ANALYSIS OF INTERACTION FIT BETWEEN MANUFACTURING STRATEGY AND TECHNOLOGY MANAGEMENT AND ITS IMPACT ON PERFORMANCE

Cesar H. Ortega Jimenez (1) & (2)
cortega@unah.edu.hn
Pedro Garrido Vega (2)
Jose Antonio Dominguez Machuca (2)

(1)   Universidad Nacional Autonoma de Honduras (UNAH)
Instituto de Investigaciones Economicas y Sociales (IIES)
Edificio 5, Planta Baja, Ciudad Universitaria, Blvd. Suyapa
Tegucigalpa, MDC., Honduras, (Central America)

(2)   Universidad de Sevilla (Spain)
Facultad de Ciencias Economicas y Empresariales
Departamento de Economia Financiera y Dirección de Operaciones
G.I.D.E.A.O. (Grupo de Investigación en Direccion de Operaciones en la Industria y los Servicios)
Avenida Ramon y Cajal, 1
41018 – Sevilla (Spain)

ANALYSIS OF INTERACTION FIT BETWEEN MANUFACTURING STRATEGY AND TECHNOLOGY MANAGEMENT AND ITS IMPACT ON PERFORMANCE

ABSTRACT

Purpose
Using the matching/difference perspective, this paper examines the interaction fit between a set of managerial practices from manufacturing strategy and another set from technology management and the link of this fit to operational performance.

Design/methodology/approach
This paper applies multiple statistical methods to a database of an international sample of plants in the auto supplier sector to explore (deviation score analysis/multiple linear regression) and confirm (correlation and variance subgroup analysis) whether a matching model presents organisational disequilibrium, where states of fit are related to effectively higher performance than states of misfit.

Findings
Results from regression show that there were no states of misfit between the levels of both manufacturing practice sets/areas. This means that there are no significant differences in performance that may be tested for matching interaction. However, subgroup analysis provides greater detail on why there might not be any misfits (i.e. state of fit), by illustrating that when grouping by plant type (high/world class performer, HP, and standard performer, SP), the slight lack of significant difference in the correlation between manufacturing strategy (MS) and Technology Management (TM) was in favour of HP. The implementation levels of MS-TM found were not significantly different, showing for HP slightly higher levels for both practices (+ & +) than for SP, with slightly lower values in both cases (- & -). Therefore, it seems that both groups might perform equally well, due not to interaction but to the presence of a state of MS-TM fit alone. A state of fit such as this, known as selection or congruency, would be the reason for there being no significant matching interaction originally.

Originality/value
Most of the interaction fit bibliography is from the accounting perspective. Therefore, the impact of the matching interaction fit between MS and technology management (as well as its impact on performance) has not been well documented theoretically, and much less, empirically, in POM.

Keywords: Manufacturing industries, Automotive components industry, Production management, Operations management, Manufacturing strategy, Technology management, Performance, High performance manufacturing

1. INTRODUCTION

With the aim of improving performance in response to increased competition, companies have implemented a continual current of new production practices, from the oldest, such as MRP, to the most recent, related to supply chain management (Alfalla-Luque and Medina-López, 2009). However, there is a unique path to high performance for each manufacturer based on the implementation of the best manufacturing practices and contingent factors and links between manufacturing practices (Filippini et al., 1996; Filippini et al., 2001; Schroeder and Flynn, 2001). Previous studies on this topic still shed little light on the reasons why implementing the same manufacturing practices might lead to high performance in some plants, but not in others (e.g. Forza, 1996; Filippini, 1997; Filippini et al., 1998; Maier, 2000). Lack of success in some plants may be partially due to a faulty link between practices. Starting from this foundational idea of

interconnection, the present study tests the performance effects of the link between manufacturing strategy (MS) and technology management (TM).

Porter (1983, 1985) puts great stress on the need to think through the interconnection between both sets of practices covered in this study (strategy and technology). In this respect, part of the specialised literature (e.g. Skinner, 1969; Porter, 1983) explains that in order to drive competitiveness in organisations, strategy should drive technology development. Therefore, technological development can provide the plant with a group of competitive weapons and a better technological base, applicable to other products and markets (Hofer and Schendel, 1978; Itami and Numagami, 1992). This implies the adoption of a unidirectional perspective, that is to say, the causal relationship goes from strategy to technology, and not vice-versa.

The other side of the coin (also unidirectional) that is apparent from specialised literature (e.g. Hayes, 1985) considers technological capacity as the foundation of strategy, i.e., it presents a perspective in which technology should guide strategy. From this perspective, the plant tends to look inwards for its strategic options—inside its limitations and technological capacities. It can be argued that in this situation, technology can act as a tool to a plant's advantage (Porter, 1983), or as a restriction to which it must then adapt (Hofer and Schendel, 1978). The plant's product/process portfolio therefore influences the kind of technology that the organisation tries to maintain or develop. This then affects the technology on which the plant chooses to base its strategy: therefore, strategy is limited by technology (Porter, 1985).

Up to the 1990s, most of the studies essentially viewed the relationship between strategy and technology from one of these two unidirectional perspectives. This has meant an alternative focus has been sidelined that may allow testing for both perspectives simultaneously, bidirectionally. Thus, beyond the general argument that manufacturing strategy and technology should be harmonised, contingency and interconnection ideas allow them to be re-examined for possible bidirectional interactions between MS and TM practices.

This idea of link is that neither MS nor TM by themselves will achieve their potential unless they are both components of a general performance platform. Despite the importance of discovering how to achieve this interrelationship, its empirical exploration has not been well documented in the Production and Operations Management (POM) literature. Hence, this work focuses on the possible impact of the interaction between manufacturing strategy and technology management practice sets on performance —a fundamental aspect of our empirical research.

A countless number of possible links exist between MS and TM which can be used to test the extent to which they are related and their implications on performance, but this research focuses primarily on supplementarity (Roca and Bou, 2006). A supplementary relationship is a similarity or convergent adjustment between two independent variables. This would imply a convergence, intersection or tendency shared by both MS and TM. The following research questions can be formulated on this basis: 1) is there matching interaction fit between MS and TM? and 2) does this interaction affect performance? This paper seeks to explore and confirm both questions.

In the following section, the literature on the relationship between manufacturing strategy and TM is reviewed. Section 3 describes the research design and outlines the possible relationship within the framework of this study's proposals and hypotheses and 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 sets out the final considerations of the paper, detailing its contributions, implications and limitations and the directions future research could take.

2. LITERATURE REVIEW

As far as the general POM literature is concerned, previous studies have dealt more with the links between technology and business strategy than with the specific uni- or multidimensional links between technology management (TM) and manufacturing strategy (MS). Some researchers have

classified the important dimensions of technology that are adjusted to a particular strategy (e.g. Foster, 1986). For his part, Parker (2000) explored the current and future dynamics between business strategy and technology, and their effect on performance, without considering time series (longitudinal studies).

POM researchers have studied the empirical connections between specific dimensions of technology and business strategy (e.g. Hambrick et al., 1983). Some of their discoveries indicate the need to determine the fit between specific dimensions of business strategy and technology (e.g. Parthasarthy and Sethi, 1993).

Thus, some of the above studies have proposed integrated models that describe fit between several dimensions of technology and business strategy (e.g. Maidique and Patch, 1988). However, they do not consider whether there is a supplementary relationship between strategy and technology in their impact on performance

Although these studies have increased the general understanding of the link between strategy and technology, they have not examined differential aspects and their impact on performance. Furthermore, although they have provided ideas on the relationships between strategy and technology, the corresponding empirical validations thus far have been minimal and even fewer have been valuable from the present point-of-view of considering Manufacturing Strategy specifically, since most of these studies analyse the relationships from the perspective of business strategy rather than that of MS.

