Employees' skills, manufacturing flexibility and operational performance

A structural equation modelling applied to the automotive industry

A dissertation submitted to the

Management and Economy department of

UBI – University of Beira Interior

Portugal

in partial fulfilment of the
requirements for the degree of

MASTER OF MANAGEMENT

June, 2010

by

José Cândido Ferreira Machado
M2440

Master of management dissertation, in the resources flexibility area presented to management and economic department of Social Sciences College from Beira Interior University, under the supervision of PhD Luís Antonio Fonseca Mendes

COVILHA, JUNE of 2010

Abstract:

Flexibility and human resources, have a great importance in our days, in our industries, in a competitive environment, who can not be flexible loses market share to their opponents. The survival depends how you can deal with the unpredictability and volatility. In this field, human resources are fundamental, no one can be flexible if don't have available a multi – task team prepared to learn and improve daily.

The main goal of this research is to show the importance of the relationship between the employee skills and manufacturing flexibility and the relationship between employee skills and operational performance of the firm.

In this research it was used the structural equation modelling (SEM) as a statistic method to check for the consistency of the model proposed. In data collecting, it was used a survey and send to the selected companies by e-mail and confirmed after by phone. The market selected for analysis was the automotive market, selecting their suppliers of raw material and sub-components. The surveys were sent to 441 companies, achieving a return rate of 32.6%, corresponding to 144 valid surveys.

The results show the tight connection between employee skills and operational performance and employee skills and process and product flexibility, showing human resources are core variable to continuous improvement and product development, meanwhile, we cannot see this impact in volume flexibility, in this case is necessary to use other support means to reach the organization goals.

Keywords: resources based view theory, operational performance, employee skills, manufacturing flexibility

JEL Codes: L62; M11; M12

DEDICATION

This dissertation is dedicated to everyone who never give up their dreams and to all that have enough courage to face life barriers.

ACKNOWLEDGEMENTS

I would like to thank my wife (Susana) and my daughters (Inês and Sofia) for their patience and support during this long and challenging process. Surely, I could not have done this without their love and encouragement. Thanks.

Second, I want to thank to professor Luís Mendes, who has provided support, encouragement, and direction throughout the entire dissertation process.

I am grateful for the time and effort he invested in reviewing this research in progress and making suggestions to improve the final document and the conclusions on it.

I also want to thank to my friend Filipe Borges, the support and help in allowing me to lose a few hours of dedication to the company.

To my master degree colleagues to allow me to remember this passage by the university as a pleasant memory.

Finally I want to thank the several companies that answer to the field survey.

List of tables:

List of figures:

Contents:

1. Introduction:

Today, the biggest challenge in strategic planning is growing in the uncertainty of demand and the reduction of productive capacity (Frank et. al., 2009), particularly in the automotive industry where exist product differentiation and there is great competition, in a global market with distinct product life cycles. Due to these facts the biggest strategically concern has been the adequate use of the resources.

Nowadays, increasingly, the resources are scarce and valuable; as a result the managers are forced to find alternative solutions in order to give a better use to these resources. In the modern days an organization must be expert in continuously monitoring its environment (Todorut, 2008), in order to take the best in resources use. In such a way it can acquire a competitive advantage over its competitors for type of product. The organization needs to be prepared for the environment constant changes and requirements demanded, for this, flexibility is a solution that allows an organization become better adapt to market difficulties and barriers, as well as increasing its capacity without expansion necessity.

Flexibility is a way to express the competitive advantage in an unstable market and to minimize instability with a clear capacity of adaptation to new challenges. The levels and the type of required flexibility, in real time are influenced by the competitors of this market (Todorut, 2008). With a greater number of manufacturing operations, implies a greater ability to respond to changes in customer orders, reduced pressures and assumes a prominent position in the market (Slack, 2005b). Exists a clear relation between productive flexibility and organization performance (Vokurka et. al., 2007) and one of the most valuable resources used to boost firm performance and develop a competitive advantage the face of a dynamic environment are the human resources (Ketkar and Sett, 2009).

Managers consider flexibility must be applied to individual resources of manufacturing (Slack 2005a). This type of behaviour can influence dependent processes that will be able to influence the organization performance, that's why, exist a clear relation between productive flexibility and organization performance (Vokurka et. al., 2007).

This research aims to demonstrate that multi-skilled human resources have an important role in manufacturing flexibility and in the operation performance of the firm. This research will be focused in the relationship between the employee skills and the manufacturing flexibility primary dimensions consider in this research; *(i)* volume, *(ii)* new product and *(iii)* mix, and in the relationship between employee skills and operational performance of the firm. With this proposal, this research will try to answer at two important questions:

"Multi – skilled employees are necessary to improve manufacturing flexibility"

A firm need to have an experiment team and prepared to execute different tasks and jobs, because only in that way is possible to face the unpredictability of a dynamic environment. The experience level is very important in order to understand any kind of strategy moves, any process change, in order to pass from paper to reality in the production field.

With a multi-skilled team, managers can be prepared to any kind of flexibility on customer demands and tastes. It's important to have a team focus in continuous learning to find new ways to perform their jobs and tasks in order to reach an higher productivity level and with that make valuable contributions to the organisation's goals (Martín et. al., 2009).

"Multi-skilled employees and manufacturing flexibility lead to a major operational performance of the firm"

In a chain positive reaction, it's expected with multi-skilled employees and a good flexibility level in manufacturing system, the operation performance become improved, it's expected better results in the firm performance. Human resources practices play as a structural mechanism in achieving superior firm performance. This is a form of strategic flexibility that helps a firm to preserve and develop its competitive advantage the face of a dynamic environment (Ketkar and Sett, 2009).

This research was conduced in order to analyse an important market in the actual economy, the automotive industry. But this industry is so complex, that was selected only a part of this industry, the raw material and sub-components suppliers. In order to check the consistency of the selected model, it was used a structural equation modelling (SEM), a statistic technique used when in the research are defined variables that need to have a scale of items to be operationalized.

It was define a survey with all the key information necessary to analyse the relationships proposed in this research. In that survey it was collected some particular information, like number of employees, age, market segment, in order to validate each answer received. The method used to pass the information to the firms selected was the e-mail and after a phone call in order to re-enforce the participation on the survey. The contacted firms were divided in two big goups; the first was based in a mailing list represented by Portuguese and Spanish suppliers of sub-components in a total of 192 companies. In this first group it was achieved almost 50% of the valid surveys, but it was not sufficient, that why it was used a second group defined by 249 companies from an international group and some of its suppliers in a total of 441 companies with a valid return rate of 32,6%, corresponding to 144 valid surveys.

The rest of the paper is organized as following:

Firstly, relevant literature concerning the concept of flexibility and its importance in the industry and in manufacturing processes. Based on literature review, a model was built addressing the following issues: *(i)* relationships between employees' skills and manufacturing flexibility, *(ii)* relationships between employees' skills and operational performance, and *(iii)* relationships between manufacturing flexibility and operational performance.

Secondly, the research design section is developed, highlighting that a structural equation model of manufacturing flexibility was performed and explaining how data was collected, how measurements and scales were developed, and how reliability and validity were assessed.

Finally, results are presented and discussed in light with theoretical considerations and results of previous researches.

2. Literature Review

Manufacturing flexibility has been proclaimed as a major competitive weapon for manufacturing organizations operating in increasingly uncertain environments and turbulent markets (Oke 2005)

How can it possible to achieve flexibility? Is necessary to have intentional and be in temporal, with that is possible to define three dimensions, the first is temporal; how long it takes an organisation to adapt. The second is range; the number of options that an organisation has open to it for change that was foreseen and the number of options it has available to react to unforeseen change. The third is intention; whether the organisation is being proactive or reactive.

Nowadays, the flexible technology can not be fully effective without flexible working and vice versa. It may not be effective without a set of procedures, systems and controls which will be able to copy with the flexibility of physical processes (Slack, 2005b)

The Lead Time[1] when the organization use flexible technology is shorter compared with the Lead time needed to investment in new installations or in the improvement of the actual (Fine and Freund, 1990), it means to answer to that is necessary to have operators fully prepared.

Human resources and labour force represents a unique opportunity for organizations to achieve excellence. Clearly a flexible workforce, with more flexible equipment, can achieve reductions in the level of inventory and avoid excess capacity. The human ability to learn, feel and adapt, plays an important role, making people the most flexible of the tangible assets (Jha, 2008).

The new method of thinking in organizations increased the ability to achieve desirable forms of flexibility, including a wide range of products (modification flexibility), place of production (volume flexibility) and rapid introduction of new products (flexibility in changing). (Schmenner and Tatikonda, 2005) and with that work as a major competitive weapon for manufacturing organizations operating in increasingly uncertain environments and turbulent markets (Oke, 2005).

Managers sometimes have the need to reduce or control the increased flexibility for their production systems by adopting other strategies such as control of internal needs, confining them to a limited part of the production system (Slack, 2005a). The success of alternative solutions like JIT with special attention to Toyota in terms of production systems, help to understand this type of manufacturing operation, making popular the idea of incorporating flexibility in manufacturing systems without sacrificing efficiency (Anand and Ward, 2004). JIT improved cycle times and began to address the decision between efficiency and flexibility, he began to think in producing at low rates, falling stocks and investing is growing in continuous improvement (Vokurka et. al., 2007). With the increase of JIT and Lean production, the choice of

[1] Lead Time – Is the time needed to make a product since it entrance in the production line, until its output.

buffers become unattractive, feeling the need for a way to get a flexible production with flexible resources (Anand and Ward, 2004).

2.1 Definition of manufacturing flexibility and research evolution

Our flexibility understanding still based on the intuition (Mieghem, 1998). Flexibility it is the ability for the change, to think about as a productive system can move or as part of this system can make it. Flexibility represents capacity do adapt to new things or different or the change of requirements and all the resources have an important role in flexibility (Slack, 2005b: Todorut, 2008).

.Manufacturing flexibility is a multidimensional construct that represents the ability of the manufacturing function, to make adjustments needed to react to environmental changes without significant sacrifices to firm performance (D'Souza and Williams, 2000). Manager's seam to agree that manufacturing flexibility refers to the quickness and easy with which firms can respond to the changes in market conditions (Cox, 1989).A basic issue that must be clear is the level definition of the manufacturing flexibility and the alternatives include (Gerwin, 2005b); *(i)* the individual machine or manufacturing system, *(ii)* the manufacturing function such as forming, cutting or assembling, *(iii)* the manufacturing process for a single product or group, *(iv)* the factory and *(v)* the firm's system

At each level the flexible concept maybe different and could have alternative means to achieve flexibility. Flexibility is not free of charge, that's why the importance to define the desired level in order to don't lost financial or other resources. Analysing the data in table 1, concerning the researchers studied on this investigation it seams clear the most popular dimensions consider in the previous research are volume flexibility, new product flexibility, mix flexibility. This three dimensions are define in some research's as external flexibility and it's directly related to customer requirements and thus to a firm's competitive advantage and because of that is recognize by customers, since it directly affects a firm's competitiveness (Chang et. al., 2007). Due to this analysis it's suggest to use in this research only three primary dimensions (volume, mix and new product) to evaluate the impact of employee flexibility and operational performance.

