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IT Integration, Operations Flexibility and Performance: An Empirical Study

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Abstract:

Purpose: This study examines the relationship between IT implementation and performance with manufacturing flexibility based on a sample drawn from a set of manufacturing firms.

Design/methodology/approach: The relationships were analyzed using structural equations modelling (SEM) using EQS 6.2 software. Previously, an explanatory factor analysis confirmed one-dimensionality of the scales, Cronbach's alpha was calculated to evaluate its internal consistency and a confirmatory factor analysis was run to observe scales' validity.

Findings: This research proves a significant positive and direct effect of IT implementation on operations performance with 4 out of 6 flexibility dimensions (Machine, Labour, Material handling and Volume). Mix and Routing flexibility dimensions show no significant impact on firm performance.

Research limitations/implications: It is necessary to be cautious when generalizing this findings these findings, as service firms were not part of the sample even when statistical results prove robustness suggesting that the findings are quite reliable. Some flexibility dimensions show no significant impact in performance (Routing and Mix flexibility). This is consistent with the fact that these flexibility dimensions act as variability absorbers within the manufacturing process.

Future research lines: Future studies can focus on determining further internal and environmental factors that affect operations flexibility according to specific sector characteristics.

Originality/value: This research proves a significant positive and direct effect of IT implementation on operations performance. Results show not only the links between IT implementation and operations performance, but also the magnitude of every impact. The model considers IT integration as the degree of alignment that existing technology resources in a firm have with the business strategy, in terms of importance and support for this strategy.

Keywords: IT integration, manufacturing flexibility, performance, strategy, complementarity perspective

1. Introduction

In the last decades, operations and manufacturing flexibility has received an increasing attention in literature due to its crucial importance for maintaining a competitive advantage that leads to higher levels of performance (Oke, 2005). In today's uncertain and changing environment, manufacturing flexibility plays an essential role related to supply chain management, especially regarding the process of rapid and constant introduction of new products on the market (Stevens, 1989; Markus, Steinfield & Wigand, 2006; Numilaakso, 2008). In this context, different studies have analyzed whether it is advisable for firms to adopt and invest in Information Technologies (IT) that allows a better supply chain integration with suppliers and customers not only in terms of information exchange but also for resources optimization (see among others Ageron, Gunasekaran & Spalanzi, 2013; Chan & Chan, 2009; Vickery, Droge, Setia & Sambamurthy, 2010; Zhang & Dhaliwal, 2009). Literature supports the strategic value of IT by stressing the capability of IT's to receive, process, and transmit information in real time, thereby facilitating coordination, flexibility, optimization and decision making in real time (Sanders & Premus, 2002; Vickery et al., 2010; Zhang & Dhaliwal, 2009). Hence, IT and operations flexibility are undeniably a strategic priority for firms (Sawhney, 2006). Hence, IT and operations flexibility are undeniably a strategic priority for firms (Sawhney, 2006). The relationship between IT and manufacturing flexibility has been analyzed from different external and internal perspectives. While some studies tackle the strategic capability of IT's from its capability to determine the competitive priorities of the firm to increase competitiveness (Arias-Aranda, 2003); other studies start from an internal focus and sustain that the firm's resources and capabilities with IT integration directly increase competitiveness of the firm (Schmenner & Tatikonda, 2005). Despite this difference, recent literature has analyzed these elements within the supply chain perspective outlining the impact of internal lacks and weaknesses when IT implementation is not aligned with manufacturing and supply processes (Ranganathan, Dhaliwal & Teo, 2004; Vickery et al., 2010). This fact is especially compelling when it involves firms configuring common parts of the supply chain (Zhang & Dhaliwal, 2009).

This study examines the relationship between IT implementation and performance with manufacturing flexibility. IT implementation is a costly investment for firms which could lead to support the development of manufacturing flexibility and to obtain higher levels of performance (Giménez, Van der Vaart & van Donk, 2012). IT integration and flexibility have been considered as antecedents for achieving agility in the supply chain in previous studies (Swafford, Ghosh & Murthy, 2008). It is essential to develop in greater depth the idea that supply chain can involve multiple organizations with cross effects in performance. Internal integration can improve the different dimensions of flexibility and, as a result, improve internal efficiency, increasing performance for the supply chain. Based on these considerations, our conceptual model does not attribute direct impact on performance to IT per se but instead views it as adding competitive value to operating performance with the action of flexibility. From an academic perspective, this study provides an analysis of operating flexibility from a perspective of complementarity among organizational resources to increase performance.

This paper is structured as follows. In the next section, the theoretical basis of IT, manufacturing flexibility and performance is presented as well as an analysis of the linkages among them from the perspective of the complementarity approach (Milgrom & Roberts, 1995) and the Theory of Resources and Capabilities (Nelson & Winter, 1992) to state the hypotheses of the study. The next section presents the research methodology, sample and data collection as well as the measurement of the different variables involved in the study. After that, results will be discussed. In the last section, the implications of the findings, limitations of the study and academic and practitioners implications will be disclosed together with limitations of the study and future lines of research.