Specifically, if we explore the results obtained from the High Performance Manufacturing Project compiled in the book edited by Schroeder and Flynn, 2001, one may see that out of the over 110 studies included, only Morita and Flynn (1997) directly deal with the MS - TM relationship. However, they do so in neither an exclusive nor an exhaustive way, since from the MS perspective, they approach the relationship only through the dimension of strategic adaptation with other practices sets. Furthermore, from the technological point-of-view, they deal only with the concept of technology being adapted to its scales. Amongst their conclusions, they indicate that an important link does exist between these concepts and that there is a high degree of correlation of this link to different dimensions of performance.

Similarly, only three papers on this important issue were found after the HPM book was published. Matsui (2002) studied the contribution of different manufacturing practices—including MS (with different dimensions)—to the development of technology managerial practices (that is, effective process implementation, interfunctional design efforts, design product simplicity). His results provide clear evidence that the employment of several manufacturing practice sets (including MS) in the development of technology has a strong impact on the competitiveness of a manufacturing plant. Meanwhile, McKone and Schroeder (2002) identified the type of plants that make use of process and product technology by taking into consideration a plant's relationship with its context (including strategic aspects but not including performance). Finally, Ketokivi and Schroeder (2004) seek to use strategic eventualities involved in the adoption and implementation of several manufacturing practices to achieve high performance. However, they include "design for manufacturability" as the only technology-related variable. Thus, none of these HPM papers tests for interaction between TM and MS.

In conclusion, in general terms previous research has had fundamentally conceptual orientations. Likewise, the few existing empirical studies have not documented the impact of the MS-TM supplementary interaction on performance, as can be seen in the bibliography below (most of the studies related to supplementary interaction have been done from the accounting and not from the POM point-of-view). Because of this, it is not clear whether a supplementary relationship between MS and TM exists, or whether this interaction has any impact on operational performance. This research seeks to investigate possible impacts of the supplementary interaction between MS and TM on operational performance.

3. THEORETICAL BACKGROUND AND HYPOTHESES

It is a fact that manufacturing practices (MPs) impact on performance, whether positively or negatively, and although empirical confirmation of this may shed more light on fascinating inferences, it is a more interesting challenge to investigate how links between MPs contribute to setting plants on their paths toward high performance (Schroeder and Flynn, 2001).

In this respect, one important focus of investigation in POM has been to outline the impact of the link between different manufacturing practices on performance (e.g. Schroeder and Flynn, 2001). Following this line of research, this paper investigates whether a set of technology managerial practices and a set of MS practices influence each other in their relationship with performance. This work uses the concept of fit between the two practice groups. Broadly-speaking, fit means that congruency between two or more factors leads to improved performance (see Venkatraman and Prescott, 1990). This concept has also been proposed in other areas with other denominations (e.g. Aldrich, 1979).

In the following, a proposed 'matching' model and its respective hypotheses are described for the relationship being studied. This is done by conceptualising the role of the effect on performance of the interconnection between the practices in question from the perspective of *interaction* fit (Venkatraman, 1989; Delery and Doty, 1996). Interaction tries to measure an outcome in the link between two independent variables since both fits and misfits are expected in the link. The interaction form is discussed in more detail below. Most of the fit literature considered here is in keeping with contingency theory (e.g. Drazin and Van de Ven, 1985), which will be commented upon in 3.1.

3.1 Interaction fit

The Contingency Perspective has been a very important focus in empirical research and has generated a substantial body of knowledge (e.g. Chenhall 2003). It states that the effect of a factor cannot be universally superior in all contingent and organisational contexts. Thus its fundamental postulate is that one single better way of organising does not exist. Donaldson (1994) states that the concept of fit between structural and contextual (contingency) characteristics is at the core of contingency theory and that failure to achieve a fit would lead to inferior results.

Contingency studies in the nineteen-sixties and -seventies (Woodward, 1965; Van de Ven and Delbecq, 1974) concentrated on seeing how this fit was achieved from *selection* perspectives. The adjustment premise assumed in selection is congruency between two independent variables mutually influencing each other while operating in a plant. No outcome is measured since we expect no misfits in the two variable interrelationship. In other words, its possible impact on performance is not analysed. Although some researchers outlined hypotheses on dependencies between fit and effectiveness, these relationships were not usually conceptualised or evaluated. Over time this form of testing fit came to be questioned (e.g. Pennings, 1992) and it was argued that contingencies should be understood as relationships with a typical outcome, such as performance (Van de Ven and Drazin, 1985; Venkatraman, 1989), where effectiveness is the result of the interaction between at least two variables, generally one contextual and one structural (interaction perspective).

Research based on contingency has mainly focused on the study of fit assuming that managers act with the intention of adapting their organisations to changes in context to achieve fit and to increase performance. Although the contingency view is a very important focus in POM (e.g. Weill and Olson, 1989) the concept of fit, especially interaction, has been modelled in forms that limit statistical comparisons, since POM researchers mostly postulate relationships switching back and forward between interaction, moderation and contingency terms.

However, this paper does not seek to be critical of the seemingly simple explanations of contingency theory (e.g. Schoonhoven, 1981; Van de Ven and Drazin, 1985; Meilich, 2006)

because of vague predictions and an inability to make it work properly. It considers such drawbacks and tries to overcome them when modelling fit.

Two theoretical forms of fit are generally used to classify an investigation based on contingency: bivariate and systemic. The bivariate model examines the way in which contextual (contingent) factors are related to the structural aspects of plants (e.g. a manufacturing plan) connecting this association with performance (Drazin and Van de Ven, 1985). The systemic model considers the way in which multiple structural and contextual aspects combine in a variety of ways to improve performance (Chenhall, 2003). This research focuses on the development of methods for the bivariate model.

The bivariate model is used here because, within contingency, it incorporates and tests the unique and identifiable effects of contingent variables in their relationship with a company's structural characteristics in order to improve the outcome. This model contemplates two initially independent variables and one dependent variable. Going beyond contingency, our study examines two independent variables (MS and TM practice sets) to determine whether some type of interaction between the two exists. The goal is to detect whether these variables simultaneously play both contingent and structural roles in improving performance (our dependent variable). Although this is not the contingency perspective *per se*, but rather a fit type used within it, it serves as a starting point for comparison since the small amount of existing literature on the link between these practices (with their different approaches) has been written from within the contingency view (e.g. Bergeron and Raymond, 1995).

In contingency-based research, two ways of conceptualising bivariate fit commonly appear (Van de Ven and Drazin, 1985; Venkatraman, 1989): selection and interaction. Fit in POM may be given when the management tries to control or improve a manufacturing practice (MP1; in this paper, either a manufacturing strategy or a technology management practice set) by regulating or adapting its implementation level to take into account the implementation level of a second practice (MP2; in this paper, the corresponding set) and/or vice-versa (Drazin and Van de Ven, 1985). On the one hand, selection represents a congruence approach by testing the dependency between MP1 and MP2, without any examination of whether this relationship influences performance. In other words, it assumes implicitly that fit is the result of a natural selection process that ensures that only high performers survive to be observed at any point in time, and thus there is no need to test the link with performance (Drazin and Van de Ven, 1985).