Primary Dimension	Cox (1989)	Gerwin (1993)	Koste and Malhotra (1999)	D'Souza and Williams (2000)	Judi et. al. (2004)	Oke (2005)	Pramod and Garg (2006)	Chang et. al. (2007)
Volume	X	X	X	X	X	X	X	X;
Machine			X				X	
New/Variety	X	X	X	X	X	X	X	X
Material Handling			X	X	X			
Mix/Process	X	X	X	X	X	X		X
Delivery						X		
Materials		X						
Changeover		X						
Rerouting		X						
Responsiveness		X						
Worker/labour			X					
Operation			X					
Modification			X					
Expansion			X					

Table 1: Temporal researchers on manufacturing flexibility primary dimensions

2.2 Dimensions of manufacturing flexibility:

In the context of a productive system, flexibility in supplying represents the capacity of process adaptation to the changes in customer requirements (Chen and Tseng, 2008). According Slack (2005a) the core argument is that flexibility should be considered at four levels; *(i)* the production resources themselves, *(ii)* the tasks which the production function needs to manage, *(iii)* the overall performance of the production function and *(iv)* the competitive performance of the whole company

To be flexible you need to have mobility. Mobility refers to ability to deliver change in the scale of change that can be measured by time or cost (Yi et. al., 2009). Mobility implies the ability to change the size of production while controlling the product or process diversification. Therefore, mobility is uniformity of flexible response, represented by the cost and / or time to take, is largely determined by the coordination capacities of the firm. (Yi et. al., 2009). As it was describe before it will be consider and analysed only three primary dimensions.

2.2.1. Volume flexibility

One of the most important dimensions is the volume and is the ability to change the level of aggregate output (D’Souza and Williams, 2000: Judi et. al., 2004: Oke, 2005: Slack, 2005a; Vokurka et. al. 2007).Volume flexibility can be increased simply by increasing the processing capabilities of the system (Gerwin, 1993: Pramod and Garg, 2006). The change in volume depends on the capacity and what is its rigidity. (Judi et. al., 2004: Gerwin, 2005).Investment in excess capacity, empty floor space and lack time in the production schedule is necessary to have volume flexibility (Gerwin, 1993).

The literature suggests that a high level of risk-taking practices could enable firms to enhance new product and volume flexibility. The manufacturing industries always act traditionally and, therefore, have some reluctance in taking risks by implementing these kinds of flexibility systems. Risk-taking stimulates manufacturing firms to achieve higher levels of new product flexibility and volume flexibility (Chang et. al., 2007). Some times, flexibility represents the capability to manage risks (Yi et. al., 2009), demand uncertainty makes companies found in outsourcing an attractive issue, because it allows firms to shift of the risk associated with declining in demand to supplier firms (Sánchez et. al., 2005). Firms in dynamic environments might be in need of external flexibility to keep up with technology development or access relevant capabilities with less risk (Sánchez et. al., 2008).

Volume flexibility is completed by two important characteristics; Range and Mobility.

According D’Sousa and Williams (2000), measures of this element suggest as the smallest volume a system can produce without significantly effecting firm profitability. One is the ratio of average volume fluctuations to total capacity, and the other is an average of volume fluctuations over time.

According D’Sousa and Williams (2000) fewer treatments of manufacturing flexibility address the issue of mobility as it pertains to volume flexibility. Those that do, however, are consistent in their use of ‘‘time’’ and ‘‘cost’’ as critical components for the mobility element of volume flexibility.

2.2.2. New Product flexibility

Managers have an interest in building a wide range of products that can react to environment or market quick reactions (Anand and Ward, 2004), and with that strategy, managers can be prepared to any kind of flexibility on customer demands and tastes. New product flexibility is the ability to introduce and manufacture new products or to modify the existed ones (Oke, 2005: Slack, 2005a). Product flexibility can be increased by increasing part processing flexibility, the processing capabilities of the system and/or the processing capabilities of individual groups (Pramod and Garg, 2006).

A proactive firm assumes an opportunity-seeking, forward-looking perspective through introducing of new products ahead of competition as well as practices that help anticipate future demand to create change and shape the environment (Venkatraman, 1989: Chang et. al., 2007). Many studies suggested that new product and volume flexibility will be enhanced when firms behave proactively (Chang et. al., 2007). Evidence from empirical studies suggests that proactiveness may help a firm to become pre-emptive or first mover, which typically requires aggressive development of new products, and adjustment of production volume (Chang et. al., 2007).

An entrepreneurial firm is willing to devote the necessary resources to cultivate capacities that enable it to create new products, innovate existing products, or adjust the level of production ahead of competitors to seize emerging opportunities (Chang et. al., 2007)

2.2.3. Mix Flexibility

The mix flexibility is the ability to change the range of products being made by the manufacturing systems within a given period (Oke, 2005: Slack, 2005a). Mix flexibility can be increased by employing larger quantity of less flexible machines when part-processing flexibility is low (Pramod and Garg, 2006).

There is a general consensus that resource (machine and labour) flexibilities are the building blocks of a flexibility pyramid and directly influence mix flexibility (Koste and Malhotra, 1999). Machine flexibility refers to the variety of operations that the machine can perform without requiring a prohibitive effort in switching from one operation to the other (Pramod and Garg, 2006) and internal labour flexibility refers to the flexibility manifested by the pool of human resources in the organisation at a certain point of time (Martin et. al., 2009).

Flexibility is a necessary condition for innovation and provably to be proactive some times is necessary innovate. This fact suggests that flexible companies have the most significant innovation level in comparison with those with a lower rate (Todorut, 2008).

Many studies suggest that innovativeness contributes to new product, product mix, and volume flexibility. Innovativeness reflects the propensity of a firm to engage in new ideas and creative processes that may result in new products, services or technological processes, new market opportunities arise with technological innovation (Chang et. al., 2007). When innovation is discussed, two types of flexibilities have been found. One creates a system allowing organizations to gain leadership opportunities for increasing the input capacity of products, projects, investments, etc. The other prevents the existing of systematic with the aim of creating new opportunities that can lead to innovation (Todorut, 2008). An organization provides flexible creativity, innovation and speed of execution, all included in their processes (Todorut, 2008).

The definition of primary flexible dimensions consider as object of research in this analysis are define on table 2:

Dimension	**Definition**
Volume	Ability of manufacturing system to change volume or output of manufacturing process
New product / Variety	Ability of manufacturing system to produce many different products simultaneously and to incorporate new design
Mix / Process	Ability of manufacturing system to adapt to changes in production process including to change sequence of steps through which product must progress

Table 2: Manufacturing flexibility primary dimensions

2.3. How to measure flexibility:

There are difficulties in accurately measuring the flexibility because of their dependence on factors of uncertainty. To measure the flexibility of a manufacturing system should be considered as the value of time needed for the system transformation from one to another job task (Pramod and Garg, 2006).A production system that moves

well from one state to another, which is fast and cheap should be considered more flexible system than that which can not equally do it (Judi et. al., 2004).
The consistency of performance measurement can be assessed by the efficiency, productivity, quality and processing of products and services offered to customers (Judi et. al., 2004). Some of the variables to take in account when try to measure efficiency are workforce, the equipment available and the process of production control (Cox, 1989).

All world-class producers understand customer satisfaction as the ultimate measure of product and quality services. To measure customer satisfaction, there isn't a precise science and varies greatly between organizations. They have some rules to measure customer satisfaction like the latest customer survey, noting the number of complaints and measuring the number of repetitive sales for the same customers (Maskell, 1989).

2.4. Methods to improve the flexibility:

According Slack (2005a), a flexible production system, can usually provide: *(i)* better product possibilities, *(ii)* less lead time and *(iii)* quicker delivery of products with a high level of customization. The flexibility can be measured by the number of changes made during a period of time, but it must take into account the degree of differentiation between new and old material (Judi et. al., 2004: Slack, 2005a: Gerwin, 2005).

Skills possessed by employees but not currently used may open up new opportunities of business for the firm, and indeed, may influence strategic choices (Bhattacharya et. al., 2005). Skill flexibility refers to two attributes: *(i)* the number of potential alternative uses to which employee skills can be applied (resource flexibility) and *(ii)* how individuals with different skills can be quickly redeployed (Ketkar and Sett, 2009)
A wide range of employee skills contribute to flexibility. This wide range can be gained by having a smaller number of employees with broad-based skills or a larger number of employees with more narrow, specialist skills (Bhattacharya et. al., 2005).

Management needs to realize that maintaining and upgrading the skills of their workforce is a major value to they competitive strategy. The development of multi-skilled operators is the key to improve flexibility and operational performance (Lau, 1996).

Firms improve flexibility and therefore their chances for being successful in an uncertain environment by having access to flexible resources that allow them to create a range of strategic options (Martin et. al., 2009).With this flexibility, when the need arises, the firm may reorganize its employees (e.g., through project teams) to achieve the desired skill profile (Bhattacharya et. al., 2005).Is necessary to see in the employee's willingness to cooperate and collaborate with others both within and outside the organisation (Martin et. al., 2009).

2.5. Employee skills as source and driver of manufacturing flexibility

2.5.1 - Achieving good manufacturing flexibility throw employee skills

One important input variable is human resources in the organization, involved on manufacturing process. Human resources must be trained in order to stand out their best skills, so that is flexible enough to perform several tasks at various levels, as well as share skills with each other so that they are more dynamic in the uncertainty of demand (Lau, 1996: Kayis and Kara, 2005).

According Bhattacharya et. al., (2005), skill flexibility can be generated by firms that may have employees who possess a set of broad-based skills and are capable of using them under different demand conditions. Broad-based skills are valuable because they generate output streams for existing requirements and are also capable of producing output for possible alternative requirements thus, these flexibilities may not only generate value by themselves but may also facilitate synergies with other resources, creating strategic opportunities. For example, when a firm is able to use its skill flexibility to quickly respond to changed demand for products and services, it may also foster greater creativity, innovation, and first mover advantages.

According to Sánchez et al., (2008), functional flexibility is a process through which firms adjust to changes in the demand for their output through an internal reorganization of workplaces based on multi skilling, team working and the involvement of employees in job design and the organization of work. Functional flexibility may enhance the innovation behaviour of employees in core value-creation areas. Functional flexibility improves the quality of working life because it can reduce the monotony and repetitiveness in the workplace. This perspective it’s represented in figure 1.