2. Theoretical Review and Hypothesis Development

2.1. Integration of Information Technologies into Business Strategy and its Impact on Operating Flexibility

IT integration impact on performance has been analyzed considering different IT dimensions such as investment in IT, adoption of specific information systems, and IT infrastructure (Mitra & Chaya, 1996; Tam, 1998). There are studies that consider management aspects directly affected by IT implementation such as management abilities, employee training or knowledge management (Ranganathan et al., 2004; Bhatt, Grover & Grover, 2005). Recently, practices of integration with “key” customers have received specific attention regarding its high complexity (Giménez et al., 2012).

Literature has shown the positive relationship between investment in IT, productivity, profitability, and even customer satisfaction (Hitt & Brynjolfsson, 1996). However, more recent studies suggest that IT benefits are strengthened only when synergy with other investments or complementary resources are achieved not only within business processes but also amidst capabilities (Ray, Muhanna & Barney, 2005; Tanriverdi, 2006; Zhu, 2002). In terms of the strategic goal of the IT integration process, Ranganathan et al. (2004) findings support the fact that IT implementation ameliorates the firm's internal operations (e-business intranets) while improving supply chain even in e-business extranets. In both cases, there are cross effects from internal and external outcomes (Melville, Kraemer & Gurbaxani, 2004; Zhang & Dhaliwal, 2009). Some of these internal outcomes are related to organizational issues for internal diffusion of IT such as formalization of IT deployment, knowledge management as well as integration of manager's abilities (Barney, 1991; Swanson, 1994). External outcomes are more related to technological issues for IT external diffusion among suppliers, customers, partners, etc (Chwelos, Benbasar & Dexter, 2001). The intensity of the interdependence of the firm with its suppliers, customers or partners will shape the intensity with which they deploy ITs in the supply chain (Zhu, Kraemer & Xu, 2006). Hence, the intensity of competence, or the so-called "positive effect of competence" drives other firms to adopt technologies to improve their operating efficiency and coordination with other partners in the supply chain increasing the intensity of IT integration deployed throughout the supply chain (Zhu et al., 2006).

Operations flexibility as competitive priority has received plenty of attention from the academic community in the last decades for manufacturing as well as service industries. Despite there has been a clear evolution in the concept still no clear consensus about the definition of flexibility has been settled (see among others Baykasoglu & Özbakir, 2008; Beach, Muhlemann, Price, Paterson & Sharp, 2000; Francas, Kremer, Minner & Friese, 2009; Koste & Malhotra, 1999; Mihi-Ramírez, García-Morales, Arias-Aranda, 2012; Oke, 2005; Prahalad & Hamel, 1990; Sethi & Sethi, 1990; Teece, Pisano & Shuen, 1997; De Toni & Tonchia, 1998; Upton, 1997; Vokurka & O'Leary-Kelli, 2000). Notwithstanding, all studies agree that flexible organizations are those which have developed the ability to generate new products rapidly and often that are able to vary production volume without incurring into higher costs, time, or performance. Therefore, operations flexibility allows firms to respond to threats from competitors and fulfil customer's expectations in time and place (Swafford et al., 2008; Upton, 1997; Zhang, Vonderembse & Lim, 2003).

There is a growing interest in literature to determine how IT implementation influences operations flexibility (Mihi-Ramírez, García-Morales, Arias-Aranda, 2012; Petersen, Handfield & Ragatz, 2005; Soroor, Tarokh & Keshtgary, 2009). IT integration requires high levels of coordination among all functional areas of the firm as well as full cohesion of activities and processes with customers, partners and suppliers in order to achieve a common improvement of performance (Avittathur & Swamidass, 2007; Flynn, Huo & Zhao, 2010; Frohlich & Westbrook, 2001; Petersen et al., 2005; Stank, Keller & Daugherty, 2001). In this context, Swafford, Ghosh and Murthy (2006) found a direct and positive relationship between the agility of a firm's supply chain and the flexibility of the supply chain processes.

This relationship is reinforced when operations and other functional processes are previously integrated such like inventory management, new product development and even interfunctional relations (Das, Narasimham & Talluri, 2006) which drives the firm towards optimizing the IT adoption and implementation process (Zhang, Vonderembse & Cao, 2006). Consequently, integration of IT in the business strategy for decision making and improvement in internal efficiency involves higher flexibility due to an increased real time control and effectiveness in decision making regarding production planning and programming among others (Jin, Vonderembse, Ragu-Nathan & Smith, 2014).

Gerwin (1993) identifies 7 dimensions of manufacturing flexibility accordingly to different types of uncertainty and strategic goals. These dimensions help operations managers to prioritize which dimension(s) of flexibility must be strengthened according to achieve every strategic goal. Table 1 shows how the initial four dimensions of flexibility are associated with market-oriented uncertainties, particularly those related to products demand. The next three dimensions are more related to uncertainties regarding manufacturing processes (see Table 1).