On the other hand, interaction misfit between the two practices may occur when the MP1 implementation level does not easily adapt to that of MP2 and shows a wider range of adaptation variance with respect to the optimal level of MP2 implementation and/or vice-versa (i.e. misfit between the two practices sets). Specifically (see Figure 1), a given value of the MP2 implementation level may interact with different values of the MP1 implementation level and/or vice-versa, leading to different values of performance (P) changes. When this happens, there is a state of disequilibrium in the plant's performance due to a misfit between MPs. Figure 1 shows different performance values (optimal and lower performances) associated with different misfit levels between the two manufacturing practices. The optimal line shows better performances associated with highest fits (lowest misfits), while the different points of lower performances show worse performances associated with lowest fits (highest misfits).

Take in Figure 1

The effect on performance of misfit between practices may be seen as a waste of resources. That is, an effort has been made to implement a certain practice, but it is not providing all the potential benefits because the other practice has not followed in its own implementation. The suggested option would be to adjust both practices' implementations to the level of that which is more implemented, as the expected performance will be greater.

Furthermore, if we take MS and technology management (TM), TM may be a univariate variable ranging from a low level (-) to a high level (+) of implementation. MS design may also be measured with respect to "implementation level" ranging from low to high. Figures 2 and 3 illustrate the expected relationship between MS levels and performance for low and high levels of technology management implementation, respectively. An interaction form of fit is seen because the expected relationship between MS levels and performance differs between both low and high levels of TM, respectively (Drazin and Van de Ven, 1985). The alternative is also possible: TM implementation levels-performance differ from levels of the MS implementation relationship.

Take in Figure 2

Take in Figure 3

Two interaction forms, difference/matching (residual analysis or deviation score) and the multiplicative form, seem to dominate the contingency literature (Schoonhoven, 1981; Venkatraman, 1989; Pennings, 1992). In this paper, the interaction of matching may be summarised as distinguishing how close the equivalent implementation values of the MS set and the TM set are (Venkatraman, 1989, pp. 430-432). Hence, the causal relationship is between this type of fit and performance, where matching explains interaction as function changes of a curvilinear performance. Multiplicative interaction exists when the impact of one independent variable on performance differs for different values of the other independent variable, where interaction is described as gradients altered by functions of linear performance. This paper focuses on the matching form, based on the theoretical suppositions that are proposed in the following.

3.2 Proposals

As outlined above, there are different opinions in the literature regarding the nature of a possible relationship between MS and TM. However, this study focuses on examining the effect of the *interaction (matching)* between both sets of manufacturing practices on performance using a *fit theory*. The fit concept may explain why different practices affect specific performance measures. For example, if the goal of a plant is the cost reduction, a certain group of these practices may be the best choice. If, on the contrary, a plant wants to pursue high quality, a different group of practices may be better suited. Commonly, the co-alignment complexity between factors makes it difficult to foresee the nature of the specific interconnections. Moreover, the fit concept is not sufficiently developed in POM research for the combinations of practices that will lead to low costs or to improvements in any other performance measure to be prescribed exactly.

As already indicated, in order to achieve higher performance, manufacturing practices should somehow be linked in the way they are implemented. Hence, when a plant seeks to capitalise on the implementation of one of the practice sets in question (TM or MS), benefits will be maximised when the plant also implements practices from the other set. Thus, using the fit concept (Van de Ven and Drazin, 1985; Venkatraman, 1989), MS and TM will be examined within linked theoretical frameworks to enable both the effects of their combined implementation on performance, and their possible differential effects, to be studied. More specifically, when different practices of MS and TM are implemented in combination, a greater level of operational performance is presupposed. It is therefore assumed that manufacturing plants that have implemented dimensions of both MS and TM practice sets/areas, rather than a single practice set alone, may be classified as *high performers*.

As previously stated, the matching perspective will be used to test how MS and TM practice sets fit each other in a state of disequilibrium. This model is conceptually defined as the effective combination (coexistence) of two variables and although it does not specifically relate to an outcome, its effect on this may be examined. Together, these optimal combinations form a fit line,

where performance is assumed to be maximised when the levels of both MP sets fit each other. Thus, the fit line should coincide with a performance line denoting maximum performance at each level of the MP sets.

Hence, while the matching form assumes incremental changes in fit, the multiplicative interaction form cannot be used here since it only recognises two predictors that optimise performance (i.e. it implicitly assumes that performance is improved by fit, but fit as an optimal combination between both predictors is never conceptualised.). The implicit multiplicative fit may be one of hetero-performance, where maximal performance would vary. The multiplicative form tests the effect of a predictor on a dependent variable at one level of a second predictor with that at another level of this last predictor (Venkatraman, 1989; Jaccard and Turissi 2003, p 7).

Thus, incremental changes in any MS or TM set do not necessarily affect a plant's performance negatively, provided that measures are taken by the firm to adjust the level of implementation of the other MP set (TM or MS, respectively) accordingly. Drawing on Schoonhoven (1981), matching is an interaction form where performance increases when the MP1 level matches the equivalent value of the MP2 level (Figura 4).

Take in Figure 4

Although, matching entails that a "- & -" combination would be as effective as a "+ & +" combination, this seems less plausible in POM *a priori*. From Figura 4, performance is lower when there is misfit than when there is fit. In the latter case, it is expected that performance will be greater when the fit occurs at a higher level (+ & +) of implementation of the practices than at a lower level (- & -). However, when the implementation level of one of the practices is kept low, it is operationally better to keep the other low instead of having a misfit (- & + or + & -). This last option would mean a higher (i.e. optimal) performance than a misfit but not the highest expected performance.

Thus, the model may be supported if it can be demonstrated that -in a state of disequilibrium- plants using an MS practice set that is fitted to (or coincides with) a TM practice set achieve higher performance, while plants with the MS set misfitted to the TM set present lower performances.

In other respects, according to the results obtained by Ortega et al. (2008b), in which a degree of congruency/selection fit was found between the same MS and TM practice sets considered below, it can be anticipated that conditions for disequilibrium that would allow the matching fit to measure significant differences in performance do not exist. This does not mean that differences in performance between both plant groups (High Performers/World Class and Standard Performers) do not exist in real terms or that there is no interrelationship between the MP sets, but rather that an adaptation fit might exist due to possible similar efforts made to implement the MPs in both groups (Ortega, 2009).

Therefore, taking the above into account and assuming that there are no misfit conditions (where each value of MS cannot be assumed to be optimal for a certain value of TM), the following hypotheses are formulated:

> H1: *There is no matching fit between implementation levels of MS and TM practice sets*
> H2: *Even if there is no interaction, higher implementation levels of MS and TM are found in HPM*

4. METHODOLOGY
4.1. Data collection
The proposals mentioned in the previous sections were tested by means of a survey in plants from the auto supplier sector. The survey was conducted in ten countries across North America, Europe

and Asia within the framework of the international High Performance Manufacturing (HPM) project.

For each unit of analysis (the plant), the different scales of measurements and objective questions were arranged in a total of 12 questionnaires directed at 12 different positions within the company. The questionnaires were returned from a total of 21 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 plant workers and supervisors) and likewise of minimising 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 which scales were being used. Once the questions and scales were defined by the international HPM project, they were included in the questionnaires.

The questionnaires had been widely tested for reliability and validity. Nevertheless, during this study, the original questionnaires were the object of review in each national context to take into account potential contextual influences. The questionnaires contained around one thousand items, distributed over almost two thousand questions.

The process for surveys applied to the plants in this sample is explained as follows. Firstly, plants of at least 100 employees from a stratified sampling were asked to take part. Up to 60% of the plants contacted in all countries submitted data for the study. The final sample consisted of 90 plants with an average size of 867 workers.

