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INVESTIGACIÓN EMPÍRICA SOBRE ARTICULACIONES ENTRE PRACTICAS DE PRODUCCIÓN EN LA INDUSTRIA ELECTRÓNICA

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RESUMEN

El artículo busca testear y validar los efectos de ajuste entre prácticas de dos de los principales programas de producción:, estrategia de operaciones (OS) y gestión de tecnología (TM), explorando además el papel que juega el entorno de las fábricas como un inhibidor de ajuste entre OS y TM. El artículo se fundamenta en el análisis estadístico de encuestas que involucra 88 fábricas de la industria de electrónica, distribuidas entre Alemania, Austria, Canadá, Corea del Sur, España, Estados Unidos, Finlandia, Italia, Japón, Suecia. El estudio prueba la existencia del ajuste entre las prácticas de OS y las de TM. El artículo provee argumentaciones analíticas y empíricas mostrando que la OS y la TM refuerzan mutuamente sus prácticas sobre el rendimiento de operaciones. Esto parece indicar que la implementación común de las prácticas de producción estudiadas a través de la industria de la electrónica es importante en los entornos en los cuales operan las fábricas. El artículo sugiere un patrón de mejora donde la OS y la TM tienen que ser implementados mano a mano para lograr una ventaja total de su eficacia. Las articulaciones de prácticas de producción proveen una base sobre el cual el ajuste se origina, extendiendo sus beneficios a través de la organización. La investigación representa un intento de operacionalizar y validar empíricamente las articulaciones entre prácticas de producción en un entorno industrial internacional. Además, el artículo provee recomendaciones originales para los profesiones de cómo lograr lo mejor de la implementación de la OS y la TM.

Palabras clave: prácticas de producción, electrónica, articulación.

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EMPIRICAL RESEARCH ON PRODUCTION PRACTICES LINKAGES IN THE ELECTRONICS INDUSTRY

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ABSTRACT
The paper aims to test and validate linkages effects between practices from two of the main production programs in manufacturing: operations strategy (OS) and technology management (TM).The paper is based on statistical analysis on a survey that involves 88 plants from the electronics industry, distributed among Austria, Canada, Finland, Germany, Italy, Japan, South Korea, Spain, Sweden, and USA. The study proves the existence of fit between OS and TM practices. The paper provides analytical and empirical argumentations showing that OS and TM mutually reinforce each other's practices on operational performance. This may indicate that common implementation of studied production practices across the electronics industry is important in environments in which plants operate. The paper suggests a pattern of improvements where OS and TM have to be implemented hand-in-hand to take full advantage of their effectiveness. Production practices linkages provide ground over which fit originates, spreading its benefits throughout the organization. The research represents an attempt to operationalize and empirically validate linkages between production practices in an international industrial environment. The paper also provides original suggestions to practitioners on how to make the most out of implementing OS and TM.

Keywords: production practices, electronics, linkage.

INTRODUCTION

Previous studies on Production Programs (PPs) do not give definite answers on how implementations of any given PP lead to competitiveness in some organizations, but not in others. Theoretically, before PPs are selected, adapted (as required), implemented and linked, a well-conceived strategic plan based on circumstances of the organization (environment) also needs to be put in place. If this is not done, PPs will not have the desired effect: the attainment of competitiveness. All of the above should be linked to a planned path of continuous improvement. These three elements (contingency, linkages and continuous improvement) are, in general terms, the approach of the High Performance Manufacturing (HPM) conceptualisation.

In this search of competitiveness and continuous improvement, the effective use of technological resources should be essential for achieving a sustainable competitive advantage and for increasing the performance of organization. However, although technology management program may in principle increase competitive advantage, it is necessary to analyse them in combination with the operations strategy program within organizations, since there seems to be a clear influence between them (Schroeder and Flynn, 2001). Furthermore, this paper stresses the need to investigate the combined impact of both programs to distinguish between plant classes: high performers and the rest.

Hence, to test for this linkage, this paper focuses on the electronics industry as a stage on a sequent of sector and intersect or studies. Such industry is characterised by technological innovation, rapid changes and aggressive competition in a global market environment with complex supply networks. In this environment, sources of competitive advantage can come from consolidating technologies and production skills that support product generation that the competition cannot anticipate.

Furthermore, this sector is one the most dynamic, influential and important industries in the world in terms of production, commercial exchanges, and wealth creation[1]. Despite substantial macroeconomic challenges, it shows clear signs of competitiveness. On the one side, tablets, laptop/notebook, and smartphones show the following projections: 1) tablet unit sales will reach 116 million in 2013 (45% from 2012, when 80 million were sold), meaning revenues will surpass US$37bn (up from US$31bn in 2012); 2) laptop/notebook computer sales will be US$17bn in revenue as units continue to rise to 26 million in 2013; and 3) smartphones unit sales will reach 130mn in 2013 with to surpass US$37bn (up from 111 million units and from US$33bn revenue in 2012).