Dimension of Flexibility	Type of Uncertainty	Strategic Goal
Mix flexibility	Market acceptance of different types of products	Diverse product line
Product innovation flexibility	Length of product life cycle	Product innovation
Product modification flexibility	Specific characteristics of the product	Response to customer expectations
Volume flexibility	Aggregate product demand	Market share
Process routing flexibility	Inactive machines	Customer due date
Material flexibility	Characteristics of materials	Product quality
Response flexibility	Changes in the uncertainties mentioned	Strategic adaptability

Table 1. Manufacturing flexibility dimensions (Gerwin, 1993)

Information Technology implementation in the supply chain plays a crucial and strategic role in collaborative partnering as it enables integration of the information for improvements in products, quality, and flow of materials among others. It also leads to optimization of space availability, teamwork, improved productivity, and increased product and process flexibility (Stevenson & Spring, 2007; Soroor et al., 2009). Most of these benefits are derived from adjustability in manufacturing programming, provision of materials, and planning of delivery deadlines (Jin et al., 2014).

This integration needs a high level of involvements from all areas of the firm and partners within the added value chain (Liu, Shah & Schroeder, 2012). Once the products are manufactured, subsequent functions involving distribution up to the end customer must ensure that delivery occurs within the terms and deadlines agreed upon. To fulfil this multidisciplinary effort, the firm must assume a level of uncertainty derived from its internal (mistakes, delays, defective materials, etc.) as well as external environment (demand and/or supply variability), which can have a direct impact on the flexibility level of the entire production system. It is important to consider the multiple relationships of interdependence both within and outside the firm, as uncertainties have the potential to expand throughout the chain (De Toni & Tonchia, 2005; Handfield & Nichols, 2002; Sawhney, 2006).

Firms can thus face uncertainty and variability based on the strategic orientation of flexibility:

- Reactive orientation: in this case, developing flexibility involves the ability to fit production to market demand with the least time and cost (Beach et al., 2000; Collins, Cordon & Julien, 1998; Gerwin, 1993; Gupta & Somers, 1996; Iravani, Van Oyen & Sims, 2005; Mackenzie, 1998; Milliken, 1987; Schmenner & Tatikonda, 2005; Swamidas & Newell, 1987).

- Proactive orientation: flexibility seeks to generate competitive advantages by developing abilities that enable the firm to focus products to a market niche, adapt the product to the consumers requirements, or increasing innovativeness (Bolwijn & Kumpe, 1990; Sawhney, 2006).

Stevenson and Spring (2007) structure 21 dimensions of flexibility in a hierarchy with 4 levels: operations, tactical, strategic, and supply chain levels. The first three levels are bound to manufacturing flexibility while supply chain covers a wider aspect of flexibility. From these dimensions, Zhang et al. (2003) consider machine, labor, routing, and material handling flexibility (operations flexibility) as competences and mix and volume flexibility as capabilities (tactical flexibility). For these authors, the competences impact performance through flexibility as shown in Table 2. From the perspective of competitiveness, volume and mix flexibility are considered crucial as capabilities referred to short term reaction to variability in order volumes while the rest of the dimensions are more related to long term counteraction as they generate abilities for adapting resources that previously required high levels of financial compromise (Cox, 1989; New, 1996; Oke, 2003; Zhang et al., 2003).

Competences
• Machine flexibility: ability of a part of the team to perform different operations efficiently and economically. • Labor flexibility: ability of labour to perform a wide range of functions efficiently and economically. • Material handling flexibility: ability to transport different parts among various work centers through multiple routes efficiently and economically. • Routing flexibility: ability to process a set of parts using multiple routes efficiently and effectively.
Capabilities
• Product modification flexibility • Mix flexibility: ability to handle a wide range of products efficiently and economically, given a certain volume. • Volume flexibility: ability to increase or decrease the aggregate production level

Table 2. Competences and capabilities for Manufacturing flexibility dimensions (Zhang et al., 2003)

Flexibility as a competitive priority concerns operations strategy processes to build capabilities for anticipating the firm's current needs (Hayes & Wheelwright, 1984; Urgal-González & García-Vázquez, 2007) through the practice known as production proactivity (Ward, Leong & Boyer, 1994; Chang, Lin, Chen & Huang, 2005). This practice generates commitment to continuous technological advances, development of multidisciplinary teams, and integration of production into the functions of marketing and design. Operations, machinery, process routes, tasks, product, work, material, program, and expansion of production influence as well the generation of new strategic capabilities. Managers need to find the right mix in the operations flexibility dimensions according to the strategic goals. Chang et al. (2005) found that dimensions that affect internal efficiency, such as Flexibility of Machines, Flexibility of Components, Flexibility of Material, or Routing Flexibility affect positively efficiency in fulfilling customers demand, while dimensions such as mix and volume flexibility have a positive impact when dealing with uncertainties in the environment and demand variations (Chang et al., 2005). Hence, from the strategic point of view, the flexibility dimensions have a direct impact on operational performance (Bustinza-Sánchez, Molina-Fernandez & Arias-Aranda, 2010).

Based on the foregoing theoretical review and following the framework provided by Zhang et al. (2003) of flexible manufacturing competencies and capabilities the present study intends to analyze the distinct relationships between It integration, the different dimensions of flexibility and performance to establish the following hypothesis:

H1a. An increase in the degree of IT integration increases machine flexibility.

H1b. An increase in the degree of IT integration increases labour flexibility.

H1c. An increase in the degree of IT integration increases material handling flexibility.