4.2. Research variables and measurement

This study considers and defines operational performance, MS and TM with some of the constructs from the HPM project. The focus is on the competitive implications from relationships between practice clusters of both MS and TM and operational performance dimensions, and particularly on the impact of the link between both clusters on performance.

As production plants do not control financial measures of performance directly, this study will focus on the performance measures that are controlled at plant level, such as cost, quality, delivery and flexibility (see Hayes and Wheelwright, 1984; Roth and Miller, 1992; Ketokivi and Schroeder, 2004), which are the basic objectives of the production function (Skinner, 1969; Ferdows and De Meyer, 1990; Miller and Roth, 1994; Hutchison and Das, 2007). This paper will consider the following competitive performance dimensions (Schroeder and Flynn, 2001): unit cost of manufacturing; conformance of product to specifications; on-time delivery; fast delivery; flexibility of product mix; flexibility of product volume. These dimensions represent different scales of the above mentioned performance measures.

With regard to Manufacturing Strategy, Bates et al. (2001) explain that MS determines how the production area supports the general objectives of the company through the appropriate design and use of production resources and capacities (Roth and Miller, 1990; De Toni et al., 1992). In this support, it is essential to ensure the alignment of MS with both marketing strategy and business strategy (Schroeder and Flynn, 2001). In other respects, there are clear signs that manufacturing strategies play a fundamental role in the assessment of new technologies (Bates et al., 1995; Pretorius and Wet, 2000), since an analysis of appropriate technology can eliminate many risks and also because world-class technology is a key factor in global competitiveness. In other regards, taking the classic conception defined in strategy literature that distinguishes between processes and content (e.g. Swamidass and Newell, 1987; Weir et al., 2000; Dangayach and Deshmukh, 2001), it can be said that the formal strategic planning process is key to the formulation of manufacturing strategy. In this study, the following MS managerial practices are included (Bates et al., 1995; 2001; Sun and Hong, 2002): anticipation of new technologies, formal strategic planning, and the manufacturing-business strategy linkage.

Finally, as far as Technology Management is concerned, we agree with Maier and Schroeder (2001) when affirming that "technology" is concerned not only with its concrete aspects (equipment), but also with its entire context: manufacturing/process technology, product technology and information technology (IT). It is not our intention, however, to comprehensively consider all the variables that can be encompassed by the term Technology and their manufacturing practices. We have selected a number of these from the literature (Bates et al., 1995; Schroeder and Flynn, 2001; Maier and Schroeder, 2001; Matsui, 2002; McKone and Schroeder, 2002; Ahmad, Schroeder and Sinha, 2003) that meet the requisites of validity and reliability, to be specific: interfunctional design efforts, effective process implementation, and technology supplier involvement. The first is related to product technology and the other two are related to process technology (Schroeder and Flynn, 2001).

Thus, three groups of scales were used to measure operational performance, manufacturing strategy related practices, and technology related practices, respectively.

Most of the data are perceptual scales, each consisting of several questions (items). All the questions for performance were answered using a five-point Likert scale, whereas a seven-point Likert scale was used for both MS and TM. Thus, content and construct validity, the reliability of the operational performance indicators and the manufacturing strategy and technology management practice sets were then all checked.

According to Nunnally (1967), the measurement instrument for the study was developed from an extensive review of relevant literature on manufacturing practices. The content validity was reinforced by a panel of experts who reviewed each of the scales that were developed. 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 two broader concepts mentioned above (MS and TM). Thus, a second-order factor analysis was performed for each of the two super-scales to ensure that the set of scales formed corresponding unidimensional measures, (Hunter and Gerbing, 1982) as follows: Three scales were used to measure MS practices according to the definition of MP practices described earlier. These three scales were factor analysed to test that they were measuring a common construct, as seen in Table 1. The factor loadings of the scales were much higher than the cut-off value of ± 0.40 (Hair et al., 1998). In addition, the reliability of the super-scale was found to be 0.83, as shown in Table 1. Thus, the super-scale measuring MS is reliable and unidimensional with all of its scales contributing significantly to its construction.

A similar procedure was used to construct the technology super-scale from the 3 dimensions described earlier. Table 1 shows the results of the reliability and unidimensionality analyses. With regard to operational performance, a composite measure reflecting a plant's achievement in the six respective dimensions mentioned above was constructed in order to observe the total effectiveness of all four competitive priorities. Table 1 also shows that the composite performance measure is reliable and unidimensional. Furthermore, Table 1 also summarises the way the measures were distributed by respondent (or by group of respondents) in the plant. The natural numbers in the body of the Table indicate the number of responses for each category in each plant.

Table 1. Study scales and measures in questionnaires

Super scales and scales	Acc	PD	PM	PRM	PE	SU	Load Factor	Cronbach's Alpha
Manufacturing strategy								**0.83**
Anticipation of new technologies			1	1	1		0.78	
MS-BS link			1	1	1		0.91	
Formal strategic planning			1	1	1		0.90	
Technology management								**0.73**
Interfunctional design efforts		1			1	6	0.88	
Effective process implementation				1	1	6	0.79	
Technology supplier involvement		1					0.60	
Performance								**0.73**
Unit cost of manufacturing			1				0.53	
Product conformance to specifications			1				0.60	
On-time delivery performance			1				0.77	
Fast delivery			1				0.74	
Flexibility in changing product mix			1				0.56	
Flexibility in changing volume			1				0.71	

Acc: Accounts; PD: Product Develop. PM: Plant Manager; PRM: Production Manager; PE: Process Engineer; SU: Supervisor

Tables 2, 3 and 4 show the descriptive statistics for operational performance, MS and TM measures and super-scales, respectively.

Table 2. Average values of manufacturing performance measures

Measure	Av.	S.D.
Unit cost of manufacturing	3.25	0.85
Conformance to product specifications	3.88	0.71
On-time delivery performance	3.90	0.82
Fast delivery	3.70	0.80
Flexibility in changing product mix	3.89	0.70
Flexibility in changing volume	3.83	0.80
Composite performance	**22.20**	**3.15**

N =79; 5 point Likert scale

Table 3. Average values of manufacturing strategy measures

Measure	Av.	S.D.
Anticipation of New Technologies	5.13	0.74
Formal Strategic Planning	5.46	0.72
MS-Business Strategy link	5.49	0.63
Manufacturing strategy	**5.36**	**0.60**

N =89; 7 point Likert scale

Table 4. Average values of technology management measures

Measure	Av.	S.D.
Effective process implementation	5.05	0.62
Interfunctional design efforts	4.76	0.64
Technology supplier involvement	4.91	1.20
Technology management	**4.90**	**0.62**

N =79; 7 point Likert scale

4.3. Methods

To test interaction, we use multiple regression with an extra term added to the joint MP regression model. As already stated, if differences exist due to MP misfit, this term measures the direction and/or the strength of the relationship between the independent and dependent variables. Thus, using deviation score (Dewar and Werbel, 1979; Venkatraman, 1989, pp. 431-432) the hypothesis that the deviation between MS and TM (i.e. every MS-TM combination may produce two different deviation scores: MS on TM and TM on MS) has an impact on operational performance (P), is expressed in the following equation:

$$P = a_0 + a_1 MS + a_2 TM + a_3 \left| MS - TM \right| + \varepsilon_1 \qquad [1]$$

As seen from equation (1), the matching model is a realistic fit model, which theoretically mitigates possible multi-collinearity problems. Moreover, only the interaction term is added to the regression equation. P will be maximised[1] when MS comes close to TM (although the term is not defined for a situation where MS=TM). As the value of MS changes, the value of P decreases provided the value of TM is not adjusted accordingly. Thus, "for each level of the MS variable there is a corresponding level of TM variable, that is the fit (i.e. yields the highest performance)" (Donaldson 2003, p. 187). In a matching model, all fits are assumed to be equally good, i.e. they are assumed to produce the same performance (Donaldson 2003, p. 192). Therefore, in this model, the focus is on the combined $\left| MS - TM \right|$ effect where the additive form of this term is a linear function. If there are differences in performance due to a misfit, the interaction effect is measured by a_3: if it differs significantly from zero, this confirms that operational performance is a function of the matching fit between MS and TM.