On the other hand, worldwide semiconductor sales for 2012 were US$291.6bn (outperformed forecasts due to strong demand in several market segments, giving industry's third-highest yearly total ever). Finally, Original Equipment Manufacturers (OEMs) spending on semiconductors for wireless applications is set to rise by 13.5% in 2013 to reach a value of US$69.6bn, up from US$62.3bn in 2012, representing highest growth rate of the seven major application markets. In 2013, wireless semiconductor spending reflects is due to smartphones and media tablets (to support this trend is also required robust corporate infrastructure expenditures). Cellular phones continued to be the leading category for wireless semiconductor spending, but tablets are on the rise, surpassing wireless infrastructure in 2012 for the first time ever.

Therefore, considering the electronics sector context, this paper aims to test and validate linkages effects of the implementation levels of operations strategy and technology management.The study relies on statistical analysis using the HPM database, a survey involving 88 plants in ten countries across electronics manufacturing plants.

The paper is organized as follows. Section 2 provides the definitions and hypotheses. Next (3), research variables are

[1]http://www.pwc.com (lastaccessed on July 21-2013)

presented. The methodology is laid out in section 4. In epigraph 5 results are discussed. Finally, we present conclusions and future research.

FRAME OF REFERENCE

There is a general trend towards an increase in the use of Technology Management (TM) in manufacturing plants due to the belief that it will improve some performance measures (e.g. reductions in costs or human resources, improved quality or flexibility). However, these investments are often criticized for not creating the desired results, i.e. technology initiatives often lead to neither effective deployment of new practices nor the desired performance outcomes being reached fast enough. For this to be understood, it is necessary to take into account that the interconnection between technology and performance is influenced by a number of factors: some who can be controlled, and others who cannot, nonetheless they are all important for the final result. Thus, when dimensions from both product and process technology are widely applied in a factory, it can be said that the plant is on a path to high performance by a more complete view of technology. However, the plant has to have a more progressive and dynamic vision yet of the development of technologies in manufacturing, which takes into consideration sets of other manufacturing practices. Therefore, this paper assumes an open definition of technology comprising not only of hardware systems, but also human and organizational aspects of the way the plant operates (Heim and Peng, 2010). Thus, this paper focuses on two main aspects of technology, product and process (Trentin et al., 2012; Morita et al., 2011).

On the other hand, it may be well said that there is still not enough broad empirical research in production and operations management (POM) literature documented (and even less in high performance manufacturing (HPM) papers) addressing clearly the implementations of operations strategy (OS). However, there are clear signs that operations strategies may play a fundamental role in the assessment of new technologies, since an analysis of appropriate technology can eliminate many risks, given that high performing technology is a key factor in global competitiveness (Machuca et al 2011).

Thus, since many authors believe that the basis for generating global competitive advantages comes from decisions in production, which must be framed in operations strategy (OS). Besides, technology management (TM) is an absolutely essential part of these decisions. Hence, to use strategy effectively, technology capabilities must therefore also be considered (Ortega et al., 2012; Ortega, 2009). Hence, technology may be a factor limiting strategy in two ways: 1) existing technology determines the strategy that an organisation can pursue; and 2) a plant that wishes to pursue a different strategy may need to expand/adjust its technology base. Thus, it is clear that both technology and strategy may influence one another, suggesting a link between them. However, it is not very clear yet the contexts on which such link occurs. Therefore, one research question surfs out here on how practices may influence the link between both programs (Aoki et al., 201; Phan et al.., 2011).

Bivariate fit will be used as the frame of references to answer this question by examining how TM and OS are related (Ortega et al., 2011). Fit means consistency of two or more factors and a good fit between relevant factors should improve plants.
The study of this fit will focus on identifying specific TM practices linked to different OS practices. It is not intended that the direction of causality should be identified with the model used, but that a cross study is done that enables it to be established whether there is any fit between implementation levels of manufacturing strategy and technology management.

Thus, the first hypothesis which is guiding this empirical research is as follows:

> ***H1: A plant's implementation levels of OS practices are (positively) related to levels of TM practices.***

Furthermore, in order to envision paths in competitiveness, this paper includes completing methods to test for plants' type, by considering performance in the electronics industry. Thus, the following hypothesis is tested:

> ***H2: Competitive plants have higher levels of OS and TM practices.***

1. RESEARCH VARIABLES

In order to operationalize the frame of reference and the hypotheses in the preceding section, we introduce some research variables below. They are divided into three categories: four practices for OS program, four for TM, and competitiveness.