H1d. An increase in the degree of IT integration increases routing flexibility.

H1e. An increase in the degree of IT integration increases volume flexibility.

H1f. An increase in the degree of IT integration increases material mix flexibility.

This hypothesis is subdivided in 12 sub-hypotheses, one for every relationship between the main constructs and the different dimensions of operations flexibility as shown is Figure 1.

H2a. Machine flexibility is positively related to performance.

H2b. Labour flexibility is positively related to performance.

H2c. Material handling flexibility is positively related to performance.

H2d. Routing flexibility is positively related to performance.

H2e. Volume flexibility is positively related to performance.

H2f. Mix flexibility is positively related to performance.

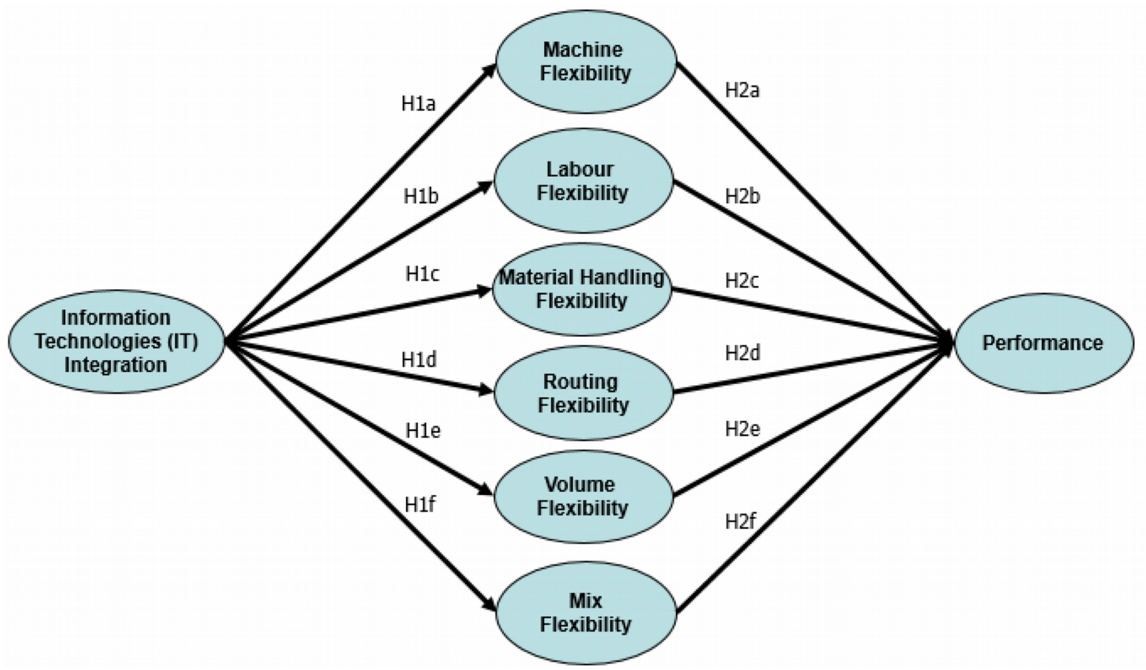

Figure 1. Conceptual Model

3. Methodology

3.1. Data Samples and Scales

This study is based on a sample drawn from a set of manufacturing firms from the SABI database. The data collection process was based entirely on a telephone survey. A pilot test with ten firms was performed in the initial questionnaire in order to ensure a clear understanding of the questions and items included. During the next stage, production, quality and operations managers were interviewed and informed about the research. 1,032 firms were contacted obtaining 201 valid surveys with a response rate of 19.47 per cent, and an estimated sampling error of 5.47 per cent. Next we analyze the possible non-respondent bias. For this purpose, we run t-tests to observe the difference between early and late respondents in the variables sales volume, number of employees and industry. Results did not indicate any significant difference between both groups. Thus, both groups of respondents do not introduce significant bias into the results of this research. Finally, we also analyze the common method variance (CMV). For this purpose, we performed a confirmatory factor analysis (CFA) to Harman's one factor test (Podsakoff, Mackenzie, Lee & Podsakoff, 2003). If all the items are significantly related to a unique factor, CMV represents a problem. Our results show that a one-factor model has a poor fit with the data (RMSEA = 0.144; CFI = 0.393; NFI = 0.401) and consequently CMV is not a problem for our analyses.

Referring to the sample description, 24.38 per cent of the final sample reported annual revenues of 2 million Euros or less, 51.24 per cent reported annual revenues between 2 and 10 million Euros, while the rest 24.38 per cent reported revenues over 10 million Euros. Regarding the number of employees 73.13 per cent reported fewer than 50 employees, 19.40 per cent reported 51 to 250 employees, and 7.46 per cent reported 251 or more employees as shown in Table 3. The firms in the sample perform activities in different sectors such as agri-food manufacturing (fruit, vegetables, meat, etc.); technology components manufacturing (electronic, computers); and textile and footwear manufacturing (CNAE code 2009: 10 – food industry, 11 – Beverage manufacturing, 13 – Textile industry, 14 – Apparel manufacturing, 15 – Leather and footwear industry) (see Figure 2).

