Operations in manufacturing programs: their fits to performance

Cesar H. Ortega Jimenez (cortega@iies-unah.org)
Universidad Nacional Autonoma de Honduras

María A. López
Universidad Nacional Autonoma de Honduras

Pedro Garrido
Universidad de Sevilla

Abstract

Manufacturers are currently facing rapid response markets, which means that implementing manufacturing programs effectively should lead to better performance. Hence, this paper analyzes operations of programs in three industrial contexts with a threefold aim: (1) different programs operations implemented in different sectors; (2) programs links to performance; and (3) environment explaining differences.

Keywords: Manufacturing programs, Performance, Partial least square

Introduction

Finding responsive operations paths to high performance for plats based on the implementation of manufacturing programs and contextual factors, and fits among them has been going on for quite a while (Schroeder and Flynn, 2001). However, previous studies on this topic still shed little light on the reasons why the application of the same manufacturing programs lead to competitiveness in some plants, but not in others (e.g. Garrido et al., 2014). Lack of success in some manufacturers may be partially because there are faulty fits between programs. Starting from this foundational idea of interconnection, the present paper tests the impact of manufacturing programs on performance, as well as the outcome effects of this last one on the market.

Responsive operations are seen here mainly as an outcome from either flexibility or, but especially, reconfigurability, reflecting timely purposeful change guided by external demands (He and Zhang, 2013). On the one hand, by increasing the technological responsiveness of production systems to unpredicted events, such as sudden market changes or unexpected machine failures, manufacturers can achieve reconfigurability. Reconfigurable programs (RPs), i.e. reconfigurable manufacturing systems (RMSs), are simply technological abilities to provide exactly the functionality and capacity needed, exactly when needed, permitting a reduction in the lead time for launching new systems and reconfiguring existing systems, and the rapid modification and quick integration of new technology and/or new functions into existing systems (Bader et al., 2014).

Some authors have proposed and tested operations models for manufacturing programs currently implemented for greater flexibility, but they are still isolated representations rather than cumulative studies that systematically build upon each other for reconfigurable practice deployment (Rehman and Babu 2013). The current empirical testing of reconfigurability along other manufacturing programs is simply a first, but important step in the process of developing a theory for near-future reconfigurable practice deployment. Even if reconfigurable practices from programs such as RMS are not yet readily available, there must be some signs that show plants are seeking responsiveness among multidimensional performance, especially in current non-technological reconfigurable environments where flexibility currently play an important role (Wang et al., 2014).

Thus, this paper tries to have a better understanding for the need of implementing reconfigurable capability, when technology such as RMS is finally on hand. It takes into account the fact that some reconfigurable practices make up an adaptable program, called here "adaptability", and this last one has to interrelate with other production programs, such as just in time (JIT), total quality (TQ), etc., which signals the need of plants as a transition from flexibility to reconfigurability. Thus, the objective of this paper is to test adaptability and other programs, and environment to get high performance and impacts on markets. Hence, background and hypotheses are next presented. In Section 3, the methodology is shown, explaining the research variables, and the data collection method. Epigraph 4 presents and discusses the results. In the last section, conclusions are provided and some directions identified for future research.

Background and hypotheses

This paper shows relationships among some technology and non-technological programs where flexibility is presently considered, in order to analyze future RMS implementation and operations, considering plant environment, program linkages to performance, and the market. There are three main aspects to this integrating review: (1) different programs operations implemented in different sectors; (2) programs links to performance; and (3) environment explaining differences.

Hence, a simple analytical framework is proposed, with three major building blocks, to assess the operations of different manufacturing programs to performance and market. They are as follows: (1) input (manufacturing strategy (MS), total quality (TQ), just in time (JIT), environment, and adaptability); (2) performance from competitive dimensions; and (3) output customer market (abilities to meet customer needs, and customer priorities) (Garrido et al., 2015; Ortega et al; 2014). The first block consists of core manufacturing operation programs and plant environment that provide an infrastructure on which adaptable systems may be established and MS is formulated. This block puts adaptability as the construct containing reconfigurability together with other programs and the environment to determine the second block: performance of production plants. The third block are market variables as output of performance. The relationships among those factors are depicted in Figure 1.