1.1. Operations strategy (OS)

1.1.1. Manufacturing-business strategy linkage

It represents the consistency between manufacturing strategy and business strategy (i.e., whether business strategy translates into production).

1.1.2. Formal strategic planning

It means the extent to which strategic plans are formalized as exercised by management. This is evidenced by the existence of a written mission, long-range goals and strategies for implementation.

1.1.3. Communication of manufacturing strategy

This practice measures management's efforts to communicate competitive strategy, goals, and objectives throughout plants.

1.1.4. Anticipation of new technologies

As new technologies become available, it is thought plants that anticipate their availability are better prepared to implement and use them as a source of competitive advantage. Hence, this practice determines whether the plant is prepared, in advance of technological breakthroughs, to engage in the implementation of new technologies when they become available.

1.2. Technology management (TM)

1.1.5.Effective process implementation

This practice represents whether the company appropriately implements a new process/production technology after having procured it.

1.1.6.Inter-functional design efforts

It represents the level and amount of input that the production department has in the new product introduction process. It includes cooperation and coordination across functional boundaries.

1.1.7.New product introduction cooperation

This scale represents the type of new product introduction process used.

1.1.8.Supplier involvement

It represents whether the plant works closely with its equipment suppliers in developing new and appropriate process technology.

1.2. Competitiveness: performance indexes

The last category of variables is concerned with competitive performance indexes of the manufacturing plant, relative to global competitors in the industry. They are subjectively judged by each plant manager on a five-point Likert scale. The following nine performance indexes are includedin three fundamentalobjectives in the production function, as follows: 1) cost (unit cost of manufacturing); 2) quality (conformance to product specifications); and 3) responsiveness (cycle time, development lead time, on-time delivery performance, on-time new product launch, flexibility to change product mix, flexibility to change volume.)

2. DESIGN

The unit of analysis used is the individual surveyed electronics manufacturing plant, which had a minimum of 100 workers. Thus, the data used for the subsequent analysis was taken from 88 randomly chosen plants from ten countries, located in America, Asia and Europe. Twelve questionnaires aimed at different plant posts from plant manager to operators were used in this project. The questionnaires consider items for the eight production practices (four for OS and four for TM) and nine performance indexes through more than 40 different items (questions). All questions were answered using Likert scales.
Each practice is conceptualized as a first-order factor and measured through a bundle of distinct items (content and construct validity, and reliability were tested and were significant, way higher than the cut-off from Kim and Mueller; Ford et al., 1978; Cronbach, 1951).

With regard to Performance (P), a measure of responsiveness reflecting a plant's achievement was constructed from speed, dependability and delivery dimensions (Ortega and Eguia, 2010). Thus, cost, quality and responsiveness were then used in order to observe the total effectiveness.
All corresponding measurement results will be provided upon request.

As indicated, a fit model will be used for the data analysis. It will mainly focus on selection (Meilich, 2006) by Canonical Correlation Analysis (CCA) as it is suitable for this paper's objective since it is based on the supposition that the implementation levels of a manufacturing process must be regulated or adapted taking into consideration the level of another manufacturing process and vice versa, for said manufacturing process to be controlled or improved. However, complementing model based on interaction will also be used in order to test for performing effects caused by fit. Techniques, such as Sub Group Analysis (SGA), and Multiple Correspondence Analysis (MCA), are the appropriate analytical schemes. These techniques for the models do not aim to determine the direction of causality of the two main variables but to test the kind of fit between them in different performing environments. This enables to conceptualise how each plant (High Performer/HP vs. Standard Performer/SP)type considers the bivariate fit of the practices under study, for the relationship between OS and TM to be ascertained.

3. DISCUSSION OF RESULTS

The following test uses selection fit, i.e., whether there are common implementations of all practices together from TM and OS. Table 1 shows such results by canonical correlation analysis. The first canonical correlation stands at 0.762 (which was high). Furthermore, the redundancy index shows that some one-third of the variance in OS and TM indices is explained by the first canonical variables. Specifically, the redundancy index in OS is 0.372, whereas technology has redundancy index of 0.276. These redundancy values are close, which points to the variances being shared if the first canonical function is accepted.
All OS practices are significantly related to the TM canonical variables (canonical variables represent practices), except for T4. From this analysis it can be highlighted that in general terms this relationship is justifiable as technology development must be strategic for this industrial sectors and must be contained within operations strategy.
On a general level it can be mentioned that OS practices have relationships with TM practices, by a common implantation of their practices. A bi-directional effect could therefore exist between practices from both programs, with the exception of T4. We therefore accept hypothesis H1, with that only reservation.
Finally, with performance measures included, plants have been classified as follows. HP: If cost, quality and responsiveness are greater than their respective means, and SP: otherwise. There are 18 HPs out of 81 plants, representing 22.2 %.