		Revenues (Million Euros)			
		< 2	2-10	> 10	Total
Employees	< 50	22.39%	43..78%	6.97%	73.13%
	50-250	1.99%	6.97%	10.45%	19.40%
	> 250	0.00%	0.50%	6.97%	7.46%
	Total	24.38%	51.24%	24.38%	100%

Table 3. Sample description (Revenue and Employees)

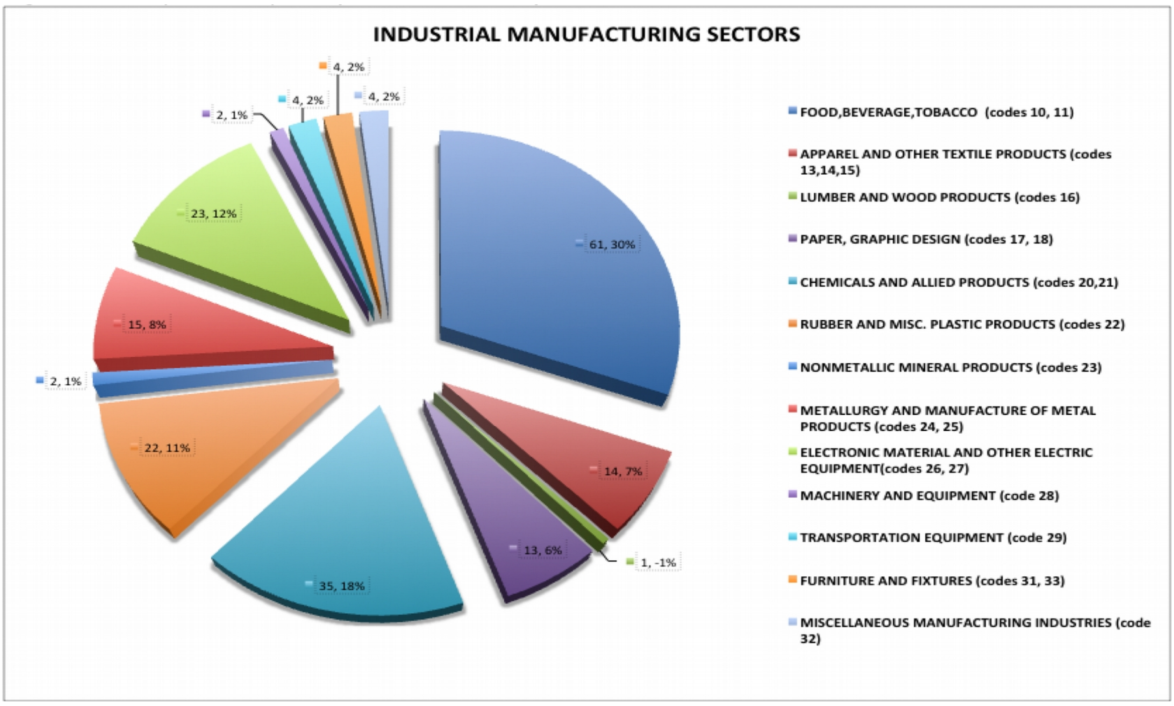

Figure 2. Sample description (industrial sectors)

The scale developed by Chan, Huff, Barclay & Copeland (1997) and subsequently by Byrd, Lewis & Bryan (2006) was included in the final questionnaire in order to measure IT integration into business strategy. This scale measures the orientation of existing IT within the business strategy. The items included in this study focus specifically on analyzing two strategic dimensions of IT: aggressive and defensive IT orientation within the business strategy. The different items of the questionnaire evaluate the degree of agreement with the integration of existing IT in the firm according to such strategic dimensions. For measuring operations flexibility, the scales validated by Zhang et al. (2003) regarding flexibility competences were used. The study considers the dimensions of machine, labour, material handling, routing, volume and mix flexibility (Tu, Vonderembse, Ragu-Nathan & Sharkey, 2006; Zhang et al., 2006; Charles, Lauras & Van Wassenhove, 2010). Operations performance has been measured adapting the scales of Abernethy and Lillis (1995). Different measurements of performance have been included in the research based on efficiency of the system as well as customer satisfaction by benchmarking firms performance with competitors. All items shown in Table 5 are measured through a 7-point Likert scale, in which 1 indicates completely disagree and 7 completely agree on every statement.

4. Results

4.1. Scale Validation Process

Prior to confirming empirically the validity of the hypotheses and the scales validation, we include the descriptive statistics of observed variables (see table 4). . Next, the validation process was divided into two stages. First, we performed an explanatory factor analysis that enabled us to confirm the one-dimensionality of each scale. Second, we observed the scales' internal consistency by calculating the Cronbach's Alpha. In all cases, the resulting scales showed values higher than the recommended minimum of 0.7 (Nunnally & Bernstein, 1978), guaranteeing internal consistency (see Table 5). To calculate one-dimensionality and internal consistency, we used SPSS 22.0 software.