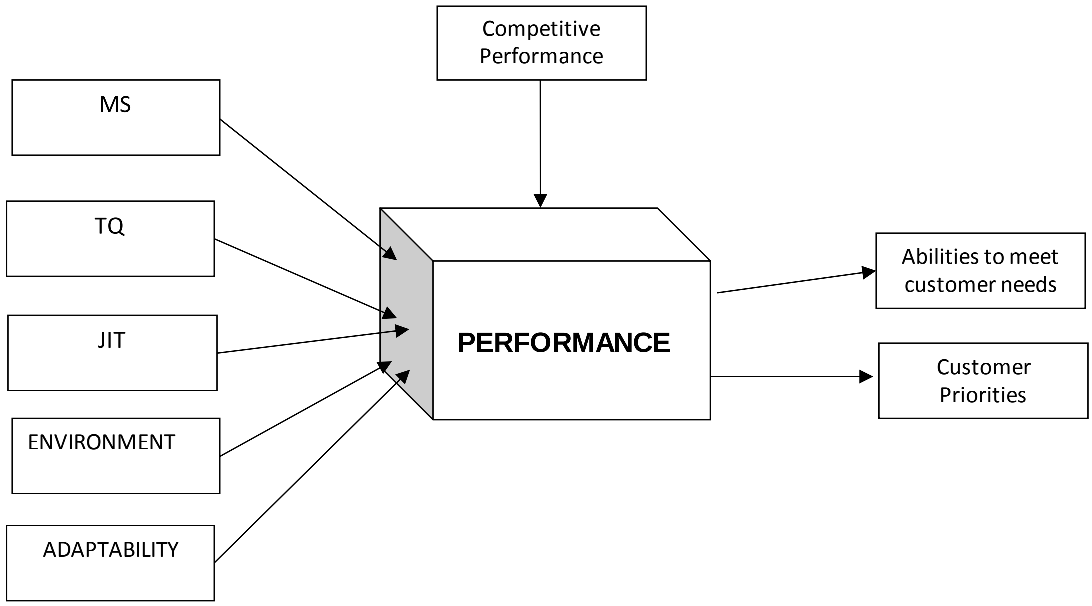

Figure 1. Analytical framework

The hypotheses tested are as follows:

H1. There are positive and significant fits from MS, JIT, TQ, adaptability and environment to performance achieved by plants.

H2. There are positive and significant fits from performance achieved by plants to ability to meet customer needs, and customer priorities.

Methodology

Research variables

In order to operationalize the analytical framework and the hypotheses in the preceding section, we introduce some research variables below. They are divided into seven constructs with their own scales, as seen in Table 2.

Sample and scales

The empirical evidence used to test the hypotheses was taken from surveys conducted to plants that had a minimum of 100 workers. The international sample, from auto supplier, electronics and machinery industries, was 164 plants from seven countries in three continents (America, Asia and Europe). Twelve questionnaires with 5-point Likert scale were used aimed at twelve different managerial and shop floor worker positions. Items related to the three groups of variables of interest have been used for the study: input manufacturing programs, performance, and output manufacturing programs. Since the criteria for assessing reflective and formative constructs are different, the two types of constructs are assessed separately. The measurement items for the formative performance construct is presented in Table 1.

Table 1. Performance as a formative construct

Construct	**Scales**	**weight**	**T-Stat**	**P-value**	**VIF**
Performance	Unit cost of manufacturing	0.8934**	7.3423	0.0000	2.9234
	Conformance to product specifications	0.6386*	3.1245	0.0000	1.0021
	Fast delivery	0.5387*	5.1234	0.0002	3.001
	Flexibility to change product mix	0.3155***	5.4567	0.0000	2.9098
	Flexibility to change volume	0.3345**	6.6456	0.0000	2.4566
	Inventory turnover	0.7098**	1.4576	0.0000	1.312
	Cycle time (from raw materials to delivery)	0.5843***	4.6788	0.0000	1.7375
	Speed of new product introduction into the plant (development lead time)	0.3721**	6.2212	0.0034	1.3456
	Product capability and performance	0.8634**	3.0214	0.0000	1.1147
	On time new product launch	0.2256**	5.4532	0.0000	2.2945
	Product innovativeness	0.6188**	2.3579	0.0000	2.4567
	Customer support and service	0.8364***	9.3487	0.0000	1.2224
	Employee relations	0.4241***	5.4567	0.0000	3.2345
	Supplier collaboration	0.6656*	4.3245	0.0000	1.3456
	Enterprise resource planning	0.2887**	3.2120	0.0000	2.3678
	Quality improvement program	0.5123**	5.0034	0.0000	1.1134
	Degree of mass customization	0.5655**	6.2134	0.0000	1.4512
	JIT and lean manufacturing	0.7721***	4.4532	0.0000	2.2346
	Labor cost	0.4567***	7.9087	0.0000	3.2345

N 115
II -8.10E+04
* p<0.05; ** p<0.01; *** p<0.001

The performance construct was examined by the formative item weights, multicolinearity between items, and nomological validity. For each formative item, this paper examines its weight (instead of its item loading), sign, and magnitude. Each item weight is greater than 0.10 (Andreev et al., 2009) and the sign of the item weight is consistent with the underlying theory (Table 1). All items are significant at the levels of 0.05, 0.01, and 0.001. In addition, all VIF values are less than 3.3, indicating that multicolinearity is not critical (Diamantopoulos and Siguaw, 2006).