The functional form of matching is curvilinear since this kind of interaction is studied mathematically as curved-linear functions (inverted U or V form, as in Figure 4). In a matching model, MP2 levels improve performance for some levels of MP1 and reduce it for others, thereby shifting the performance function. Figure 2 illustrates interaction in a matching model by displaying performance as a function of MP1 levels at different values of perceived MP2 levels. Considering implementation values of both the MP levels from 1 (lowest) to 5 (highest), the figure shows that a reduction in MP2 levels (e.g. from MP2 level=5 to MP2 level=4), reduces the positive effect of MP1 on performance when MP1 level = 5. However, when MP1 level<5, this increases the positive effect of MP1. The result is a shift in the curve and a new maximum position is established. Thus, in a matching model, the MP2 level always results in new maximum positions, where MP2 levels affect relationships between MP1-performance individually in different directions.

Take in figure 5

The suppositions of the functional form of matching are: a) that correspondence exists between deviation score and performance; b) that the value of the level of MP1at which higher performance occurs depends on the level of MP2; and c) that there is a detectable level of selection forces (a degree of congruency) between the levels of both MPs.

To operationalise the proposed model, the most commonly used technique will be used; analysis of deviation score[2] (Dewar and Werbel, 1979; Van de Ven and Drazin, 1985; Venkatraman, 1989). In order to confirm the results, an analysis of subgroups (based on performance) will be carried out.

---

[1] Assuming the sign of the regression coefficient is negative.
[2] Matching is also known as deviation score.

For the first technique, two two-stage procedures will be followed (a) MS on TM, and b) TM on MS):

　　1.　Finding the deviation scores, the $|MS\text{-}TM|$ term, as the residual value of the regressions of: a) MS on TM; and b) TM on MS.

　　2.　Regressions of the deviation scores of both "a" and "b" (stage 1) on operational performance.

　　Furthermore, it is both critically important and beneficial to study the interrelationships between manufacturing practices using multiple perspectives (e.g. Venkatraman, 1989; Gerdin and Greve, 2004), especially where research in the area is not yet conclusive in rejecting theories about interactions. This paper seeks to examine the proposed relationships by using multiple statistical tests within the same data set. Thus, we investigate whether matching interaction is appropriate with the consideration of confirmatory methods. Therefore, in order to determine whether MS and TM show interaction, this paper uses not only the fit concept of matching by regression, but also the alternative methods of subgroup analysis, where the sample was split into two performance subgroups: standard and high/world class performers, which are defined below. Then correlation and ANOVA may be used as follows.

a)　Correlation Subgroup Analysis: for the purposes of interaction this analysis can be based on the findings of Miles and Snow (1978) and Abernethy and Brownell (1999). Interaction fit is supported if there are significant differences in the subgroup correlation coefficients. After the two subgroups have been separated, the predictors (MS and TM, in our case) are then correlated with each other within each subgroup, examining differences in correlation between high and standard performers. In this way, it can be shown whether states of fit are more related to the achievement of higher performance than are states of misfit. This form of analysis also reveals some information on how much the predictor combinations affect performance. Thus, there is an analysis of differences in *strength*.

b)　Variance Subgroup Analysis: this second method involves a sample of plants, units or similar being split into a number of subgroups and their features then being compared. A test is performed to find whether the performance of 'fit' plants is greater than that of 'non-fit' plants. (Abernethy and Brownell, 1999). Here, with the subgroups consisting of high and standard performers, it is possible to show that levels of both predictors (MS and TM) are higher in the high performers' subgroup than the standard performers'. This technique allows it to be demonstrated that smaller deviations from the optimal combination of both predictors are related to higher performance than larger deviations. In addition, it reveals the nature of the relationship between both predictors.

　　It might be added that, in general terms, the use of the two alternative subgroup methods (correlation and variation analysis) for the matching interaction perspective may provide much more information than regression analysis by itself. On the one hand, the subgroup correlation analysis examines the differences in strength in the relationship by splitting the sample into high performers (HP) and standard performers (SP) and then correlating MS and TM within the groups. On the other hand, the subgroup variation analysis may show that, statistically, differences between HP and SP groups, whether significant or not, might be due to manufacturing practice area states of fit being related to high performance rather than states of misfit. If there is no misfit, this might mean that there is selection fit in the relationship. Should this be the case, a state of misfit could lead to the plant disappearing or reinventing itself in its industrial environment.

5.　RESULTS

　　With regard to the results of the analysis to test the first hypothesis (H1), the manufacturing strategy and technology management multiple linear regression in equation 1 (Section 4) was used

by taking deviation scores in two stages. It can be seen in Tables 6 & 7 that the matching term ($\lvert$**MS-TM**$\rvert$**)** does not present a significant result (p=0.1). Firstly, Table 5 shows the results from the regression of the MS deviation scores on TM while Table 6 shows those from the regression of the TM deviation scores on MS. In the first instance, these results would seem to show that there is no interrelationship between the two sets of practices, MS and TM. Nevertheless, they could indicate that there are no great differences in performance due to a misfit between manufacturing practices (MPs). This may confirm that there is no state of disequilibrium that might allow significant differences in performance to be measured by the matching model (regression model), which thus supports hypothesis H1. As will be seen in the following, the use of the two alternative matching models commented on in section 4 confirms this.

Table 5. Results of MS on TM matching regression

Measure	Value
Manufacturing strategy	2.604***
Technology management	0.419
$\lvert$MS-TM$\rvert$: MS on TM	0. 803
F	10.311***
R^2	0. 279
R^2 adjusted	0. 252

N =84; * P ≤ 0.1; **P ≤ 0.05; *** P ≤ 0.01

Table 6. Results of TM on MS matching regression

Measure	Value
Manufacturing strategy	2,458***
Technology management	0. 428
$\lvert$MS-TM$\rvert$: TM on MS	1.263
F	10.712***
R^2	0. 287
R^2 adjusted	0. 260

N =84; * P ≤ 0.1; **P ≤ 0.05; *** P ≤ 0.01

It might be important to note that TM is not significant either (p=0.1). This may imply that it has no impact on performance and also may affect interaction impacting on performance. Although, the TM set of practices does not have a significant impact on performance, all the plants would seem to have TM techniques integrated into their decision making process routines (Ortega et al., 2008a). In other words, TM is no longer an order winner, but an order qualifier in the auto supplier sector, where it must be well implemented in plants in order for them to survive.

On the other hand, to see whether the preceding hypothesis was confirmed, and to test H2 -any possible differences in the degree of fit between the MPs in the plants- we have used both subgroup analysis methods (e.g. Venkatraman, 1989). This analysis is used this study to reveal major differences among the groups of high and low performers and not to predict group membership of manufacturing plants.

We first conducted a test using subgroup correlation analysis of the HP plants and the SP plants (all remaining plants). HP plants were classified by objective measures, such as quality (customer satisfaction measure and percentage of products that pass the final inspection with no reprocessing), delivery (percentage of orders dispatched on time) and flexibility (product customisation). The result was the identification of ten HP plants, with the remaining 79 being SP.