The next step in the validation process was to perform a confirmatory factor analysis to enable analysis of the scales' validity. To achieve this, we used EQS 6.2 software. The conditions for validity require that the factor loadings be significant ($t\text{-value}>1.96$, $p<0.05$) and have individual reliability (R^2) higher than 0.4 (Hair, 2010; Kim, Kumar & Kumar, 2012). As a result of this process, some items were eliminated from the scales. Table 5 includes the items remaining after the validation process, which are shown to fulfil the requirements to guarantee validity of the scales. Table 5 also includes the descriptive statistics of the items used. Following Szulanski (1996), we also analyzed the discriminant validity of the scales. The results showed that each construct is significantly different. Finally, we observed the composite reliability of scales that exceeded the recommended value (0.7), and the average variance extracted (AVE) that exceeded the accepted value (0.5). After the full validation process, the resulting items were used in the subsequent analysis.

Variable	Mean	SD	Correlations							
IT Integration	35.419	.85622	1							
Machine Flexibility	32.264	104.340	.186**	1						
Labour Flexibility	38.915	.73817	.286**	.263**	1					
Material Handling Flexibility	38.313	.93122	.292**	.279**	.316**	1				
Routing Flexibility	32.215	101.584	.338**	.443**	.275**	.450**	1			
Volume Flexibility	39.450	.80469	.224**	.223**	.286**	.223**	.320**	1		
Mix Flexibility	37.123	109.065	.282**	.118	.153*	.334**	.314**	.202**	1	
Performance	35.609	.71857	.284**	.191**	.283**	.243**	.156*	.206**	.153*	1

[*] Correlation is significant at the 0.05 level; [**] Correlation is significant at the 0.01 level.

Table 4. Descriptive statistics and reliability analysis

Items	Code	Mea n	S.D.	Standardized factor loadings and t-values (>0.4[a]; t>1.96[a])	R2 (>0.5a) 1	Cronbach's Alpha (>0.7[b])	Composite reliability (>0.7)	Average variance extracted (>0.5)
Information Technology Integration						.898	.900	.584
The IT's we use help us to be or become one of the leading firms in our market.	ITI1	3.335	.9914	.660 (t=10.03)	.436			
The IT's we use help us to be on the cutting edge with respect to our competition.	ITI2	3.48	10.294	.718 (t=11.42)	.516			
The IT's we use help us to achieve market share.	ITI3 Eliminated	---	---	---	---			
The IT's we use help us to develop strong ties to our main customers.	ITI4	3.698	10.581	.839 (t=15.92)	.705			
The IT's we use help us to develop strong ties to our main suppliers.	ITI5	3.678	10.085	.826 (t=14.73)	.683			
The IT's we use help us to connect strongly to the market in general.	ITI6	3.518	.9892	.834 (t=15.30)	.696			
Machine Flexibility						.772	.775	.537
Our machinery can be installed/configured rapidly.	MACH1	3.364	1.311	.683 (t=9.49)	.466			
Any machine can perform different types of operations.	MACH2 Eliminated	---	---	---	---			
Any machine can use different devices effectively.	MACH3 Eliminated	---	---	---	---			

Items	Code	Mean	S.D.	Standardized factor loadings and t-values (>0.4[a]; t>1.96[a])	R2 (>0.5a) 1	Cronbach's Alpha (>0.7[b])	Composite reliability (>0.7)	Average variance extracted (>0.5)
Our machines often become obsolete when new operations are introduced in the firm.	MACH4 Eliminated	---	---	---	---			
The devices on our machines can be changed rapidly.	MACH5	3.095	12.108	.682 (t=9.03)	.464			
It is easy to install/configure our machinery.	MACH6	3.22	12.536	.826 (t=9.18)	.683			
Labor Flexibility						.843	.845	.579
Our workers can perform different types of operations efficiently.	LAB1	3.98	.8483	.712 (t=8.57)	.507			
Any worker is able to work efficiently with different devices.	LAB2	3.731	.9314	.701 (t=10.06)	.491			
Our polyvalent workers(qualified in various fields) can perform a large number of tasks in the firm efficiently.	LAB3	3.98	.8829	.868 (t=12.35)	.753			
Our workers can/are trained to work various types of machines.	LAB4	3.874	.9161	.752 (t=9.83)	.565			
Our workers can easily be transferred to other departments or units in the same firm.	LAB5 Eliminated	---	---	---	---			
Material Handling Flexibility						.867	.868	.688
Our material handling system enables us to manipulate, move, and/or transport different kinds of components.	MAT1	3.874	10.195	.843 (t=12.48)	.711			
Our material handling system can work in different processing areas.	MAT2	3.821	10.361	.775 (t=9.98)	.600			
Our material handling system can move different kinds of components through our factory installations.	MAT3	3.799	10.862	.868 (t=14.02)	.753			
Our material handling system enables us to exchange/replace components rapidly.	MAT4 Eliminated	---	---	---	---			

