Production practices and competitiveness: empirical model of two stage least square

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Abstract
The objective of this paper is to share some interesting findings in order to have a more holistic view of fit for POM research by empirically testing, with an international survey (164 plants worldwide) and a 2SLS model, complementarities among production practices in the search for higher competitiveness.

Keywords: Production practice, Two stage least square (2SLS), Competitiveness

Introduction

Flexible practices (FPs) are currently the previous step for reconfigurable practices (RPs). Flexibility may be define here as an inherent property of manufacturing systems which allows them to change within their own limitations. It has internal resources to achieve different types of internal flexibility, both at a short term (i.e. it is the needed operational process consisting of flexibilities such as machine, product, material handling, routing, and volume), and a medium term (i.e. it is the tactical process having flexibilities such as operations, material and program). Such internal flexibilities are there to support external flexibilities, where systems are contextualized, for the long term such as the competitive flexibility concerned with strategic aspects, consisting of production, expansion, and market. Although there may be overlapping in this classification since there is a strong link between long, medium and short term concepts and thus a simple differentiation does not provide additional insights, it gives an important strategic composition of flexibility (Awwad et al., 2013)

However, investments in current flexible systems do not yield the desired results. Empirical studies show that such systems are not living up to its full potential. Evermore, some plants may even have acquired excess capacity and features. Furthermore, many problems are associated with current flexible systems, such as training, reconfigurability, reliability and maintenance, software and communications, and initial cost. Paradoxically,

the main disadvantage with such systems is its inflexibility. While the vital ability for responsiveness is "long-term" flexibility, i.e., a feature to change a system to produce new products, currently there are limited capabilities in terms of upgrading, add-ons, customization and changes in production capacity, thus providing a "short-term" flexibility (Mehrabi et al., 2002). Hence, we approach the "reconfigurability" question, from the perspective of the "inflexibility" of current production practices.

On the other hand, a countless number of possible links exist between production practices that can be used to test the extent to which they are related and their implications on competitiveness, but the present research is centered primarily on complementarity (Roca and Bou, 2006). A complementarity relationship is a similarity or convergent adjustment between two or more different independent variables, in which they improve or emphasize each other's qualities. This would imply a convergence, intersection or tendency shared by the parts of production practices. The following research questions can be formulated on this basis: 1) are there interactions between reconfigurability and other production practices? and 2) do these interactions affect performance?

In the following section, the specialized literature is reviewed. In section 3, there is a description of the research design, together with an outline of the possible relationship within the framework of this study's proposals and hypotheses, as well as its "constructs". Section 4 describes and discusses the methodology of the study, in particular the development of the questionnaires, data collection and model methods. Section 5 presents the results and discussion. Section 6 lays out the final considerations of this work, detailing its contributions, implications and limitations along with directions for future research.

Literature review

As a starting point of the current stage for reconfigurability, we may consider flexible environments (Barad, 2013), where for instance, there are attempts to combine the advantages of fixed automation with those of programmed automation (Rahman & Mo, 2012). Using this method, plants are able to obtain low cost per unit as well as a high degree of flexibility. Since RPs are considered the next step of flexibility, as such they must also be framed where the latter are currently implemented.

In this highly globalized world, the effectiveness of production practices, such as JIT and RP, are closely interrelated with not only IT, but also with the flexibility of the relationship in the SCM. Likewise, this interrelation influences the success of any reconfigurable system in a plant: IT, flexibility of the relationship (SCM flexibility) and other production practices together affect performance. A possible missing link between IT and flexibility of the relationship and the other areas of a plant is a major cause of failure (Ortega et al., 2011; 2012; Machuca et al. 2011)

Production programs

Production programs and their practices are selected and measured according to the specification provided below. While there are many practices and programs in production, the next five reasons are used as the basis for choosing the specific practices and programs to be examined (Garrido et al., 2015; Ortega et al., 2014:

1. JIT as current practices being implemented

2. Quality affecting JIT

3. Adaptability as the source for reconfigurability

4. Manufacturing strategy (MS) having links with adaptability

5. Practices, which have been theoretically or empirically associated with one or more specific dimensions of either IT or SCM flexibility.

Hence, this paper proposes a research model with four major parts to assess the current production stage to adopt reconfigurable ability: (1) MS and adaptability and their practices; (2) QM and JIT; (3) IT and SCM flexibility as complementing the links; and 4) competitiveness measured as performance. This is seen in Figure 1.