It was observed in both HP and SP plants that MS is positively linked to TM, as the results show significant correlation coefficients for both groups (r=0.545; r=0.507, p≤ 0.01). The SP group results are not quite so strong, but there is no great difference from the other group. For example, when the two correlation coefficients are compared, Z=1.2347, which shows that there are no significant differences.

The foregoing results might seem to suggest that there is no interrelationship or that, if there is, it is weak, but in reality it shows no state of disequilibrium. This supports hypothesis H1. However, this does not imply that the interrelationship has no influence at all on performance. It implies, rather, that there are no significant differences between the groups for MP fit-based differences in their performance to be measured. This means that the interrelationship is extremely strong. The lower value of the correlation coefficient in SP plants could indicate a greater effort on their part to achieve the same performance achieved with interrelationship and lends support to H2.

Secondly, we used variation analysis to see if the previous results were supported. The results show averages for each variable, both for the HP plant group (performance 22.8, MS 5.39 and TM 4.69) and for the SP group (performance 22.12, MS 5.35 and TM 4.68). As can be seen, these averages for both groups (high and standard performers) are practically the same for every variable (Box test with significance >0.05 confirms the same statistical co-variance for both groups). This demonstrates that in the sector studied neither MS nor TM present significant differences between the two plant groups and thus adding weight to hypothesis H1. Furthermore, these results show slightly higher values for HP plants, supporting H2.

It is significant that it is TM that presents the smallest differences between the two groups. This might indicate that the MP is implemented to a very similar degree in the two plant groups and that, consequently, it does not have a significant effect on performance.

6. CONCLUSIONS AND FINAL CONSIDERATIONS

It can be concluded that a *manufacturing strategy-technology management matching fit is not present in the sector under study*. That is, organisational disequilibrium between both practice sets does not exist. Therefore, it was not possible to test whether states of misfit are more related to lower performance than states of fit. More precisely, there was no significant performance deviation from the high and lower implementation levels of the MS/TM relationship: no misfits that allow for performance differences to be tested for.

Furthermore, results demonstrate that there is a fit line, where fit at slightly lower implementation levels produces significantly the same performance as fit at higher levels between both manufacturing practice sets, with no significant differences between the two plant types (high performer, HP and standard performer, SP). The first of the three methods used (multiple regression) in an exploratory way shows that there is no interaction fit. The results of the two confirmatory tests validate the result and allow a better understanding of the fit to be gained, as explained in the following.

On the one hand, the correlation analysis shows that the high and standard performers have coefficients that do not differ significantly, supporting *a possible selection fit, instead of interaction*. However, they also show that the standard performers have the lowest coefficient, which might indicate that *a lesser relative level of implementation is made to fit the manufacturing practice areas in the SP group of plants and this is the reason why they are not HP*.

Meanwhile, the last method used (variation analysis) helps to demonstrate *that there are no significant differences within the plant groups with regard to practice implementation level and performance*. This indicates a degree of homogeneity between both groups (the slight difference that exists is to the benefit of the HP group). Therefore, these last two methods lead us to believe that *there is a strong selection interrelationship*, since both seem to confirm the *existence of congruency* instead of matching.

Thus, both subgroup analysis methods show signs of a positive relationship between the two manufacturing practice areas and performance, despite the fact that the degree to which they are implemented and performance are significantly similar in both high and standard performer plant groups. Furthermore, small non-significant differences found between both plant groups confirm that the *HP plants have* a slightly *greater differential of implementation level in the two practice sets, MS and TM, which may indicate that HPs can more easily* implement *the fit of both sets allowing them to focus on other areas of the plant*. This might indicate that the difference in MS and TM implementation levels between high and standard performers lies in efficiency rather than effectiveness: improved competitiveness leads to a reduction in effort or makes the implementation of manufacturing practices routine.

Hence, although combinations of high MS-TM implementations levels seem to have significantly the same performance as the lower implementation levels, results show that *the way MS and TM interact is more important for explaining the design/implementation levels of both practices sets.* Thus, from a practical and concrete point-of-view, *auto supplier plants will be able to have a more detailed understanding of the kind of interrelationship analysed and of the way to apply MS and TM to all of their plants*: beyond the matching interaction fit, this paper seems to show that *there is an association between MS and TM and that any state of misfit would lead to difficulties for survival or to a restructuring of the plant in a competitive environment* (i.e. a natural selection version of contingency theory).

As in any empirical research study, results and conclusions should be interpreted with caution due to the limitations of the techniques and constructs employed. On the one hand, there are some methodological problems with the deviation scores method. Firstly, the deviation scores method measures indiscriminately and puts actual deviations together with measurement and specification errors in predicting an MP variable (see Dewar and Werbel, 1979). Secondly, this approach hinges on an unspecified (medium) level of selection: selection forces need to be strong enough to mark out the baseline. When these forces are not so strong, performance differences between surviving organisations are too small to be detected. As stated above, this might be what has occurred here. However, correlation and ANOVA subgroups provide greater detail than deviation score.

Furthermore, showing a fit line, where there are similar implementation levels of both practices, may pose a question: why should a plant in this case change its level for either of the variables, especially when this means additional resources? This leaves the option to remodel the fit line as a hetero-performance line (i.e. multiplicative interaction), so that fits vary in their performance effects, providing an opportunity for further research. In particular, it could be tested if fits at higher levels of either predictor produce higher performances than fits at lower levels. Thus, if it were found that performance increases as plants move along the fit line, plants will be motivated to move along the fit line by investing in higher levels of either predictor.

Different results could be found in other sectors, where the relationship between MS and TM is vulnerable to strategic and technological changes which could lead to misfits between them. These cases are beyond the objectives of this paper and provide an opportunity for further research.

Furthermore, as this research relates to the auto supplier sector, it means that the results may enjoy a high inferential capacity for the population analysed. Thus, the similarity between high and standard performers may come from the auto supplier industrial characteristics, where the possible competitive situation may have changed MS and TM from an order winner to an order qualifier. Such a relationship could be a must rather than provide a competitive advantage; if anything it might help to achieve competitive parity. One possible explanation for this is that both types of plants may already have both TM and MS embedded in their decision making process routine. Hence, both types of plants may not have to devote as much effort to the implementation of the two MPs. Different results could be found in other sectors, where the relationship between MS and TM is vulnerable to strategic and technological changes that could lead to misfits between them. These cases are beyond the objectives of this paper and provide an opportunity for further research.

Finally, a second possible explanation for these results is that TM and MS measures in this study demonstrate efforts by management to implement them, but do not show the quality of their implementation.

Consequently, future analysis is recommended in other sectors to further test this interrelationship. This research also leaves IT dimensions aside for future research as IT-related practices were outside the scope of this paper. Furthermore, other MS and TM dimensions and other factors may influence operational performance. This paper was not intended to conduct a study of these factors.

These limitations provide an opportunity for future research using possible natural extensions of the bivariate fit perspective. One of these is the systemic perspective, which allows a broader holistic view of the plants.

REFERENCES

Abernethy, A. and Brownell, P. (1999), "The role of budgets in organizations facing strategic change: an exploratory study", *Accounting, Organizations and Society*, Vol. 24, pp. 189-204

Aldrich, H. (1979), *Organizations and Environments*, Prentice-Hall, Englewood Cliffs, NJ.

Alfalla-Luque, R. and Medina-Lopez, C. (2009). "Supply Chain Management: Unheard of in the 1970s, core to today's company", *Business History*, Vol. 51 No 2, pp. 202-221.