On the other hand, the item loadings, composite reliability (CR), and average variance extracted (AVE) of the reflective constructs are shown in Table 2.

Table 2. Formative constructs: input (adaptability manufacturing and other manufacturing programs, and environment) and input (customer market variables)

Construct	Scales	Loading	T-stat	Composite Reliability	Communality (AVE)
MS	Manufacturing-business strategy linkage	1.0000**	-	-	-
TQ	Customer Focus	0.7429**	48.4494	0.759829	0.762199***
	Top Management Quality Leadership	0.9002**	48.6762		
	Supplier Quality Involvement	0.8837**	41.8993		
	Continuous Improvement	0.9021***	19.7655		
JIT	Lot Size	0.7531**	18.4129	0.888323	.699821*
	Continuous Flow Production	0.9377**	36.5778		
	Kankan Pull System	0.9778***	24.2001		
	Setup Time Reduction	0.8544**	14.7636		
ENVIRONMENT	Complexity of the Environment	0.8138***	43.0057	0.917699	71.4432**
	Plant Description	0.7882**	57.7221		
ADAPTABILITY	Reconfigurability	0.7564*	46.4839	0.846798	68.2201***
	Competitor Market Knowledge	0.8568***	18.3353		
Abilities for customers	Ability to Meet Customers' Quality Needs	0.7319**	28.4881	0.896001	82.9012**
	Ability to Meet Customers' Cost Needs	0.7526***	40.3002		
Customer Priorities	Customer Priorities	1.0000**	-	-	-

N 115
II 6.30E+04
* p<0.05; ** p<0.01; *** p<0.001

All item loadings are higher than 0.70 and significant at the 0.001 level, hence validating convergence. All AVE values are higher than 0.50, showing convergent validity. All CR values are greater than 0.70, thus being reliable.

Results and discussion

In this section, we explore manufacturing programs; environment and market fits to performance. Both hypotheses are targets for testing. For this, partial least square (PLS) is used to estimate the analytical framework. Thus, Table 3 shows results indicating positive and highly significant relationships between performance and its five inputs (i.e. supporting significantly H1) and two outputs (i.e. it show support to H2). This indicates the nomological validity of performance measures.

The results of the analytical framework estimates are shown in Table 3. The analytical framework was run using the bootstrap procedure with 100 and 500 times of resampling and the magnitude and significance of the structural paths are consistent.

Table 2. Estimates for analytical framework

RELATIONSHIPS	PLS Estimates			OLS Estimates		
	Coefficient	T-Stat	P-value	Coefficient	T-Stat	P-value
PS----> Performance	0.3632***	4.5289	0.0000	0.3455***	4.4452	0.0000
TQM----> Performance	0.2681***	2.4876	0.0000	0.1782*	2.4672	0.0000
JIT----> Performance	0.3745**	4.2168	0.0000	0.3110*	4.2119	0.0000
ENVIRONMT----> Performance	0.5688*	6.3482	0.0000	0.4839***	5.1890	0.0000
ADAPTAB----> Performance	0.2972**	5.6823	0.0000	0.2290**	4.2188	0.0000
Performance ----> Abilities to customer	0.3338**	3.5212	0.0000	0.2862**	3.8428	0.0000
Performance ----> Customer Priorities	0.2621***	3.5821	0.0000	0.2107**	3.7134	0.0000

N 115

II -7.80E+04

* p<0.05; ** p<0.01; *** p<0.001

Sample size is 164, so it is well above the minimum sample size requirement of 70 as determined by the "10 times" rule of thumb. Finally, the robustness of the PLS results are checked. Since it is not possible to run covariance-based structural equation modeling (CBSEM) and compare PLS results with CBSEM results (because the analytical framework includes both reflective and formative constructs), this paper follows the average of the items within each construct and subject these average values to the OLS regression. As seen in Table 6, these last results are consistent with the PLS results

Conclusions and future directions

In general, there seems to be support for the validity of the fits between adaptability, other programs, environment, market and performance tested. Therefore, it is apparent from results that current environments and programs seem to facilitate better future transition from flexibility to reconfigurability (i.e. as part of adaptability).

However, the framework needs greater empirical examination, by making more tests. This give an opportunity for future direction. For instance, although the sample size is deemed adequate, a statistical power analysis is needed to determine if the sample size is adequate. Moreover, because the performance construct has more than one exogenous construct (i.e., adaptability, MS, TQ, JIT, environment), it is important to calculate the relative effect sizes (f2) of the exogenous constructs. Finally, Goodness of Fit (GoF) may compute the overall quality of the research model. All these tests are being carried out while writing this paper.

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