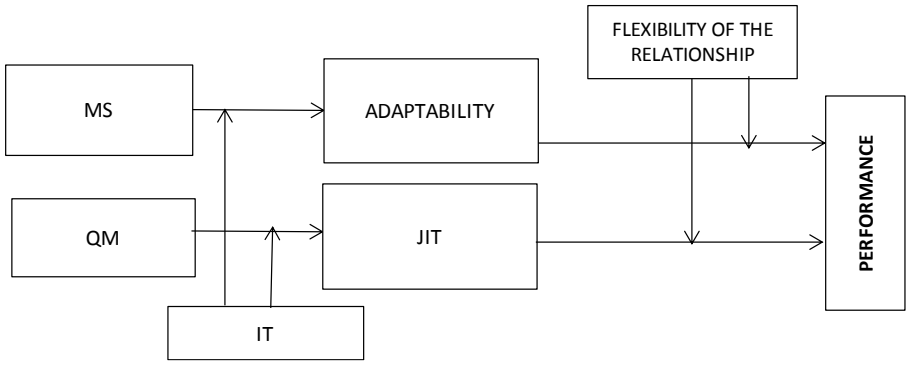

Figure 1. Research model

From this, we propose the following hypothesis:

H1a: There is a complementing relationship MS-IT on adaptability.
H1b: There is a complementing relationship QM-IT on JIT

H2a: There is complementing relationship adaptability-SCM flexibility on performance
H2b: There is a complementing relationship JIT-SCM flexibility on performance

Research setting

Data collection and measurement

The hypotheses mentioned in the previous section were tested by means of a survey in 164 plants from auto suppliers, electronics, and machinery sectors in seven countries (see Figure 2). For each unit of analysis (the plants), the different scales of measurements were arranged in 12 questionnaires with 5-point Likert scale, directed at 12 different company positions. The questionnaires were returned from 36 informants from different managerial levels. Many of the scales were included in at least two different questionnaires, with the aim of triangulating information by making comparisons between the different groups of interviewees (for example between managers and supervisors) and likewise of minimizing the variability resulting from the differences between individuals, thus obtaining a higher degree of reliability. The items that relate to each scale were rearranged within each questionnaire, with the idea that it should not be obvious which item belonged to which scale or even what scales were being used. The questionnaires had been widely tested for reliability and validity. Nevertheless, during this study, the original questionnaires were the object of review with regard to each national context, to take into account potential contextual influences.

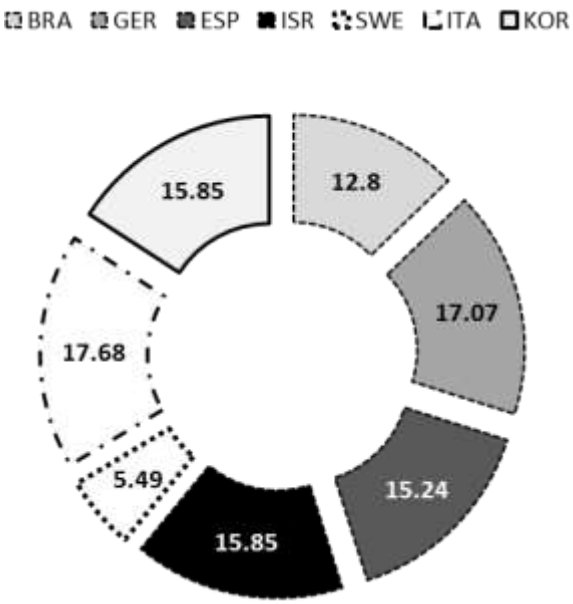

Figure 2. Country distribution

According to Nunnally (1967), the measurement instrument for the study was developed from an extensive review of relevant literature on manufacturing practices. A panel of experts who reviewed each of the scales that were developed strengthened the content validity. The instrument was then pre-tested, revised and translated with back translation when the questionnaires were administered in countries where the mother tongue was not English.

As far as construct validity is concerned, items that loaded on a second factor or scale were eliminated. The requirement in the measure of construct validity was ± 0.40

(Hair et al., 1998). Furthermore, a reliability analysis, which evaluates internal consistency, was conducted for each scale at the plant level, and measured by Cronbach's alpha. Following Nunnally (1978), a score of 0.7 was used as a criterion for a reliable scale. All the scales used in the analysis exceeded this criterion level. Corresponding measures are available upon request.

After the individual scales (dimensions) had been checked for reliability and validity, the next step was to aggregate (average) them into super-scales or sets to represent the broader concepts mentioned above.

Results

To test all hypotheses, we use these as instrumental variables in a two-stage least squares (2SLS) approach. Table 1 shows results indicating positive and highly significant complementing relationships between MS-IT on adaptability (H1a), and QM-IT on JIT (H1b), as well as between adaptability-SCM flexibility on performance (H2a), and JIT-SCM flexibility on performance. .