Items	Code	Mean	S.D.	Standardized factor loadings and t-values (>0.4[a]; t>1.96[a])	R2 (>0.5a) 1	Cronbach's Alpha (>0.7[b])	Composite reliability (>0.7)	Average variance extracted (>0.5)
The devices we use for material handling can be changed or replaced rapidly.	MAT5 Eliminated	---	---	---	---			
Routing Flexibility						.825	.828	.618
A typical part operation can be routed to different machines	ROUT1 Eliminated	---	---	---	---			
A typical part can use many different routes	ROUT2 Eliminated	---	---	---	---			
The system has alternative routes in case machines break down	ROUT3	3.342	11.535	.682 (t=8.25)	.466			
The operating sequence through which the parts flow can be changed	ROUT4	3.091	12.132	.839 (t=12.54)	.703			
Machine visitation sequence can be changed or replaced quickly	ROUT5 Eliminated	---	---	---	---			
Route changeovers are easy	ROUT6	3.231	11.734	.828 (t=13.78)	.686			
Volume Flexibility						.884	.885	.719
We can function efficiently at different production levels.	VOL1 Eliminated	---	---	---	---			
We can work profitably with different production volumes.	VOL2 Eliminated	---	---	---	---			
We can produce different lot sizes efficiently.	VOL3 Eliminated	---	---	---	---			
We can change our production volume rapidly.	VOL4	3.96	.8593	.800 (t=12.17)	.640			
We can change total production from one period to another.	VOL5	3.975	.9189	.893 (t=17.37)	.797			
We can easily change the production volume of a manufacturing process.	VOL6	3.9	.9	.850 (t=15.22)	.722			
Mix Flexibility						.883	.885	.721
We can produce a wide variety of products in our plants	MIX1	3.831	12.733	.895 (t=7.30)	.802			
We can produce different product types without major changeover	MIX2	3.791	11.559	.887 (t=7.74)	.788			

Items	Code	Mean	S.D.	Standardized factor loadings and t-values (>0.4[a]; t>1.96[a])	R2 (>0.5a)1	Cronbach's Alpha (>0.7[b])	Composite reliability (>0.7)	Average variance extracted (>0.5)
We can build different products in the same plants at the same time	MIX3 Eliminated	---	---	---	---			
We can produce, simultaneously or periodically, multiple products in a steady-state operating mode	MIX4	3.515	12.030	.760 (t=5.35)	.578			
We can vary product combinations from one period to the next	MIX5 Eliminated	---	---	---	---			
We can changeover quickly from one product to another	MIX6 Eliminated	---	---	---	---			
Performance						.848	.848	.584
Evolution of worker efficiency level	PERF1	3.569	.8145	.703 (t=7.69)	.495			
Percentage use of production capacity	PERF2	3.514	.8666	.808 (t=7.90)	.653			
Evaluation of ability to vary, adapt, or personalize product characteristics	PERF3	3.646	.8776	.765 (t=8.66)	.585			
Percentage of production vs. leisure time	PERF4	3.515	.9061	.779 (t=9.44)	.607			

a Hulland (1999); b Nunnally (1978)

Table 5. Scale items and validation

4.2. Structural Equations Model (SEM)

To contrast the hypotheses, we performed SEM using EQS 6.2 software. Figure 3 includes the results obtained in the SEM. First, if we refer to the set of hypotheses that relate integration to information technologies and the different dimensions of flexibility, the results show that all relationships are positive and significant (machine λ=.351***; t=3.408; labour λ=.431***; t=4.978; material handling λ=.552***; t=5.255, routing λ=.644***; t=5.296; volume λ=.379***; t=3.865 and mix λ=.455***; t=4.531). This result enables us to accept Hypothesis 1. For the group of hypotheses relating the dimensions of flexibility to performance, we see that only four of the six dimensions show a positive and significant relationship (machine λ=.558*; t=1.700; labour λ=.989***; t=2.742; material handling λ=.580**; t=1.990 and volume λ=.504**; t=2.012). We can thus affirm that Hypothesis 2 is partially confirmed. Finally, Table 6 includes the value of the fit indexes associated with the structural model. As can be seen, all indexes show values above the recommended minimums, indicating that the model shows good fit for interpretation.