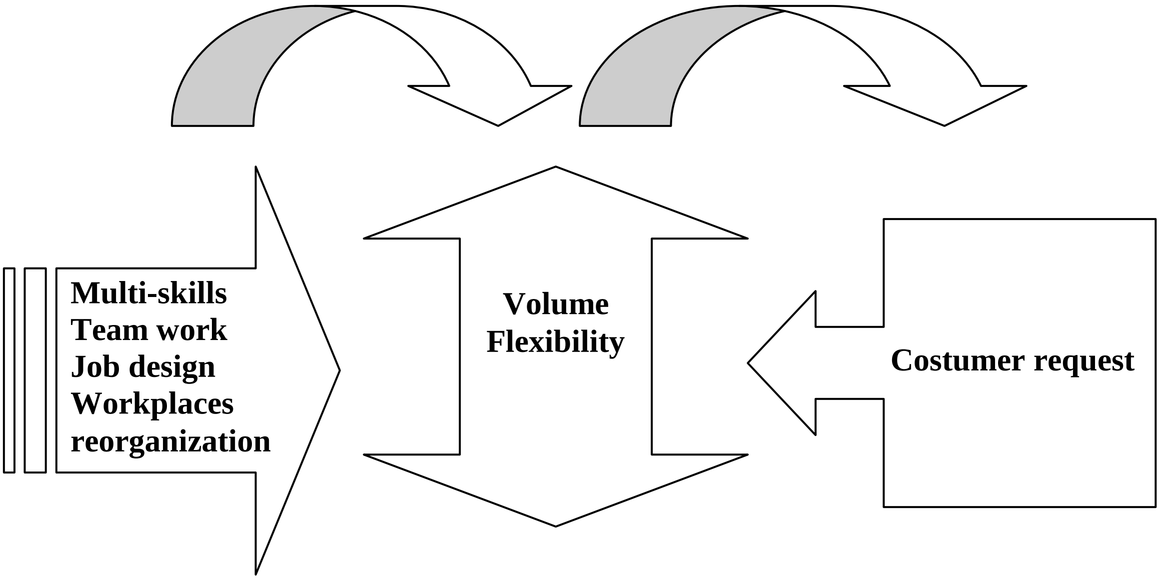

Figure 1: Functional flexibility process

Operators must continuously learn new ways to perform their job and try to keep their skills as up-to-date as possible in order to make valuable contributions to the organisation’s goals (Martín et. al., 2009), job rotation, cross-functional teams, and project-based work arrangements, all of which generate broad skill configurations specific to the firm that are not easily replicable. This suggests that the higher the level of a firm’s skill flexibility, the more likely employees are to exhibit higher performance (Bhattacharya et. al., 2005). The experience level is very important in order to understand any kind of strategy moves, any process change, in order to help that changes become real. This kind of resource constrains the options available for the organisation to increase or decrease production volume or to change from one product to another (Martín et. al., 2009).

2.5.2 Achieve operational performance throw employee skills

At operational level the performance concern is related with the design of specific methods of delivery. Achieving the flexibility to deal with uncertainties in the product mix reduces to achieve small setup times (Gerwin, 1993).

According Slack (2005b) with manufacturing flexibility, organizations sell; *(i)* better product availability, i.e. sorter delivery lead time or a wider customised product range, *(ii)* more dependable delivery, i.e. processing the part or product on schedule even in the face of unreliable supply or uncertain process reliability, *(iii)* increased productivity, i.e. better utilization of process technology, labour or material resources.

Several car manufacturers in the industry recognize the advantages of flexible factories as regards the absorption of existing fluctuations in demand and that reduces capacity as needed and at the same time can ensure a high quality service (French et al 2009). But to achieve manufacturing flexibility is necessary to have an oriented strategy and the right inputs to achieve to that goal, that's why the existence of significant direct effects highlights the important role that human resources practices play as a structural mechanism in achieving superior firm performance. This conceptualisation posits human resources flexibility as a form of strategic flexibility that helps a firm to preserve and develop its competitive advantage the face of a dynamic environment (Ketkar and Sett, 2009). This perspective it's represented on figure 2.

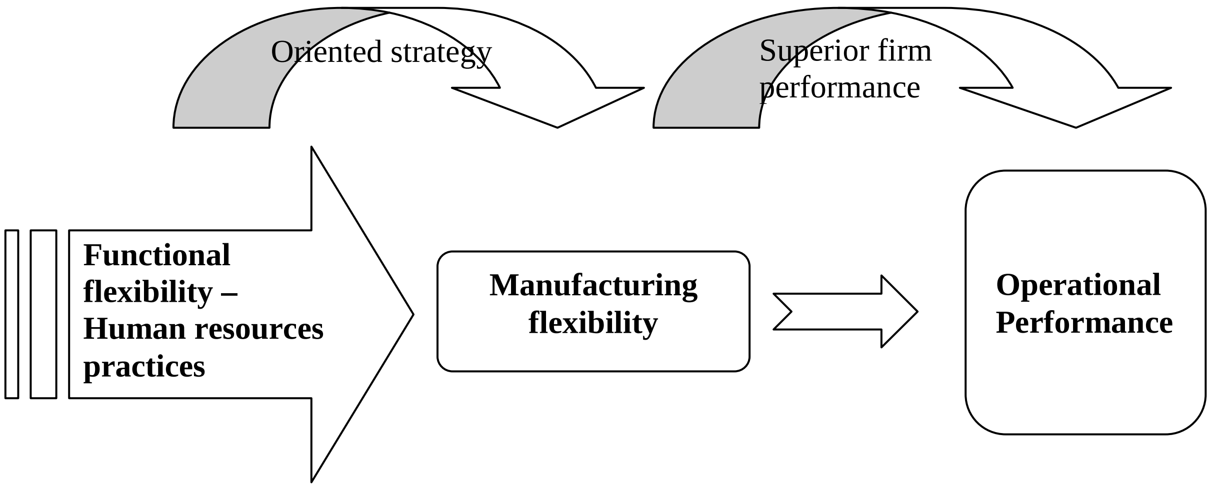

Figure 2: Oriented strategy to achieve superior firm performance

By including cost-efficiency in our performance measure, we are asserting that human resources flexibility will have a positive relationship with cost-efficiency because of the cumulative direct and indirect synergistic effects between the human resources dimensions of skill, behaviour, and human resources practices (Bhattacharya et. al., 2005).

3. Research model and hypothesis development

Based on the above discussion, a conceptual model was proposed (figure 3) to describe the relationships between employee skills, manufacturing flexibility and operational performance. Were selected international suppliers to automotive industry. One of the reasons to select this group was because this group represents one of the most important and dynamic industries in the entire world and because of that they have an important market share. All the companies have own management. But the most import was because it looks like the automotive industry is the most flexible industry, over a large demand for the final customer and it seems that this industry is very flexible due to the internal culture and its human resources.

Three types of internal manufacturing flexibility are considered most critical to a firm's competitive advantage; *(i)* new product flexibility, *(ii)* product mix flexibility and *(iii)* volume flexibility. In the automotive industry we need to test the impact of the employee skills on this kind of flexibilities and in company performance.

Figure 3 shows the research hypotheses relating to the relationship between employee skills and manufacturing flexibility and between employee skills and operational performance and between manufacturing flexibility and operational performance. In the rest of this section, we summarize the theoretical and relationship for each specific linkage, based on the observation data from automotive industry as well as the relevant literature.

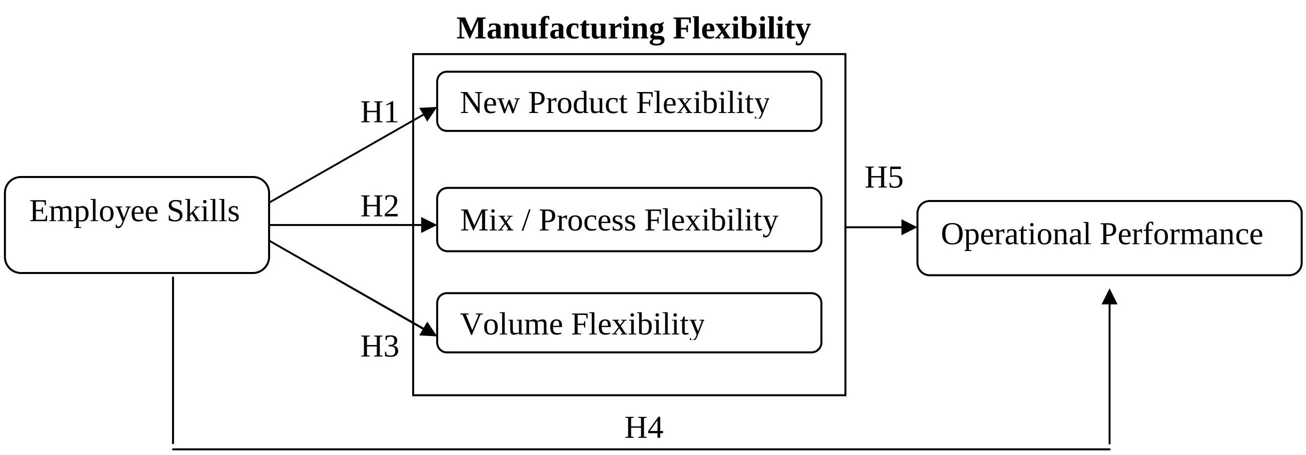

Figure 3: Conceptual model

H1: Employee skills have a positive impact in the new product flexibility

Manufacturing flexibility has the capacity to provide organisations with the ability to change levels of production rapidly (volume), to develop new products more quickly and more frequently, and to respond more rapidly to competitive threats (Oke, 2005).

Some times the employee knowledge and skills are not aligned with new product projects which currently exists in a firm, and that could may turn into core rigidity and block the introduction of new products (Yi et. al., 2009), due to that is possible to take in consideration the introducing of new product could take time and be expensive. One this situation is necessary to improve the workforce technical skills and normally, that enhance a firm's ability to design and market innovative products.

Functional flexibility implies the deployment of the knowledge skills and abilities of the workforce to a greater variety of tasks (Sánchez et. al., 2008), because of that we could say, it helps on management production systems with high number of new products.