Table 1. 2SLS regression results

PREDICTORS	**Instrument Variable 2SLS Regression**								
	ADAPTABILITY			JIT (JUST IN TIME)			PERFORMANCE		
	Coefficient	Robust Standard-Error	P-value>|z|	Coefficient	Robust Standard-Error	P-value>|z|	Coefficient	Robust Standard-Error	P-value>|z|
MS (Manufacturing-Strategy)	0.3346***	0.4127	0.0000						
Quality				0.3643**	0.0887	0.0001			
TIC	0.1126***	0.1872	0.0000	0.2976***	0.1378	0.0000			
(MS (Manufacturing-Strategy)) x (TIC)	0.4178*	0.0923	0.0000						
Quality x TIC				0.5864**	0.2899	0.0000			
Adaptability							0.3941***	0.075	0.0000
JIT							0.6923**	0.1483	0.0000
Flexibly of the Relationship (Adaptability) x (Flexibly of the Relationship)							0.1864***	0.0456	0.0000
JIT x (Flexibly of the Relationship)							0.2476***	0.1185	0.0000
Control							0.3255**	0.2389	0.0000
Employee relations							0.3788**	0.2189	0.0000
Degree of vertical integration							0.2178**	0.0234	0.0000
Supplier relations							0.0967***	0.3234	0.0000

PREDICTORS	Instrument Variable 2SLS Regression								
	ADAPTABILITY			JIT (JUST IN TIME)			PERFORMANCE		
	Coefficient	Robust Standard-Error	P-value>|z|	Coefficient	Robust Standard-Error	P-value>|z|	Coefficient	Robust Standard-Error	P-value>|z|
Customer relations							0.3187***	0.0456	0.0003
Quality improvement program							0.5430***	0.2148	0.0000
Degree of mass customization							0.4386**	0.1234	0.0000
Agile manufacturing							0.3976**	0.0544	0.0000
Labor cost							(0.4671)***	0.0321	0.0000
Labor productivity							0.6157**	0.3452	0.0000
Flexible manufacturing							0.4109**	0.2359	0.0000
Sectors									
Electronics							0.1876***	0.034	0.0025
Auto Supplier							0.3798**	0.1034	0.0000
Machinery							0.2603*	0.0234	0.0000
Intercept	4.8767***	0.0456	0.0045	4.9133**	0.1456	0.0001	6.896***	0.4345	0.0000
Model F(p-value)	55.3 (0.0000)			72.1 (0.0000)			63.2 (0.0000)		
R^2 Adjusted	0.13			0.37			0.48		

N 156
II -2.80E+04
* p<0.05; ** p<0.01; *** p<0.001

Conclusions

This paper finds that MS and QM are both synergistically complemented by IT in their impact on adaptability and JIT. Flexibility on the relationship for the SCM seems to be complementing with both adaptability and JIT on relationships on performance Future studies are encouraged to test the robustness of the present conceptual framework, and extensions thereof, in explaining variance along these associated dimensions of performance.

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Bibliography

Awwad, A.S., Al Khattab, A.A., Anchor, J.R. 2013. Competitive Priorities and Competitive Advantage in Jordanian Manufacturing. *Journal of Service Science and Management* **6**(1): 69-79.

Barad, M., 2013. Flexibility development–a personal retrospective. *International Journal of Production Research*, (online since 18 Mar 2013): 1-14.

Garrido P, Ortega Jimenez, C.H. Díez Pérez JL., Morita, M. 2015 Implementation of technology and production strategy practices: Relationship levels in different industries, International Journal of Production Economics **161**: 201-216

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C. 1998. *Multivariate Data Analysis*. Upper Saddle River, NJ: Prentice-Hall.

Machuca, J. A. D., Ortega Jiménez C. H., Garrido-Vega P., Pérez J. L. 2011. Do technology and production strategy links enhance operational performance? *Empirical research in the auto supplier sector. International Journal of Production Economics* **133**(2): 541–550.

Mehrabi, G, Ulsoy, A., Koren, Y., Heytler, P. 2002. Trends and perspectives in flexible and reconfigurable manufacturing systems. *Journal of Intelligent Manufacturing* **13** (2): 135–146.

Nunnally, J.C. 1967. *Psychometric Theory*. New York: McGraw-Hill.

Nunnally, J.C. 1978. *Psychometric Theory* (2nd Ed.), New York: McGraw-Hill.

Ortega Jimenez, C. H. O., Machuca, J. A., Garrido-Vega, P., Filippini, R. 2014. The pursuit of responsiveness in production environments: From flexibility to reconfigurability. International Journal of Production Economics. Available online 21 September 2014, ISSN 0925-5273, http://dx.doi.org/10.1016/j.ijpe.2014.09.020.

Ortega Jiménez, C. H., Garrido-Vega, P., Pérez, J., García, S. 2011. Production strategy–technology relationship among auto suppliers. *International Journal of Production Economics* **133**(2): 508–517.

Ortega, C. H., Garrido-Vega, P., Machuca, J.A.D. 2012. Analysis of interaction fit between manufacturing strategy and technology management and its impact on performance. *International Journal of Operations & Production Management* **32**(8): 958-981.

Rahman, M.A.A., Mo, J.P., 2012. Development of theoretical reconfiguration structure for manufacturing automation systems. *International Journal of Agile Systems and Management* **5**(2): 132-150.

Roca, V., Bou, J.C. 2006. El concepto de ajuste en dirección de empresas: definición, metodología e hipótesis. *Investigaciones europeas de dirección and economía de la empresa*. **12**(3): 41-62.