Bates, K, Blackmon, K., Flynn, E. and Voss, C. (2001), "Manufacturing Strategy: Building Capability for Dynamic Markets", in Schroeder, R. and Flynn, B. (Eds.), *High Performance Manufacturing-Global Perspectives*, John Wiley & Sons, Inc., New York, pp. 42-72.

Bates, K., Amundson, S., Morris, W. and Schroeder, R. (1995), "The Crucial Interrelationship between Manufacturing Strategy and Organizational Culture", *Management Science*, Vol. 41 No. 10, pp. 1565-80.

Bergeron, F. and Raymond, L. (1995), "The contribution of IT to the bottom line: a contingency perspective of strategic dimensions", *Proceedings of the 16th International Conference on Information Systems*, Amsterdam, pp. 167-81.

Chenhall, R.H. (2003), "Management control systems design within its organizational context: findings from contingency-based research and directions for the future", *Accounting, Organizations and Society*, Vol. 28, pp. 127–68.

Chenhall, R.H. and Morris, D. (1986), "The impact of structure, environment and interdependencies on the perceived usefulness of management accounting systems", *Accounting Review*, Vol. 61, pp. 16–35.

Dangayach, G. and Deshmukh, S. (2001), "Manufacturing strategy. Literature review and some issues", *International Journal of Operations & Production Management*, Vol. 21 No. 7, pp. 884-932.

De Toni, A., Filippini, R. and Forza, C. (1992), "Manufacturing Strategy in Global Markets: An Operations Management Model", *International Journal of Operations & Productions Management*, Vol. 12 No. 4, pp. 7-18.

Delery, J. and Doty, D. (1996), "Modes of theorizing in strategic human resource management: Tests of universalistic, contingency, and configurational performance predictions", *Academy Management Journal*, 39 No.4, pp. 802–35.

Dewar, R.D., and Werbel, J. (1979), "Universalistic and contingency predictions of employee satisfaction and conflict", *Administrative Science Quarterly*, Vol. 24, pp. 426-448.

Donaldson, L. (1994), *Contingency theory*, Dartmouth, Aldershot, UK.

Donaldson, L. (2003), "Organizational Theory as a Positive Science", in Tsoukas, H. and Knudsen, C. (Eds.), *The Oxford Handbook of Organization Theory: Meta-theoretical Perspectives*, Oxford University Press, Oxford, pp. 39-62.

Drazin, R. and Van de Ven, A.H. (1985), "Alternative forms of fit in contingency theory", *Administrative Science Quarterly*, Vol. 30, pp. 514-39.

Ferdows, K. and De Meyer, A. (1990), "Lasting Improvements in Manufacturing Performance: In Search of New Theory", *Journal of Operations Management*, Vol. 9 No. 2, pp. 168-84.

Filippini, R. (1997), "Operations Management Research: Some Reflections on Evolution, Models and Empirical Studies in O.M.", *International Journal of Operations and Production Management*, Vol. 17 No. 7, pp. 655-70.

Filippini, R, Vinelli, A. and Voss, C. (2001), "Paths of Improvement in Plant Operations", in Schroeder, R. and Flynn, B. (Eds.), *High Performance Manufacturing-Global Perspectives*, John Wiley & Sons, Inc., New York, pp. 19-40.

Filippini, R., Forza, C. and Vinelli, A. (1998), "Sequences of Operational Improvements: Some Empirical Evidence", *International Journal of Operations and Production Management*, 18 No. 2, pp. 195-207.

Filippini, R., Forza, C. and Vinelli, A. (1996), "Improvement initiative paths in operations", *Integrated Manufacturing Systems*, Vol. 7 No 2, pp. 67–76.

Forza, C. (1996), "Work Organization in Lean Production and Traditional Plants: What Are the Differences?" *International Journal of Operations and Production Management*, 16 No. 2, pp. 43-63.

Forza, C., and Salvador, F. (2000), "Assessing Some Distinctive Dimensions of Performance Feedback Information in High Performing Plants", *International Journal of Operations and Production Management,* 20 No. 3, pp. 359-85.

Foster, R. (1986), "Working the S-Curve—Assessing Technological Threats", *Research Management*, Vol. 29, 17–20.

Gerdin, J. and Greve, J. (2004), "Forms of contingency fit in management accounting research—a critical review", *Accounting, Organizations and Society*, Vol. 29, pp. 303–26.

Hambrick, D., MacMillian, I.C. and Barbosa, R.R. (1983), "Business Unit Strategy and Changes in Product R&D Budget", *Management Science*, Vol. 2, 757–60.

Hutchison, J. and Das, S.R. (2007), "Examining a firm's decisions with a contingency framework for manufacturing flexibility", *International Journal of Operations and Production Management*, Vol. 27 No. 2, pp. 159-80.

Hayes R.H. (1985), "Strategic planning - forward in reverse?", *Harvard Business Review*, Vol. 63, pp. 67-77.

Hayes, R.H. and Wheelwright, S.C. (1984), *Restoring Our Competitive Edge: Competing Through Manufacturing*, Wiley, New York.

Hofer, C.W. and Schendel, D. (1978), *Strategy Formulation: Analytical Concepts*, West Publishing, St. Paul, MN.

Itami, H. and Numagami, T. (1992), "Dynamic Interaction between Strategy and Technology", *Strategic Management Journal*, Vol. 13, pp. 119–36.

Jaccard, J. and Turissi, R. (2003), *Interaction effects in multiple regression* (2nd Ed.), Sage Publications, Thousand Oaks, CA.

Ketokivi, M. and Schroeder, R.G. (2004), "Manufacturing practices, strategic fit and performance. A routine-based view", *International Journal of Operations & Production Management*, Vol. 24 No. 2, pp. 171-91.

Maidique, M.A. and Patch, B.J. (1988), "Corporate Strategy and Technology Policy", in Tushman and Moore (Eds.), *Readings in Management of Innovation* (2nd Ed.), Ballinger, Cambridge, MA, pp. 236–48.

Maier, F. (1997), "Competitiveness of German manufacturing industry-An international comparison", in Powell, R.E., Olson D.L. and Flores B.E. (Eds.), *1997 Proceedings Decision Science Institute* – Vol. 3 POM - Manufacturing, San Diego 1997, pp. 1171-73.

Maier, F. and Schroeder, R. (2001), "Competitive Product and Process Technology", in Schroeder and Flynn (Eds.), *High Performance Manufacturing-Global Perspectives*, John Wiley & Sons, Inc., New York, pp. 74-114.

Matsui, Y. (2002), "Contribution of manufacturing departments to technology development: An empirical analysis for machinery, electrical and electronics, and automobile plants in Japan", *International Journal of Production Economics* Vol. 80, pp. 185–97.

McKone, K.E. and Schroeder, R.G. (2002), "A plant's technology emphasis and approach. A contextual view", *International Journal of Operations & Production Management*, Vol. 22 No. 7, pp. 772-92.

Meilich, O. (2006), "Bivariate Models of Fit in Contingency Theory. Critique and a Polynomial Regression Alternative", *Organizational Research Methods*, Vol. 9 No. 2, pp. 161-93.

Miles, R.E., and Snow, C.C. (1978), *Organizational strategy, structure, and process*, McGraw-Hill, New York.

Miller J.G. and Roth A.V. (1994), "A taxonomy of manufacturing strategies", *Management Science*, Vol. 40, pp. 285-304.

Morita, M., and Flynn, E.J. (1997), "The Linking among Management Systems, Practices and Behavior in Successful Manufacturing Strategy", *International Journal of Operations and Management*, Vol. 17 No. 10, pp. 967-93.