H2: Employee skills have a positive impact in mix flexibility

Uncertainty as to which products will be accepted by customers created a need for mix flexible which is the ability of manufacturing process to produce a number of different products at the same time (Gerwin, 2005)

Experienced operators to produce a more varied mix when involved in decision making and there interventions lose their relative effectiveness when machines are highly reliable and consistent across operations (Karuppan and Kepes, 2006). Operators can boost mix flexibility when they make part of decision making (Karuppan and Kepes, 2006) and with that reduce to switch from one product to another. But to achieve that is necessary to have motivation and is possible to achieve productivity and employee motivation by designing flexible production systems which can provide stable functioning of the system under given conditions (Pramod and Garg, 2006)

H3: Employee skills have a positive impact in volume flexibility

Is necessary to have skilled operators or temporary operators to face peaks of volume variation, the volume flexibility policies employed by the company could included the use of temporary labour, and overtime working, because even if you have well trained and experience workers, there is a limit concerning there capabilities and is necessary in that time to help in another way to reach the desired performance. That's way, some times it's discussed if firm should use temporary labour or overtime working, because when operators are called into meet unexpected demand for products is necessary to perform overtime work and due to that issue they receive overtime premiums (Cousens et. al., 2006), because some times the system is not prepared to the unexpected demand from customer. Experiment or temporary, with labour, it's the only way to meet unpredictable demand (Zhang et. al., 2003).

Volume flexibility is defined by the ease with which changes in the aggregate amount of production of a manufacturing process can be achieved (Gerwin, 2005).
One solution used to decrease the level of volume, where the firm is profitable, it's with the application of Lean production or JIT and with that decrease employee efforts and improve their performance (Boyle and Rathje, 2009)

H4: Manufacturing flexibility level can have a positive impact in firm's operational performance.

Empirical research indicates that the use of functional and internal numerical flexible practices influences positively on different measures of firm performance such as employees' commitment and operational performance (Sánchez et. al., 2007).
Flexibility has come to occupy a central position in how operations can be strategically developed to play an effective part in achieving competitive advantage (Slack, 2005b), but, flexibility is not free of charge: Increases in flexibility often are constrained by factors such as equipment limitations and workforce experience (Treville et. al., 2008).

H5: Employee skills can have a positive impact in firm's operational perform.

High-cooperation firms may access to a broader knowledge base than low-cooperation firms, and therefore they will be more able to deploy a wider dispersion of knowledge through functional flexibility that contributes to greater innovation performance (Sánchez et. al., 2008). Previous empirical research studies indicates that the use of functional flexible practices influences positively on different measures of firm performance such as employees' commitment and operational performance (Sánchez et. al., 2007)

4. Research design

4.1- Data collection

A survey methodology was used to collect data pertaining to the proposed research hypotheses. This group was formed by 189 companies from an international group and 60 suppliers from this group. In total 249 international companies, where most of them are in Europe. To complete the research model it was also contact more 192 companies from the same industry using a mailing list. Most of them are working in Portugal and Spain. In total the research model have 441 companies in the survey. 158 completed surveys were returned, but in the end, were only considered 144 (table 3) due to fact that some of the surveys have less than 50% of the information required. The 144 correspond to a valid answer rate of 32, 6%. This survey was mailed to plant managers and top executives.

In order to raise the response rate, the top executives of the targeted firms were additionally contacted by telephone, which stimulated professional interest and improved survey participation. This survey was performed between the months of February and May.

Country	Global	%	< 100	%	>100 to <250	%	> 250	%
Portugal	70	48%	55	38%	12	8%	3	2%
Europe	54	38%	14	10%	24	17%	16	11%
China	5	3,5%			3	2%	2	1%
Brazil	3	2%	1	1%	1	1%	1	1%
USA	6	4%	2	1%	4	3%		
Africa	5	3,5%			2	1%	3	2%
Central America	1	1%			1	1%		
Grand Total	144	100%	72	50%	47	33%	25	17%

Table 3 : Distribution of sample collected by country and employee’s number

4.2. Non response bias

In order to analyse the non – response bias (potential difference between answers from respondents and non-respondents), the final sample was split in two different groups, the G1 are the earlier respondents and the G2 are the latest respondents. It was compared both groups along firms characteristics, like age (N_Anos), size (N_Emp), manager age (Age), ownership (Ouwner) and sales (Sales), through a t-test analysis. None of the statistics were significant (see table 4), suggesting that latest responses were not different from earlier responses, leading this research to believe that non-response bias may not be a significant issue.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	N_Anos_G1 & N_Anos_G2	72	-,146	,219
Pair 2	N_Emp_G1 & N_Emp_G2	72	-,045	,709
Pair 3	Age_G1 & Age_G2	55	,080	,561
Pair 4	Ouwner_G1 & Ouwner_G2	71	-,184	,124
Pair 5	Sales_G1 & Sales_G2	40	,172	,288

Table 4: Paired Samples Correlation (t-test analysis)

4.3. Measurement and scale development

A pre-test of the survey instrument was conducted through interviews with plant managers, from three companies of an international group. Plant managers agreed that new product, product mix, and volume were the three types of manufacturing flexibility most critical to a firm's competitive edge. In addition, various objective measurements for these three types of flexibility were evaluated.

Operational performance, manufacturing flexibility and employee skills are the main sections of the questionnaire.

New product flexibility, should reflect the ability to introduce and manufacture new products or to modify the existed ones (Slack, 2005a), as a result, new product flexibility was assessed by three items: *(i)* the number of different products produced, *(ii)* the time required to introduce new products and *(iii)* the cost of introducing new products; those items were adapted from researches performed by Gerwin, (1993), D'Souza and Williams, (2000), Judi et. al., (2004), Slack, (2005a) and Chang et. al., (2007), and measured on a five-point Likert scale with endpoints" strongly disagree" and "strongly agree".

Mix flexibility should capture the ability to change the range of products being made by the manufacturing systems within a given period of time (Oke, 2005). As a result, product mix flexibility was assessed through a three items: *(i)* the twitching time needed to perform distinct operations by machine, *(ii)* he switching costs to operations by machine and *(iii)* the switch time required by operation; those items were adapted from researches performed by Gerwin, (1993), D'Souza and Williams, (2000), Judi et. al., (2004), Slack, (2005a) and Chang et. al., (2007) and measured on a five-point Likert scale with endpoints" strongly disagree" and "strongly agree".

Volume flexibility should reflect the ability to change the level of aggregate output (D'Souza and Williams, 2000: Judi et. al., 2004: Oke, 2005: Slack, 2005a; Vokurka et. al. 2007). As a result, volume flexibility was assessed through three items: *(i)* the range that firm can run profitably, *(ii)* the time required to change flexibility and *(iii)* the cost incurred to change flexibility; those items were adapted from researches performed by Gerwin, (1993), D'Souza and Williams, (2000); Judi et. al., (2004), Slack, (2005a) and Chang et. al., (2007) and measured on a five-point Likert scale with endpoints" strongly disagree" and "strongly agree".

Employee skills should capture the knowledge skills and abilities of the workforce to a greater variety of tasks (Sánchez et. al., 2008), employee skills was assessed through four items: *(i)* the operators ability to perform multiple type of tasks and jobs, *(ii)* the operators great willingness to change and learn, *(iii)* the team spirit inside a between departments and *(iv)* .the operator focus in provide high quality products and services; those items were adapted from researches performed by Lau, (1996), Olhager and West, (2002), Martensen et. al., (2007), Aik, (2007) and Ketkar and Sett, (2009), and measured on a five-point Likert scale with endpoints "disagree" and "total agree".

Operational Performance should reflect the firm's efficiency, productivity and quality in processing of products and services offered to customers (Judi et. al., 2004), operational performance was assessed through three items: *(i)* the customer satisfaction level, *(ii)* the product and service quality and *(iii)* .the operations efficiency; those items were adapted from researches performed by Aik, (2007) and Ketkar and Sett, (2009), and measured on a five-point Likert scale with endpoints “become worst” and “very much improved”.

4.4. Reliability and validity

According Pestana and Gageiro (2008:529), to make the analysis of internal data consistency its necessary to know; *(i)* each item characteristic concerning its mean and standard deviation, *(ii)* mean, standard deviation and correlation between items of the same variable and *(iii)* the relation between each item and its own variable and the effect that each item affect variable mean, variance and cronbach α

Reliability analysis, assessing inter-item consistency within a specific factor, was performed through the internal consistency method estimated by Cronbach’s alpha. Reliability coefficients of 0,70 or higher may considered adequate (Cronbach, 1951; Nunnally, 1978), although according to Nunnally (1978), although according to Nunnally (1978) permissible alpha scores may be lightly lower (over 0,60) for newer scales. As it can be observed from table 5, Cronbach´s alpha scores of all factors were above 0, 60, suggesting that theoretical constructs exhibit adequate psychometric characteristics.

Variables	Cronbach's α	Item
New Product Flexibility	**0,699**	1. Number of different products produced.
		2. The time required to introduce new products.
		3. The cost of introducing new products.
Mix Flexibility	**0,786**	1. Switching time to operations by machine
		2. Switching costs to operations by machine
		3. Switch time required by operation
Volume Flexibility	**0,715**	1. Range that can run profitably
		2. Flexibility time required
		3. Flexibility cost incurred
Employee Skills	**0,668**	1. Ability to perform multiple type of tasks and jobs
		2. Great willingness to change and learn
		3. Team spirit inside a between departments.
		4. Focus in provide high quality products and services
Operational Performance	**0,649**	1. Customer satisfaction Level.
		2. Product/service quality
		3. Efficiency of operations

Table 5: Operationalization of variables

Statistical methods

To be checked for consistency of the model will be used a structural equation modelling (SEM). According to Farias and Santos, (2000), structural equation modelling (SEM) can handle systems with several dependent variables. The concern with this technique is the order of variables. With this technique it is possible to test a theory of causal order among a set of variables. Allows the possibility to investigate how well the predictor variables (predictors) explain the dependent variable (criterion) and also which of the predictor variables is most important. The path analysis is related to models of causal flow one way in which the measures of each variable is perfectly reliable conceptual. Each measure is seen as an accurate expression of the theoretical variable. Indeed, the social sciences assume that perfect confidence is unreal. This was restricted for a long time, the application of this technique of data analysis. One of the partial solutions found to this problem was the inclusion of unobserved variables, or latent and / or errors in the theoretical model. These indicators show the amount of variance explained by exogenous variables (independent).

4.5. A structural equation model of manufacturing flexibility

It can be consider two important measurements to assess overall model quality, one is the root mean square error of approximation (RMSEA) which should not exceed 0.08 (Großler and Grubner, 2006). This criterion is matched by this model (0.038) leading to the conclusion that a good model fit has been achieved. Other indices show additional indications of good model fit: the comparative fit index CFI =0,955 >0, 9 it's at generally accepted criterion levels (Arbuckle 2008). In table 6, is possible to check the list of 16 observed variables and 6 latent variables.

