	**-5.156**	**6.890**	**1.750**	**-6.396**
(Probability)	**(.000)**	(.485)	**(.000)**	**(.000)**	**(.089)**	**(.000)**
SRM						
T value	**-2.258**	**-4.974**	**-5.697**	**-1.827**	-1.624	.387
(Probability)	**(.038)**	**(.000)**	**(.000)**	**(.085)**	(.114)	(.701)
JIT						
T value	**-2.595**	**-2.101**	**-3.695**	-.179	-1.255	-1.045
(Probability)	**(.020)**	**(.049)**	**(.001)**	(.860)	(.218)	(.303)
AMT						
T value	-1.018	**-4.899**	**-10.973**	**-3.011**	**-5.306**	**-1.979**
(Probability)	(.324)	**(.000)**	**(.000)**	**(.008)**	**(.000)**	**(.055)**
SSM						
T value	-1.396	**-4.585**	**-6.594**	**-3.087**	**-4.747**	**-1.922**
(Probability)	(.182)	**(.000)**	**(.000)**	**(.007)**	**(.000)**	**(.062)**
COM						
T value	-.381	**-3.398**	**-1.702**	**-1.971**	-.991	1.617
(Probability)	(.708)	**(.003)**	**(.097)**	**(.076)**	(.329)	(.114)
OP						
T value	-1.591	-.053	**-3.015**	1.545	**-1.749**	**-3.070**
(Probability)	(.131)	(.958)	**(.012)**	(.141)	**(.089)**	**(.010)**
ETED						
T value	-.606	-1.429	**-4.374**	-.716	**-3.249**	**-2.620**
(Probability)	(.553)	(.169)	**(.000)**	(.484)	**(.003)**	**(.013)**

* 1 : Starters, 2 : Internal Process Focus, 3 : External SCM Focus, 4 : Stars

Table 3: Performance Across Clusters
(Independent T-Test on Performance Factors)

	1 vs. 2	*1 vs. 3*	*1 vs. 4*	*2 vs. 3*	*2 vs. 4*	*3 vs. 4*
NPD						
T value	1.015	-.763	-1.165	**-1.819**	**-2.112**	-.410
(Probability)	(.325)	(.455)	(.252)	**(.087)**	**(.042)**	(.684)
Flexibility						
T value	.571	**-3.211**	**-2.128**	**-3.222**	**-2.484**	1.106
(Probability)	(.576)	**(.005)**	**(.040)**	**(.005)**	**(.018)**	(.276)
Cost						
T value	1.197	.185	-.177	-.892	-1.582	-.423
(Probability)	(.249)	(.855)	(.860)	(.385)	(.123)	(.675)
MBP						
T value	-.030	-.589	**-2.549**	-.476	**-2.194**	**-1.780**
(Probability)	(.976)	(.563)	**(.015)**	(.640)	**(.035)**	**(.084)**
Customer satisfaction						
T value	-.752	**-2.301**	**-3.842**	-1.329	**-2.591**	-.996
(Probability)	(.464)	**(.034)**	**(.000)**	(.202)	**(.014)**	(.326)
Productivity						
T value	.241	-.101	**-1.792**	-.320	**-1.909**	-1.686
(Probability)	(.812)	(.920)	**(.082)**	(.753)	**(.065)**	(.100)
Labor Productivity Improvement						
T value	**-2.177**	**-2.292**	**-4.262**	-.190	-1.469	-1.335
(Probability)	**(.043)**	**(.037)**	**(.000)**	(.773)	(.155)	(.190)
Profitability Improvement						
T value	-1.046	-.155	-1.157	1.189	.211	-1.389
(Probability)	(.320)	(.879)	(.258)	(.252)	(.835)	(.174)
Sales Growth						
T value	.477	.481	.191	-.239	-.414	-.253
(Probability)	(.641)	(.637)	(.850)	(.814)	(.682)	(.802)
Market Share Growth						
T value	-.317	.161	-.975	.588	-1.034	**-2.648**
(Probability)	(.760)	(.875)	(.340)	(.575)	(.310)	**(.014)**
Market Share for Primary Products						
T value	-.299	-1.047	-.879	-.701	-.674	-.123
(Probability)	(.772)	(.316)	(.389)	(.496)	(.507)	(.903)

* 1 : Starters, 2 : Internal Process Focus, 3 : External SCM Focus, 4 : Stars