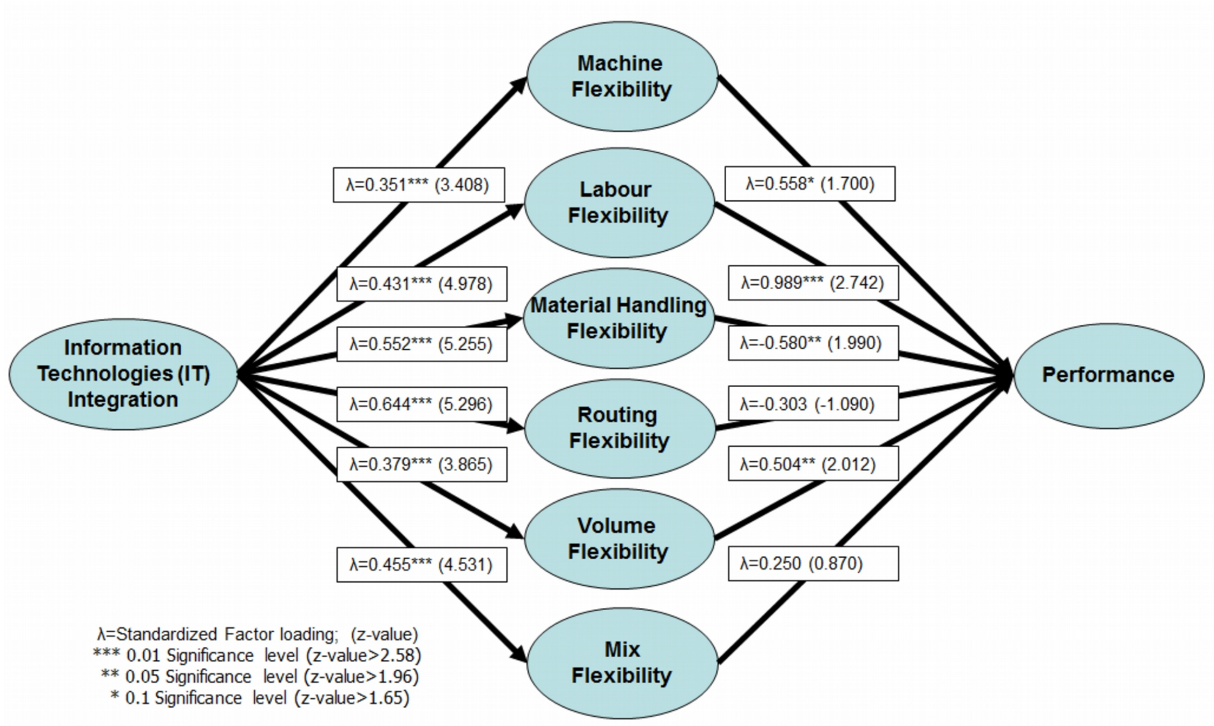

Figure 3. Relationships of the model

Fit Index	Model	Acceptance levels
Chi-square	569.966	
Degrees of freedom	328	
Normed Chi-square χ^2 / df	1.737	<3.0[b]
Root Mean Square Error of Approximation (RMSEA)	.061	<0.08[b]
Comparative Fit Index (CFI)	.919	>0.9[c]
Bollen's Fit Index (IFI)	.920	>0.9[c]
GFI Fit Index	.831	>0.5 [c]
AGFI Fit Index	.791	>0.5[c]

[a]z-values greater than 1.96 are significant at $p < 0.05$; z-values greater than 2.58 are significant at $p < 0.01$.
[b]Hair, Tatham,, Anderson and Black (2006) and Byrne (1998); [c]Byrne (1998).

Table 6. Structural Equation Modelling

5. Conclusions, Limitations and Future Lines of Research

The main goal of this study is to develop a deeper understanding of the relationship between IT integration and performance through operations flexibility beyond those suggested by previous studies. Results prove a complex set of relationships in manufacturing firms which provides important implications for academics and managerial practice. First, based on the different dimensions of operations flexibility, this study uncovers how IT implementation impacts operational performance. This finding opens new research opportunities to analyze such impact to different environmental conditions. In future studies, additional perspectives under a contingency analysis can even clarify possible hidden aspects in this relationship. At this point, practitioners can have a better understanding on how IT implementation affects the different dimensions that configure the operations flexibility.

Second, a model of analysis of the relationships among IT implementation, flexibility and performance has been developed based on the classical manufacturing flexibility frameworks. This research analyzes these critical constructs though the use of empirical methods within a field-based setting. Some flexibility dimensions show no significant impact in performance (routing and mix flexibility). This is consistent with the fact that these flexibility dimensions act as variability absorbers within the manufacturing process. Routing flexibility is a competence that decreases the job flow pattern from a random job shop to a flow shop (Hitoshi & Mitsuyoshi, 1999). Hence, when the production system is balanced, the impact of routing flexibility on performance may not be significant when variability is small. Regarding mix flexibility, it involves the capability to adjust quickly to changes in the demand. It affects performance when there is a large need for product variety. Hence, in multisectorial studies, the effect of mix flexibility on performance can be affected according to different product variability levels in different industries. In addition, current flexible technologies decrease the possibilities for mix flexibility improvements on operational performance as found by Karuppan and Kepes (2006). Therefore, future studies can focus on determining further internal and environmental factors that affect operations flexibility according to specific sector characteristics. These findings can improve practitioners decision process when choosing which combinations of flexibility dimensions fit better with strategic priorities, especially when dealing with financial options of IT investments and equipment.

Third, this research proves a significant positive and direct effect of IT implementation on operations performance. Results show not only the links between IT implementation and operations performance, but also the magnitude of every impact. Notwithstanding, it is necessary to be cautious when generalizing these findings as service firms were not part of the sample even when statistical results prove robustness suggesting that the findings are quite reliable. Further, our model considers IT integration as the degree of alignment that existing technology resources in a firm have with the business strategy, in terms of importance and support for this strategy. This integration seeks to generate value such as leveraging of IT investment, an idea also consistent with Byrd et al. (2006). The strategic role of IT is oriented to improving information flow and real-time coordination with suppliers that facilitates effective planning of production and provision of materials. When integrated into decision making, this information enables a faster evaluation of the firm's current level of flexibility to prioritize its resources, and identify resources leading to improve operations processes. This information will enable better integration with customers, allowing the firm to optimize deadlines and better adapt products to customer needs. Future sectorial analysis could provide more specific results considering as well service industries.

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