List of Variables in Structural Equation Model				
Description	**Type**	**Item variable**	**Type**	**Description**
Volume flexibility (Vol.F.)	Latent	VF_1_1	Observed	Range that can run profitably
		VF2_2_1		Flexibility time required
		VF_3_1		Flexibility cost incurred
New product flexibility (P.Flex.)	Latent	PF_1_1	Observed	Number of different products produced.
		PF_3_1		The time required to introduce new products.
		PF_4_1		The cost of introducing new products.
Mix Flexibility (Mix F.)	Latent	MF_1_1	Observed	Switching time to operations by machine
		MF_2_1		Switching costs to operations by machine
		MF_3_1		Switch time required by operation
Operational Performance (OP.P.)	Latent	OP_1_1	Observed	Customer satisfaction Level
		OP_2_1		Product/service quality
		OP_3_1		Efficiency of operations
Employee skills (Emp.Skill)	Latent	ES_1_1	Observed	Ability to perform multiple type of tasks and jobs
		ES_2_1		Great willingness to change and learn
		ES_4_1		Team spirit inside a between departments
		ES_6_1		Focus in provide high quality products and services
Manufacturing Flexibility (Man.F.)	Latent	Vol.F.	Latent	Volume flexibility
		P.Flex.		New product flexibility
		Mix F.		Mix Flexibility

Table 6: List of variables in the model

5. Results

The covariance structure model consists of two parts: the measurement model and the structural model. In this section we evaluate the measurement model, which specifies how hypothetical constructs (latent) are measured in terms of the observed variables. In this phase, we use confirmatory factory analysis (CFA) to assess the measurement properties.

5.1. Confirmatory Factor Analysis

CFA involves the specification and estimation of on or more hypothesized models of factor structure, each of which proposes a set of latent variables (factors) to account for covariance's among a set of observed variables. Linear structural equation modelling can be used to test the fit of a hypothesized model against the sample data (figure 4). CFA is performed on the entire set of items simultaneously. According Carr and Kaynak, (2007), a number of indices are used to determine the fit of the data to the model (e.g. Chi-Square / df ratio, CFI and RMSEA). In addition, all of the indicator variables for each factor in the measurement model should have a t-statistic of 2.0 or greater. It was also important that no standard error associated with the t-statistics was near zero. All of the indices were at the desired level, all of the t-statistics for the indicator variables were significant at $p<0,003$ or smaller, and no standard errors were near zero. Based on the R^2 values of previous research studies in this area, the R^2 values of this study are acceptable. The factor loads, standard error, t-values, and R^2 values are shown in table 7.

Indicator variables and their underlying factors	Standardized factor loads	Standard error	t- value	R^2
New Product Flexibility				
1. A large number of different products are produced by the manufacturing facility	0,403			0,163
2. The time required to introduce new products is low	0,613	0,559	2,967	0,375
3. The cost of introducing new products is low	0,546	0,415	2,977	0,298
Mix Flexibility				
1. A typical machine can perform number of different operations without requiring a prohibitive amount of switching time	0,843			0,710
2. A typical machine can perform a number of different operations without requiring a prohibitive amount of switching cost	0,758	0,125	7,41	0,575
3. Time required to switch from one part-mix to another is low	0,636	0,111	6,767	0,405
Volume Flexibility				
1. Range of production volumes at which the firm can run profitably is low	0,613			0,375
2. Time required to increase or decrease production volume is low	0,645	0,214	5,446	0,416
3. Cost incurred to increase or decrease production volume is low	0,784	0,238	5,430	0,615

Table 7: CFA - Factor loading, standard errors, t-value

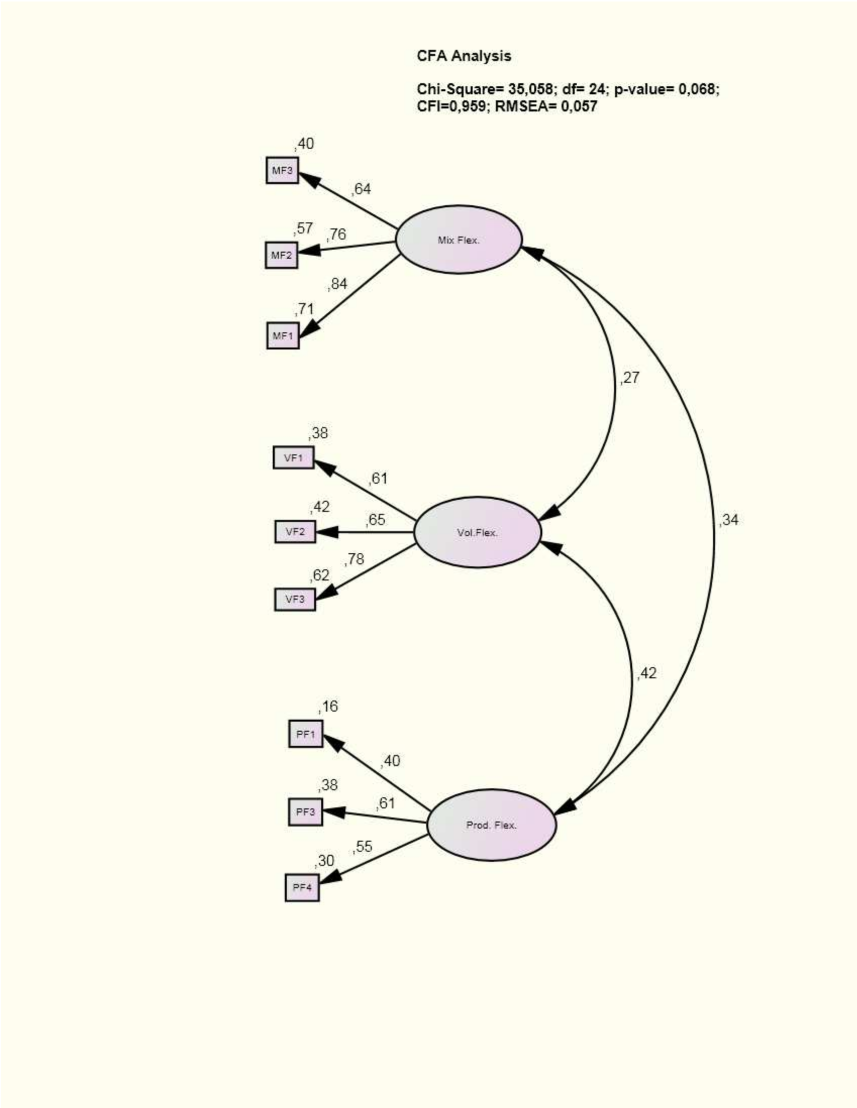

Figure 4: CFA path diagram

Analysing this path, it seams the most important is the operations cost, like already was said in this research, flexibility is not free and in a market crisis it important analyse if the changes are really needed or not. Each firm tries to adapt their manufacturing processes to market needs in order to avoid wasting valuable resources to their strategy.

In volume flexibility, the most important item is the *(iii)* the cost incurred to change flexibility, maybe it could be necessary the use of external flexibility (Sánchez et. al., 2008), this flexibility it very depend of customer unpredictability and some time the firm is not ready to face customer demands, that's why is necessary to evaluate the cost, because it could influence the firm strategy.

In the new product flexibility the most important item to consider still related with costs, *(iii)* the cost of introducing new products. Is necessary to be prepared, is necessary to have trained people to deal with this subject otherwise the costs cannot be supported by firm's strategy. Even consider as proactive measure in assumes an opportunity – seeking (Venkatraman, 1989: Chang et. al., 2007), is necessary to have some careful concerning the future profitability to the firm.

In the mix flexibility the most important item is time, *(i)* the twitching time needed to perform distinct operations by machine to have flexibility to respond to customer demands, is necessary to have a flexible process capable to change from one product to another without loosing a significant amount of switching time. To achieve this goal is necessary to invest in process innovations in order to increase their flexibility and capability to react to customer demands and change of tastes (Todorut, 2008).

According Pestana and Gageiro, (2008:530), the positive correlations between the three variables (table 8), show that there is concordance in their classification, although moderate, meaning that each variable have a part that is common to the others, but also explains something specific. If the correlations were very high, the three variables have nothing specific.

			Estimate
Mix F.	<-->	Vol.F.	,274
Mix F.	<-->	P.Flex	,342
Vol.F.	<-->	P.Flex	,420

Table 8: Correlations between latent variables

5.2. Fit Statistics for the Measurement Model

The overall fit of a hypothesized model can be tested by using the maximum *Chi-square* statistic provided in the model output. This function is a function of internal and external consistency. The p-value associated with this *Chi-square* is the probability of obtaining a *Chi-square* value larger than the value actually obtained under the hypothesis that the model specified is a true reflection of reality. Small p-values indicate that the hypothesized structure is not confirmed by the sample data. Although the *Chi-square* statistic is a global test of model's ability to reproduce the sample variance/covariance matrix, its significance levels are sensitive to sample size and departures from multivariate normality; thus, the *Chi-square* statistic must be interpreted with caution in most applications. Therefore, other measures of model fit should also be considered in assessing model adequacy. Such indices include the ratio of *Chi-square to* degrees of freedom and the comparative fit index (CFI).

Carr and Kaynak, (2007) says the ratio of *Chi-square* to the degrees of freedom provides information on the relative efficiency of competing models in accounting for the data. Most current research suggests the use of ratios less than 2 as indication of a good fit. Models exhibiting CFI greater than 0.90 have adequate fit. These critical values indicate that one expects any model that adequately explains the variances and covariances in the observed data to reflect at least a 90% improvement over the null model.

With respect to fit indices, the program using as input 144 observations demonstrates strong fit for the measurement model. The *Chi-square* estimate is non significant *(Chi-square* = 115,868, p = 0.082, *df =96),* which indicates good fit. The CFI indices 0.955 > 0,90 while the *Chi-square* per degree of freedom is 1.207. All fit indices are well within acceptable limits providing strong evidence of model fit, and consequently, internal and external consistency.

As it possible to see in the path diagram the relationships between employee skills variable and the other variables show a visible difference when you compare the relationship between volume (0,24) and the others, because of that it seams the relationship employee skills -> volume, will not be significant. The same happens when you compare all the relationships between the manufacturing flexibility and the other factors, it is possible to visualize some balance, where is not possible to see big differences between relationships, it seams in this case to think, maybe all the relationships are significant. The path diagram where is represented all the relationships between variables in the conceptual model can be observed on figure 5.