A MCA was then performed to see whether the implementation of T and S practices are linked to the HP/SP classification considered. The practice is considered "high implemented" if its value is higher than the mean for each industry individually. The correspondence analysis graph is shown in Figure 1 (with 80 plants). Except for performance (represented by HP and SP), each one of the remaining cases (practices) in the Figure is represented by one case in this data. For each case a "Yes" is entered into the category where the respective case belongs ("high implemented") and a "No" otherwise.

Table 1. Canonical correlation analysis between S and T

	First canonical variable
Canonical correlation	0.762
R^2	0.58
Level of significance	0.000
Redundancy index: S	0.372
Redundancy index: Technology	0.276
***OS* Canonical loadings**	
Formal strategic planning	**0.758**
Anticipation of new technologies	**0.919**
Communication of manufacturing strategy	**0.492**
Manufacturing-business strategy linkage	**0.820**
***TM* Canonical loadings**	
Effective process implementation	**0.965**
Inter-functional design efforts	**0.550**
New product introduction cooperation	**0.607**
Supplier involvement	0.152

Minimum loading of 0.31 for 0.05 significance levels (Graybill, 1961)

It can be seen from Figure 1 that HPs are linked to the high implementation of the practices, whereas the SPs are linked to low implementation. This would seem to indicate that SPs are not very well characterized by the low implementation of these practices, whereas the HPs are better characterized by their high implementation, giving support to H2. The MCA Burt Tables are available upon request.

4. CONCLUSIONS

Findings were as expected, since they show linkages exist between operations strategy and technology management. However, using only a survival as a measure is a quantity that, both, disregards differences between existing data and, as well does not assure tested correlation actually distinguishes between existing and failed plants. Hence, using SGA-MCA as a complementing method has the advantage of incorporating an outcome measure such as performance, in order to distinguish between different implementation levels in the relationship according to a dual plant type definition (high and standard performer). This showed that high performers have both sets of practices implemented together considering each other.

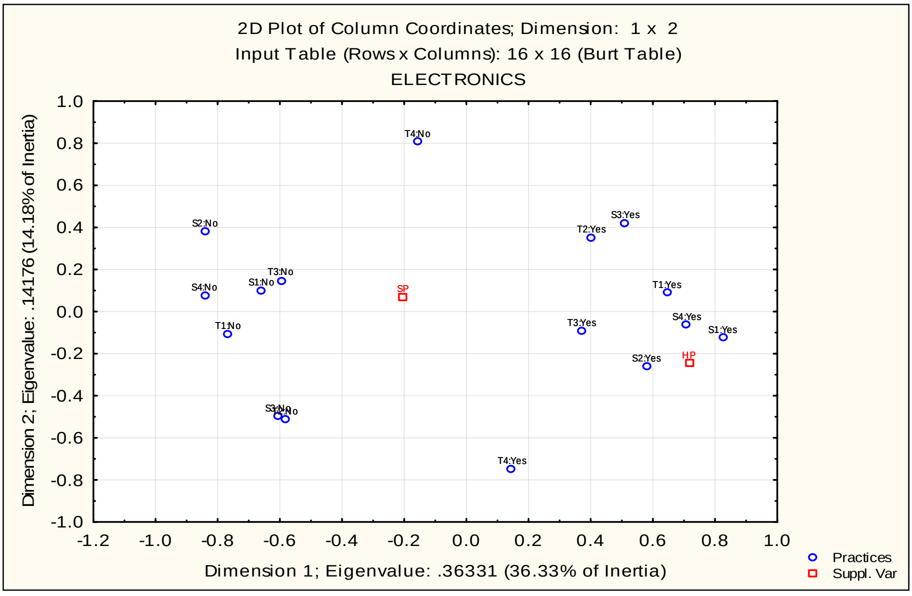

Figure 1. MCA: Burt table graph

These linkages might be due to the specific features of the electronics sector given that different types of processes, practices and equipment entail different objectives and operations strategies and this impact on technology management development.
As part of its contribution, this paper takes first steps of testing for class effects (HP vs. SP) along practices links in the international realm from the electronics sector. This shows that differences in the implementation levels exist in the linkages between proposed practices, impacting performance.
This calls for further research on contexts effects. Therefore, a final implication regards the integration, of contingency theory from bivariate and systemic models into OS-TM linkages, and of contextual factors, to fit in particular. It would be of great interest to further demonstrate, as future research, the potential of production practices linkages, by incorporating multiple contextual-infrastructure practices factors criteria, along the dual plant type criterion used here.

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Aurorización y Renuncia