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

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

Ortega, C.H., (2009), Manufacturing Strategy-Technology Link in the Honduran Industry: Selection Fit (In Spanish). Economía Política (Now Economía y Administración), 47 (2), 133-148.

Ortega, C.H., Garrido, P., Machuca, J.A.D. and Perez J. (2008a), "A Look at Technology and Manufacturing Strategy in the Automotive Supplier Sector", in Amasaka, A., Matsui, Y., Matsuo, H. and Morita, M., *Manufacturing Fundamentals: Necessity and Sufficiency*, Vol. 3 No. 3, pp. 730-44*, ISBN978-4-88361-646-6 C3834.

Ortega, C.H., Machuca, J.A.D., Garrido, P. and Perez J. (2008b), "Congruency Between Manufacturing Strategy and Technology in the Automotive Component Sector", in Amasaka, A., Matsui, Y., Matsuo, H. and Morita, M., *Manufacturing Fundamentals: Necessity and Sufficiency*, Vol. 3 No. 3, pp. 714-29*, ISBN978-4-88361-646-6 C3834.

Parker, A. (2000), "Impact on the Organizational Performance of the Strategy-Technology Policy Interaction", *Journal of Business Research*, Vo. 47, pp. 55–64.

Parthasarthy, R. and Sethi, S. (1993), "Relating strategy and structure to flexible automation: a test of fit and performance implications", *Strategic Management Journal*, Vol. 14, pp. 529–49.

Pennings J.M., (1992), "Structural contingency theory: a reappraisal", *Research in Organizational Behavior*, Vol.14, pp. 267-309.

Porter, M. E. (1983), "The Technological Dimension of Competitive Strategy", in Rosenbloom, R. S. (Ed.), *Research on Technological Innovation, Management, and Policy*, Jai, Greenwich, CT., pp. 1–33.

Porter, M. E. (1985), *Competitive Advantage—Creating and Sustaining Superior Performance*, Free Press, New York.

Pretorius, M and Wet, G. (2000), "A model for the assessment of new technology for the manufacturing enterprise", *Technovation*, Vol. 20, pp. 3–10.

Roca, V. and 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*, Vol. 12 No. 3, pp. 41-62.

Roth, A.V. and Miller, J.G. (1992), "Success factors in manufacturing", *Business Horizons*, Vol. 35 No. 4, pp.73–81.

Roth, A.V. and Miller, J.G. (1990), "Manufacturing strategy, manufacturing strength, managerial success and economic outcomes", in J. G. Ettlie, M. C. Burstein and A. Feigenbaum (Eds.), *Manufacturing Strategy: The research agenda for the next decade*, Kluwer, Boston, MA pp. 97-109.

Schoonhoven, C. B., (1981), "Problems with contingency theory: Testing assumptions hidden with the language of contingency theory", *Administrative Science Quarterly*, Vol. 26, pp. 349-77.

Schroeder, R.G. and Flynn, B. (Eds.) (2001), *High Performance Manufacturing-Global Perspectives*, John Wiley & Sons, Inc., New York.

Skinner, W. (1969), "Manufacturing - Missing Link in Corporate Strategy", *Harvard Business Review,* May-June, pp. 136-145.

Sun, H. and Hong, C. (2002), "The alignment between manufacturing and business strategies: its influence on business performance", *Technovation*, Vol. 22, pp. 699–705.

Swamidass, P. and Newell, T. (1987), "Manufacturing strategy, environmental uncertainty and performance: A path analytic model", *Management Science*, Vol. 33 No. 4, pp. 509-24.

Van de Ven, A.H. and Delbecq, A.L. (1974), "A task contingent model of work-unit structure", *Administrative Science Quarterly*, Vol. 192, pp. 183-97.

Van de Ven, A.H. and Drazin, R. (1985), "The concept of fit in contingency theory", in Staw, B.M. and Cummings, L.L. (Eds.), *Research in Organizational Behavior*, JAI Press, Greenwich, CT, pp. 215-55.

Venkatraman, N. (1989), "The concept of fit in strategy research: toward verbal and statistical correspondence", *Academy of Management Review*, 14, pp. 423–44.

Venkatraman, N. and Prescott, J.E., (1990), "Environment-strategy coalignment: an empirical test of its performance implications", *Strategic Management Journal*, Vol. 11 No. 1, pp. 1–23.

Weill, P. and Olson, M. (1989), "An assessment of the contingency theory of management information systems", *Journal of Management Information Systems*, Vol. 6 No. 1, pp. 59-85.

Weir, K., Kochhar, A., Lebeau, S. and Edgeley, D. (2000), "An Empirical Study of the Alignment between Manufacturing and Marketing Strategies", *Long Range Planning*, Vol. 33 No. 6, pp. 831-48.

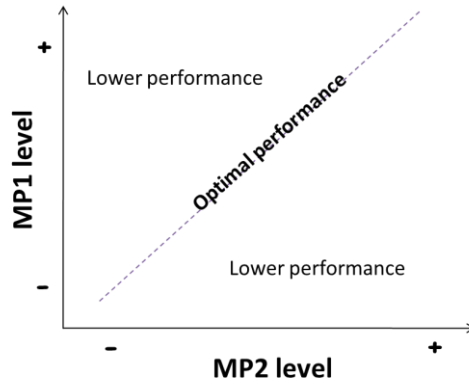Woodward, J. (1965), *Industrial organization: Theory and Practice*, Oxford University Press, London.

Figure 1. Interaction fit
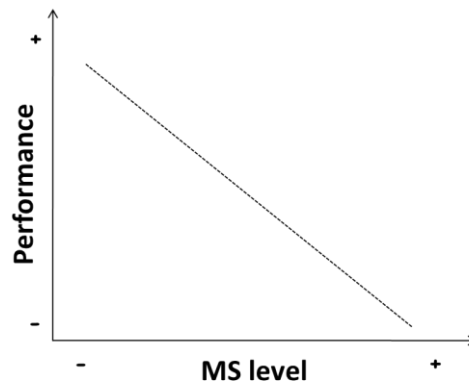(Adapted from Gerdin & Greve, 2004)

Figure 2. Interaction fit: Low level TM
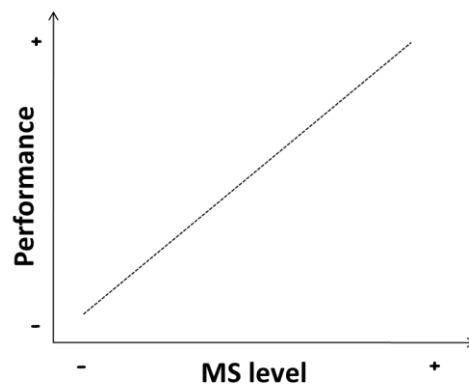(Adapted from Gerdin & Greve, 2004)

Figure 3. Interaction fit: High level TM
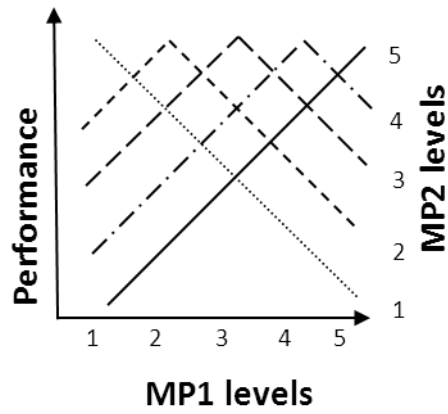(Adapted from Gerdin & Greve, 2004)

Figure 4. MP1 level performance at different MP2 implementation levels (matching)
(Adapted from Chenhall and Morris, 1986)

Figure 5. Matching Fit
(Adapted from Venkatraman, 1989)