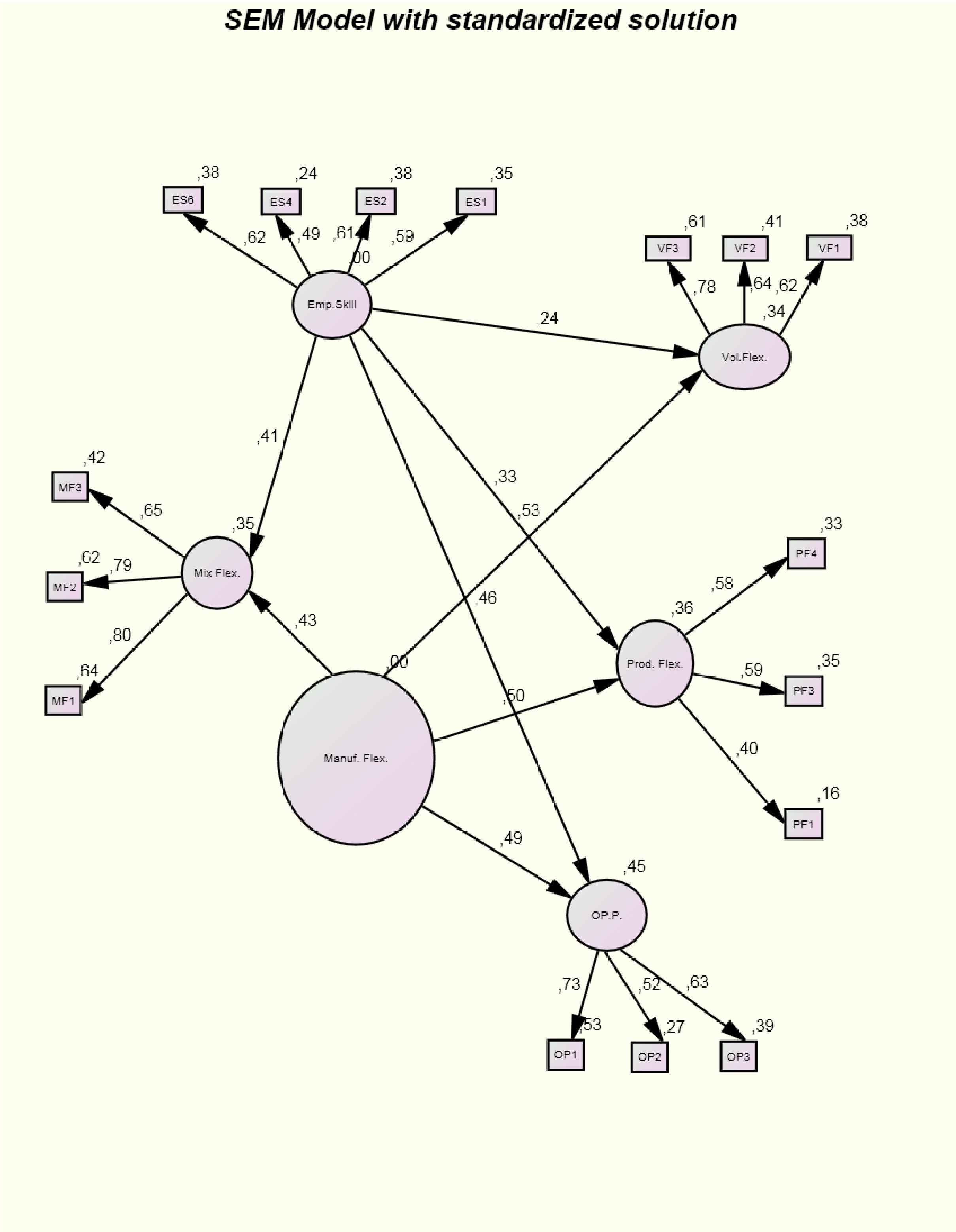

Figure 5: Standardized solution of model fit

6. Discussion and conclusions

This research has analyse a chain of relationships between employee skills and manufacturing flexibility, between employee skills and the primary dimensions of manufacturing flexibility, between employee skills and operational performance and between manufacturing flexibility and operational performance of the firm.

Results suggest that (table 9), don’t exist a relationship between employee skills and volume flexibility. When analysed item by item in detail the employee skills, on item (ES_4_1), the relationship is a little bit low when compared with the others, it means if is necessary team work between departments to make face to a sudden variation on volume necessary to satisfy customer demands, the things could no have the operational performance expected.

Hypotheses	Description	Analytic Method	P-Value	Findings
H1	Employee skills have a positive impact in the new product flexibility	Regression analysis and SEM	0,038	Positive relationship confirmed*
H2	Employee skills have a positive impact in mix flexibility	Regression analysis and SEM	< 0,001	Positive relationship confirmed*
H3	Employee skills have a positive impact in volume flexibility	Regression analysis and SEM	**0,054**	Non-significant relationship*
H4	Manufacturing flexibility level can have a positive impact in firm’s operational performance.	Regression analysis and SEM	0,027	Positive relationship confirmed*
H5	Employee skills can have a positive impact in firm’s operational perform.	Regression analysis and SEM	< 0,001	Positive relationship confirmed*

*Significance level of 95%

Table 9: Hypotheses results

To avoid pay overtime salaries, the normal solution is to use temporary workers (Cousens et. al., 2006), the alternative could pass by apply some methodologies, like lean production that could help to decrease the operators effort and improve their productivity (Boyle and Rathje, 2009).

Analysing the correlation matrix (table 10), is the confirmation expected, the volume flexibility have the lowest impact (23,8%) on employee skills when we compare with other dimensions (operation performance 45,7%; mix flexibility 40,6%; Product flexibility 32,8%).

Correlation Matrix

	Man. F.	Emp.Skill	OP.P.	Mix F.	P.Flex	Vol.F.	OP_1_1	ES_2_1	ES_4_1	ES_6_1	ES_1_1	OP_2_1	OP_3_1	MF_3_1	MF_2_1	MF_1_1	PF_4_1	PF_3_1	PF_1_1
Man. F.	1																		
Emp.Skill	0	1																	
OP.P.	**0,493**	**0,457**	1																
Mix F.	**0,428**	0,406	0,397	1															
P.Flex	**0,505**	0,328	0,399	0,349	1														
Vol.F.	**0,529**	0,238	0,37	0,323	0,345	1													
OP_1_1	0,359	0,333	**0,728**	0,289	0,291	0,269	1												
ES_2_1	0	0,614	0,281	0,249	0,201	0,146	0,205	1											
ES_4_1	0	0,492	0,225	0,2	0,161	0,117	0,164	0,302	1										
ES_6_1	0	**0,62**	0,283	0,251	0,203	0,148	0,206	0,381	0,305	1									
ES_1_1	0	0,594	0,272	0,241	0,195	0,142	0,198	0,365	0,292	0,368	1								
OP_2_1	0,255	0,236	0,516	0,205	0,206	0,191	0,376	0,145	0,116	0,146	0,14	1							
OP_3_1	0,308	0,286	0,625	0,248	0,249	0,231	0,455	0,176	0,141	0,177	0,17	0,323	1						
MF_3_1	0,277	0,263	0,257	0,647	0,226	0,209	0,187	0,161	0,129	0,163	0,156	0,132	0,16	1					
MF_2_1	0,338	0,321	0,313	0,79	0,276	0,255	0,228	0,197	0,158	0,199	0,19	0,162	0,196	0,511	1				
MF_1_1	0,343	0,325	0,318	**0,801**	0,28	0,259	0,231	0,2	0,16	0,202	0,193	0,164	0,199	0,519	0,633	1			
PF_4_1	0,291	0,189	0,23	0,201	0,576	0,199	0,167	0,116	0,093	0,117	0,112	0,119	0,144	0,13	0,159	0,161	1		
PF_3_1	0,298	0,193	0,235	0,206	**0,59**	0,204	0,171	0,119	0,095	0,12	0,115	0,121	0,147	0,133	0,163	0,165	0,34	1	
PF_1_1	0,199	0,13	0,158	0,138	0,395	0,136	0,115	0,08	0,064	0,08	0,077	0,081	0,099	0,089	0,109	0,11	0,228	0,233	1
VF_3_1	0,414	0,187	0,29	0,253	0,27	**0,784**	0,211	0,115	0,092	0,116	0,111	0,15	0,181	0,164	0,2	0,203	0,156	0,16	0,107
VF_1_1	0,325	0,147	0,228	0,199	0,212	0,616	0,166	0,09	0,072	0,091	0,087	0,117	0,142	0,129	0,157	0,159	0,122	0,125	0,084
VF_2_1	0,34	0,153	0,237	0,207	0,222	0,642	0,173	0,094	0,075	0,095	0,091	0,123	0,149	0,134	0,164	0,166	0,128	0,131	0,088

Table 10: Correlation matrix

This data confirm on table 9, employee skills have limitations (24,2%) under volume flexibility.

Results suggest the relationship between employee skills and new product flexibility is significant. If this relationship has a low significance, it means employee knowledge and skills are not aligned with new product projects which currently exists in a firm (Yi et. al., 2009), but the data prove exactly the reverse situation, the capacity of individual groups can boost innovation in product flexibility (Pramod and Garg, 2006), and that was the conclusion suggest by data on table 9.

Analysing the correlation matrix (table 10), it suggest this relation is positive but not very consistence, with (32,8%) and (27,4%) in effects under employee skills (table 11).

	Man. F.	Emp.Skill	OP.P.	Mix F.	P.Flex	Vol.F.
OP.P.	**0,886**	0,513	0	0	0	0
Mix F.	1	**0,593**	0	0	0	0
P.Flex	**0,674**	0,274	0	0	0	0
Vol.F.	**0,858**	0,242	0	0	0	0
OP_1_1	0,886	0,513	1	0	0	0
ES_2_1	0	1,134	0	0	0	0
ES_4_1	0	0,929	0	0	0	0
ES_6_1	0	1,141	0	0	0	0
ES_1_1	0	1	0	0	0	0
OP_2_1	0,603	0,35	0,681	0	0	0
OP_3_1	0,856	0,496	0,966	0	0	0
MF_3_1	0,806	0,478	0	0,806	0	0
MF_2_1	1,016	0,602	0	1,016	0	0
MF_1_1	1	0,593	0	1	0	0
PF_4_1	0,897	0,364	0	0	1,331	0
PF_3_1	1,099	0,446	0	0	1,631	0
PF_1_1	0,674	0,274	0	0	1	0
VF_3_1	1,103	0,311	0	0	0	1,286
VF_1_1	0,858	0,242	0	0	0	1
VF_2_1	0,992	0,279	0	0	0	1,156

Table 11: Total effects

This result suggests this relationship is on the limit to be validated. It suggest some difficulty to introduce and manufacture new products or to modify the existed ones (Oke, 2005: Slack, 2005a) due some processing capabilities of individual groups (Pramod and Garg, 2006). It suggests management investment in employees training and proactive strategy (Chang et. al., 2007).

This information is confirmed on table 12, where a p-value of 0,044, show the relationship is near to the limit of 5% concerning a confident interval used in this research.

			Estimate	S.E.	C.R.	P	Label
Mix F.	<---	Man. F.	1,000				
OP.P.	<---	Man. F.	,886	,399	2,221	,026	par_27
Vol.F.	<---	Man. F.	,858	,513	1,673	,094	par_32
Vol.F.	<---	Emp.Skill	,242	,128	1,887	,059	par_33
P.Flex	<---	Man. F.	,674	,397	1,696	,090	par_34
OP.P.	<---	Emp.Skill	,513	,160	3,214	,001	par_35
Mix F.	<---	Emp.Skill	,593	,179	3,306	***	par_36
P.Flex	<---	Emp.Skill	,274	,136	2,017	,044	par_37
VF_2_1	<---	Vol.F.	1,156	,216	5,341	***	par_22
PF_1_1	<---	P.Flex	1,000				
PF_4_1	<---	P.Flex	1,331	,443	3,005	,003	par_23
MF_1_1	<---	Mix F.	1,000				
MF_3_1	<---	Mix F.	,806	,114	7,091	***	par_24
ES_1_1	<---	Emp.Skill	1,000				
MF_2_1	<---	Mix F.	1,016	,129	7,885	***	par_25
VF_3_1	<---	Vol.F.	1,286	,242	5,308	***	par_26
VF_1_1	<---	Vol.F.	1,000				
PF_3_1	<---	P.Flex	1,631	,574	2,838	,005	par_28
OP_2_1	<---	OP.P.	,681	,146	4,653	***	par_29
ES_2_1	<---	Emp.Skill	1,134	,238	4,758	***	par_30
ES_4_1	<---	Emp.Skill	,929	,223	4,166	***	par_31
OP_1_1	<---	OP.P.	1,000				
OP_3_1	<---	OP.P.	,966	,200	4,832	***	par_38
ES_6_1	<---	Emp.Skill	1,141	,255	4,482	***	par_39

Table 12: Regression weights

Data analysis suggest the relationship between employee skills and mix flexibility, is significant. Maybe is because it was analysed company groups inside of an huge dynamic environment with huge necessity to innovate, it means the beat in technology is one reality well solid, and because of that suggest the employees have good conditions to perform their work.

There is a general consensus that resource (machine and labour) flexibilities are the building blocks of a flexibility pyramid and directly influence mix flexibility (Koste and Malhotra,, 1999), flexibility is a necessary condition for innovation and provably to be proactive some times is necessary innovate in order to have the right conditions to be flexible (Todorut, 2008). With employee's commitment you improve manufacturing flexibility and operational performance (Sánchez et. al., 2007).

Data analysis suggest on table 9, the employee skills improve manufacturing flexibility and operational performance. With that, this research can suggest the research question one and two are real concerning that data presented on the research. By increase their manufacturing flexibility to allow them to respond to uncertainty in the environment, and that an appropriate match between business strategy and flexibility improves performance (Gerwin, 1993).

The correlation matrix (table 10) suggest some consistency (49,3%) on the relationship between employee skills and manufacturing flexibility and (45,7%) when its compared the relationship between employee skills and operational performance.

In the table 11, manufacturing flexibility have an important role in the operational performance of the firm, with 88,6% and it seams employee skills have also an important value of 51,3%, suggesting this research show some reaction chain between employee skills, manufacturing flexibility and operational performance.

Analysing the data available in the table 12, it confirms the suggests already made by data evidence, but show an important relationship between manufacturing flexibility and volume of 85,8%, it means volume can perform an important role in the manufacturing flexibility and with that put some limits to manufacturing flexibility, because due to data showed in table 9, shows the relation between employee skills and volume is not significant it could suggest managers use other solutions, like outsourcing (Sanchez et al 2007), to guarantee a good reaction in terms of volume flexibility and don't damage the operational performance of the firm.

The operational performance, for sure have a significant improve if operators manifest a clear quality spirit focused on providing high quality products and services and the operations efficiency increase, when its include cost-efficiency in performance measure, employee skills will have a positive relationship because of the cumulative direct and indirect synergistic effects between the human resources dimensions of skill, behaviour, and human resources practices (Bhattacharya et. al., 2005).

In the figure 6 it's presented the resume of the conclusions suggested on this research.

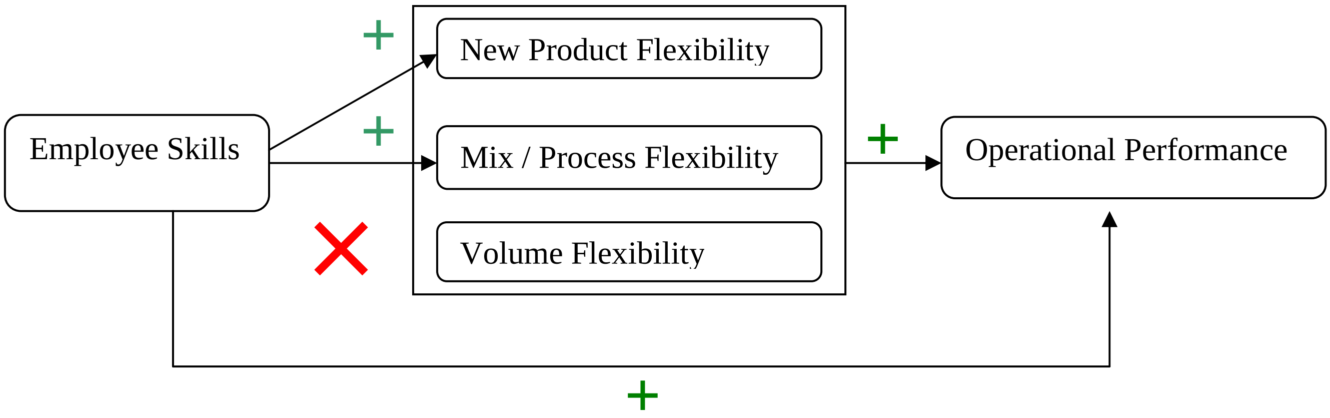

Figure 6: Relation impact between employee skills and the other dimensions

Such results may contribute to explore the relationship between employee skills and manufacturing primary dimensions and it could be enlarge to other dimensions not consider on this research. It contribute to present some causes in operational performance evolution in adaptation to dynamic environment (Ketkar and Sett, 2009), could contribute to explain the positive relationships between employee skills and operational performance of the firm, manufacturing flexibility and operational performance of the firm and employee skills and manufacturing flexibility.

This results also contribute to explain the outsource as a valid strategic activity to firm's with more limited resources on activities that contribute more to generate competitive advantages (Sanchez et. al., 2007). Furthermore, results also suggest that better understanding of human resources flexibility, should help managers to formulate more effective strategies to increase employee skills. It would help them to improve firm performance on a sustainable basis against the odds of environmental uncertainties (Ketkar and Sett, 2009)

This research showed the managers need to find and identify new sources of flexibility based on the organisation's human resources. In this regard, internal labour flexibility is a valuable strategy for firms that need to cope with continuous external challenges. With labour flexibility indicates employees' willingness to cooperate and collaborate with others both within and outside the organisation (Martin et. al., 2009). This study's findings suggest to managers that investment in flexible skills and behaviours of employee's are likely to pay off in terms of increased firm performance.

7. Limitations and future research directions

This research focused on the important role of employee skills under manufacturing flexibility and operational performance. It focused also in the influence of manufacturing flexibility under operational performance, in a short sentence the influence of human resources and its skills, when well oriented and trained, they can influence firm's strategy and results.

However, despite its different contributions, this research has some limitations that may be addressed in future research. First of all, although the sample size may be considered reasonable for such analysis, it cannot be considered excellent, and may represent a potential threat to the validity of the research. Moreover the use of managerial perceptions to operationalize the different variables may also been taken as a limitation.

Finally, results of the current research are context-specific and, as a matter of fact, should be considered cautiously if extended to different contexts, in a generalization attempt.

Future research based on panel data or cross-sectional studies conducted in phases may lead to further refinements of the findings. Another important research to be done in the future is the approach to other kind of markets like services or commerce and compares the results with this research findinds made on the industrial market. Future research suggests the attempt to develop and study the influence of other constructs in manufacturing flexibility and operational performance, like environment and supplier chain, Subsequent efforts might result in a more complete set of dimensions that are generalizable across a variety of industries. Finally as a last suggestion for future research it will very important to analyze the impact of JIT and lean on the performance of human resources as an extension of this research.

8. References:

Arbuckle, James L. ; 2008” Amos 17.0 User’s Guide”, *Amos Development Corporation*

Aik,C. T., 2007,” The Effects of Visual Training and Visual Aids on the Performance of New Workers on a Wood Products Assembly Line”, M.B.A., City University of New York-Baruch College

Anand, G. & Ward, P. T., 2004” Fit, Flexibility and Performance in Manufacturing: Coping with Dynamic Environments”, *Production and Operations Management;* Vol. 13, nº4; pp. 369-385

Martín, I. B. & Puig, V. R.& Tena, A. E.& Llusar, J. C. B., 2009” Internal labour flexibility from a resource-based view approach: definition and proposal of a measurement scale”, *The International Journal of Human Resource Management*; Vol. 20, No. 7; pp. 1576–1598

Bhattacharya, M. & Gibson, E.D. & Doty, H., 2005,” The Effects of Flexibility in Employee Skills, Employee Behaviours, and Human Resource Practices on Firm Performance”, *Journal of Management*; Vol. 31, No. 4; pp. 1-19

Boyle, T. A. & Rathje, M. S., 2009” An empirical examination of the best practices to ensure manufacturing flexibility Lean alignment”, *Journal of Manufacturing Technology Management*; Vol. 20, nº. 3; pp. 348-366

Carr, A. S. & Kaynak, H., 2007” Communication methods, information sharing, supplier development and performance an empirical study of their relationships”, *International Journal of Operations & Production Management*; Vol. 27, nº. 4; pp. 346-370

Chang, S. C. & Lin, R. J. & Chang, F. J. & Chen, R. H., 2007,” Achieving manufacturing flexibility through entrepreneurial orientation”, *Industrial Management & Data Systems;* Vol. 107, No. 7; pp. 997-1017

Chen, S. & Tseng, M. M., 2008,” Aligning demand and supply flexibility in custom product co-design”, *International Journal of Flexible Manufacturing Systems;* nº19:pp.596–611

Cousens, A. & Szwejczewski, M. & Sweeney, M., 2006,” A process for managing manufacturing flexibility”, *International Journal of Operations & Production Management;* Vol. 29, nº. 4; pp. 357-385

Cox, T. Jr., 1989,” Toward the Measurement of Manufacturing Flexibility”, *Production and Inventory Management Journal;* Vol.30, nº.1; pp 68-72

Cronbach, L. J., 1951,”Coefficient alpha and the internal structure of tests”, *Psychometrika*; Vol. 16, nº3; pp. 297-334

D'Souza, D. E. & Williams, F. P., 2000," Toward a taxonomy of manufacturing flexibility dimensions", *Journal of Operations Management;* nº. 18; pp.577–593

Farias, S. A. & Santos, R. C., 2000," Modelagem de Equações Estruturais e Satisfação do Consumidor: uma Investigação Teórica e Prática", *RAC*; Vol. 4, Nº. 3;pp. 107-132

Fine, C. H. & Freund, R. M., 1990," Optimal Investment in Product-Flexible Manufacturing Capacity", *Management Science;* Vol. 36, nº4; pp. 449-466

Gerwin, D., 1993," Manufacturing flexibility: A strategic perspective" *Management Science; Vol.* 39, nº.4; pp. 395-410

Gerwin, D., 2005,"An agenda for research on the flexibility of manufacturing processes", *International Journal of Operations & Production Management*, Vol.25, nº12; pp. 1171-1182

Großler, A. & Grubner, A., 2006," An empirical model of the relationships between manufacturing capabilities", *International Journal of Operations & Production Management;* Vol. 26, nº. 5; pp. 458-485

Jha, V. S., 2008," Strategic Flexibility for Business Excellence –The Role of Human Resource Flexibility in Select Indian Companies", *Global Journal of Flexible Systems Management*; Vol. 9, No. 1; pp. 41-51

Judi, H. M. & Beach, R. & Muhlemann, A. P., 2004," Defining Manufacturing Flexibility: A Research Prerequisite", *University of Bradford School of Management*, Working Paper No 04/38

Kayis, B. & Kara, K., 2005," The supplier and customer contribution to manufacturing flexibility: Australian Manufacturing Industry's Perspective", *Journal of Manufacturing Technology Management*; Vol.16, nº.7/8; pp. 733-752

Karuppan, C. M. & Kepes, S., 2006," The strategic pursuit of mix flexibility through operators' involvement in decision making", *International Journal of Operations & Production Management;* Vol. 26, No. 9; pp. 1039-1064

Lau, R S M, 1996," Strategic flexibility: A new reality for world-class manufacturing", *S.A.M. Advanced Management Journal;* Vol. 61, nº. 2; pp. 11-15

Martensen, A. & Dahlgaard, J. J. & Dahlgaard, S. M. P. & Grønholdt, L, 2007" Measuring and diagnosing innovation excellence – simple contra advanced approaches: a Danish study", *Measuring business excellence,* Vol. 11, Nº. 4; pp. 51-65

Maskell, B. H., 1989," Performance Measurement for World Class Manufacturing Part", *Manufacturing Systems;* Vol.7, nº.9; pp. 36-41

Mieghem, J.A.V., 1998," Investment Strategies for Flexible Resources", *Management Science*; Vol. 44, nº. 8; pp. 1071-1078

Nunnally, J. C., 1978, “Psychometric Theory, 2nd”, ed., *McGraw-Hill*, New York

Olhager, J.& West, B.M., 2002,” The house of flexibility: Using the QFD approach to deploy manufacturing flexibility”, *International Journal of Operations & Production Management;* Vol. 22, nº1; pp. 50-79

Oke, A., 2005,” A framework for analysing manufacturing flexibility”, *International Journal of Operations & Production Management;* Vol.25, nº 9/10; pp. 973-996

Pestana, M. H. & Gageiro, J. N., 2008,”Análise de dados para ciências sociais, a complementaridade do SPSS”, *Edições Silabo*, Lisboa

Pujawan, N., 2004,” Assessing supply chain flexibility: a conceptual framework and case study**”,** *Int. J. Integrated Supply Management;* Vol. 1, nº. 1; pp. 79 - 97

Pramod, M. & Garg, S., 2006,“Analysis of flexibility requirements under uncertain environments”, *Journal of Modelling in Management* ;Vol. 1, nº. 3; pp. 196-214

Sánchez, A. M. & Perez, M. P., 2005,” Supply chain flexibility and firm performance: A conceptual model and empirical study in automotive industry”, *International Journal of Operations & Production Management;* Vol. 25, nº7/8; pp. 681-700

Sánchez, A. M. & Jiménez, M. J. V. & Carnicer, P. L. & Perez, M. P., 2007,” Managerial perceptions of workplace flexibility and firm performance”, *International Journal of Operations & Production Management*; Vol. 27, No. 7; pp. 714-734

Sánchez, A. M. & Jiménez, M. J. V. & Carnicer, P. L. & Perez, M. P.; 2008, ”The moderator effect of inter-organizational cooperation”, *Workplace Flexibility and innovation*; Vol. 37 No. 6; pp. 647-665

Schmenner, R. W. & Tatikonda, M. V., 2005,” Manufacturing process flexibility revisited”, *International Journal of Operations & Production Management;* Vol.25, nº12; pp. 1183-1189

Slack, N., 2005a,” The flexibility of manufacturing systems” *International Journal of Operations & Production Management;* Vol.25, nº.12; pg. 1190-1200

Slack, N., 2005b,” The changing nature of operations flexibility”, *International Journal of Operations & Production Management;* Vol.25, nº.12; pp. 1201-1212

Yi, L. & Yuan, L. & Zelong, W., 2009,” How organizational flexibility affects new product development in an uncertain environment: Evidence from China”, *Int. J. Production Economics*, nº 120, pp. 18–29

Todorut, A. V., 2008,” Innovation, Flexibility, Change-Premises of Organizational Development”, MPRA Paper No. 7968, posted 12. April 2008 / 08:48

Treville, S. & Bendahan, S. & Vanderhaeghe, A., 2008,” Manufacturing flexibility and performance: bridging”, *International Journal of Flexible Manufacturing Systems;* nº19, pp. 334–357

Venkatraman, N.; 1989,”Strategic orientation of business enterprises: The construct, dimensionality, and measurement”, *Management Science;* Vol.35, nº.8; pp. 942-962

Vokurka, R. J. & Lummus, R. R. & Dennis Krumwiede, D., 2007,” Improving Manufacturing Flexibility: The Enduring Value of JIT and TQM”, *S.A.M. Advanced Management Journal;* Vol. 72, nº1; pp. 14-21

Zhang, Q. & Vonderembse, M. A. & Lim, J.S., 2003,” Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction”, Journal of Operations Management; Vol. 21, nº.2; pp. 173-191

Appendix 1 – Global Survey

UNIVERSIDADE DA BEIRA INTERIOR
Covilhã | Portugal

SURVEY

This survey try to focus on the major responsible for getting a high flexibility level in the industrial organization. In our days the resources management is very important and take the best advantage from each resource available could be the right way to became the number one in your market and with that leave your competition behind. This survey make part of my final theses on management master degree.

The survey is confidential. the data collection and treatment will be global, avoid by this way any kind of particular analysis and because of that your confidentiality is guaranteed.

Thank you for your Help and your Time

Organizational Data

1. Identification (optional): ☐
2. Number of employees: ☐
3. Business Volume in 2009: ☐

4. Year of Foundation: ☐
5.Location (city/country): ☐
6.Market Sector: ☐ Industry ☐ Services ☐ Comerce ☐ Other ☐
7.Market: ☐ Essentially Local ☐ Essentially National ☐ Essentially International
8.Market: ☐ Declined ☐ Stable ☐ Growing Slow ☐ Growing fast
9.Production Process: ☐ JIT ☐ Other ☐
10.Kind of products or services: ☐ Define by the company ☐ Define by the customer ☐ Both
11.Products life cycle: ☐ Introduction stage ☐ Grow stage ☐ Maturity stage ☐ Decline stage

11.Certification:

☐ ISO 9001	Since ☐	☐	Planned
☐ ISO/TS 16949	Since ☐	☐	Planned
☐ ISO 14001	Since ☐	☐	Planned
☐ OSHAS18000	Since ☐	☐	Planned
☐ SA8000	Since ☐	☐	Planned
☐ Other	Since ☐	☐	Planned

Senior Manager Caracteristics

1. Profil: ☐ Owner/Creator ☐ Owner/Descendent ☐ Contracted Manager
2. Age: ☐ 3.SEX: ☐ Male ☐ Female 4. Number of years managing the organization? ☐
5. School level: ☐ Primary School ☐ High School ☐ University degree ☐ Master degree ☐ Phd

Operational Performance

In a scale from 1 (become worst) to 5 (Very much Improved) check want is your agreement level concerning the next statements if you compare the performance reached 3 years ago:

	1	2	3	4	5
1. Customer satisfaction Level.	☐	☐	☐	☐	☐
2. Product/service quality	☐	☐	☐	☐	☐
3. Efficiency of operations	☐	☐	☐	☐	☐

Employee Skills

In a scale from 1 (disagree) to 5 (totally agree) check want is your agreement level concerning the next statements:

	1	2	3	4	5
Operators have generally a great ability to perform and handle multiple type of tasks and jobs.	☐	☐	☐	☐	☐
Operators generally manifest a great willingness to change and learn	☐	☐	☐	☐	☐
Operators generally manifest a great team spirit between departments and inside of each of	☐	☐	☐	☐	☐
Operators generally manifest a clear quality spirit focused on providing high quality products and services	☐	☐	☐	☐	☐

Manufacturing Flexibility Dimensions:

Dimension n°1: New Product / Variety Flexibility

In one scale from 1 (strongly disagree) to 5 (strongly agree) check want is your agreement level concerning the next statements:

	1	2	3	4	5
A large number of different products are produced by the manufacturing facility	☐	☐	☐	☐	☐
The time required to introduce new products is low	☐	☐	☐	☐	☐
The cost of introducing new products is low	☐	☐	☐	☐	☐

Dimension n°2: Product Mix / Process Flexibility

In a+A105 scale from 1 (strongly disagree) to 5 (strongly agree) check want is your agreement level concerning the next statements:

	1	2	3	4	5
1. A typical machine can perform number of different operations without requiring a prohibitive amount of switching time	☐	☐	☐	☐	☐
2. A typical machine can perform a number of different operations without requiring a prohibitive amount of switching cost	☐	☐	☐	☐	☐
3. Time required to switch from one part-mix to another is low	☐	☐	☐	☐	☐

Dimension n°3: Volume Flexibility

In a scale from 1 (strongly disagree) to 5 (strongly agree) check want is your agreement level concerning the next statements:

	1	2	3	4	5
1. Range of production volumes at which the firm can run profitably is low	☐	☐	☐	☐	☐
2. Time required to increase or decrease production volume is low	☐	☐	☐	☐	☐
3. Cost incurred to increase or decrease production volume is low	☐	☐	☐	☐	☐

Thank you for your Help and your Time