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Contents

KEY PARAMETERS FOR THE ANALYSIS STAGE OF INTERNATIONALIZATION

Hanzel Grillo, Josefa Mula, Sandra Martínez, Ander Errast

A B S T R A C T

In this paper, we identify the key parameters to consider in a decision model on internationalization of operations. In order to propose these parameters, the GLOBOPE framework was adopted asthe basis of this work. Thisframework contemplatesthe three commonest challenges of global operations configuration for industrial manufacturing companies in an internationalization process, which are: new facility implementation (NFI); global suppliers' network development (GSND); multisite production network configuration. A set ofsuitable parametersis herein provided for NFI and GSND in the analysis stage from strategic, tactical and operational decision levels. These parameters could be used in the future as a basisfor the development of quantitative toolsfor decision making on the internationalization of operations.

Keywords: Internationalization of operations; key parameters; new facility implementation; global suppliers' network development; analysis stage.

1. INTRODUCTION

Martinez (2013) defines internationalization of operations as the deployment of business resources all over the country by locating people and assets to execute primary activities of the value chain. Researchers and professionals have shown a relatively dispersed interest in international ization of operations.

This study is based, mainly, on the works of Errasti (2011), Martinez (2013) and Martínez et al. (2013), which summarise the main contributions made by researchers from the field of internationalization of operations processes as regards principles, tools and techniques to support managers and professionals in the analysis, design and management process of a global production and logistics network. These contributions are summarised within the framework known as Global Operations (GLOBOPE), which is divided into three main parts: new facility implementation (NFI), global suppli ers' network development (GSND) and multisite production network configuration (MPNC). The development and implementation of NFI, GNSD and MPNC is structured through the subdivision into stages, analysis, set up, stability, improvement and excellence.

In this paper, the focus is on the analysis stage of NFI and GSND types. The aim is to explore different indicators could be used in the analysis stage in order to evaluate the suitability for an enterprise or supply chain in the decision making process of internationalizing their operations. The main objective is to identify those indicators in order to set them as a basisforfuture research directed to develop math ematical analysis and modelling for decision supporting in this area. A revision of each of the references mentioned by Martinez (2013) is being synthesized in the analysis stage for NFI and GSND,

where specific indicators are sought for. The main contributions of this paper are to present the resulting set of the main key parameters to consider in the analysis stage of the NFI for strategic, tactical and operational decision levels and GSDN for tactical and operational decision levels.

The rest of the paper is arranged as follows. Section 2 introduces a brief description of related works; meanwhile section 3 presents a quick general introduction of the GLO BOPE framework. Section 4 presents the resulting set of in dicators obtained after the literature revision. Section 5 pre sents a discussion over the set of indicators proposed and, finally, section 6 provides the conclusions.

2. RELATED WORKS

The scientific literature includes a variety of studies that mainly analyse case studies of companies that have had to extend their operations, of either the production or ser vices type, to other frontiers. Andersen (1997) revises theories and conceptual models to establish the supply chain, transaction costs and organizational capacity to enter new markets; it has been established that there is a lack of co herence between theory and the operational level. Coviel lo et McAuley (1999) review empirical research works con ducted into the internationalization ofsmall companiesin a direct foreign investment context. They identify standards in several dimensions in the various cases they analyse, such as characteristics, methods used, etc. Prasad et Bab bar (2000) examine the literature on the structure of inter nationalization of operations, where a tendency of delim iting the region or country where companies are located, level of industrialisation, etc., is identified in the research works. Etemad (2004) reviews theoretical frameworks that refer to internationalization of small and medium enter prises (SMEs), the characteristics that lead companies to undertake internationalization, and the pros and cons of this process compared to large firms. Sommer et Troxler (2007) analyse outsourcing and offshoring processes from a more empirical perspective by conducting interviews and making evaluations with consultants from several companies who have undertaken both processes. They stress the advantages, risks and impact of the occupational situation in saturated markets. De Toni et Parussini (2010) review the scientific literature on the origins and evolution of the international production network. Other studies focus on a more profound analysis of the specific areas or processes in developing internationalization. Initially by analysing the internationalization of four Swedish companies, Johanson et Wiedersheim (1975) describe the process that has allowed them to reach their current international position. Johanson et Vahlne (1977) develop an internationalization process model of a company that focuses on gradual acquisition, integration and use of knowledge in terms of overseas markets and their growing commitment with the company. Johanson et Vahlne (1990) describe the internationalization mechanism based on the previous model. Dawson (1994) explains the need for the theoretical explanations of existing frameworks in the internationalization of operations-related cost paradigm not having so many differences between some companies and others; this work

analyses the specific retail case of the internationalization of operations. Eriksson et al. (1997) analyse the relationship between lack of knowledge on markets, busi nesses and foreign institutions and the subsequent internationalization process cost. More recent studies present the first theoretical essays to qualitatively and quantitatively analyse the decision made to internationalize. Hammami et al. (2008) determine the importance of characteristics such as cost, constraints and decisions in the delocation process problems that must be included in the supply chain's design models. Kedia et Mukherjee (2009) present an analytical framework with the reasons why companies subcontract processes or services in global markets. Aspe lund et Butsko (2010) examine decisions made by SMEs to subcontract production operations to low-cost countries, including motivation, location, etc.; they also study the relationship between decisions and subsequent international market expansion. Mediavilla et al. (2012) explore the application of the model of Ferdows (1997) to make good use of overseas plants, which they include in their analysis of the strategic role in global operations networks to extend the scope of the model by applying a road map to gradually improve the plant's role in the global market. Armengol et al. (2014) propose a conceptual model for a representative cost structure associated with the internationalization of operations.

Other similar studies from the existing wide variety could be cited; however, most of them describe the inter nationalization processes, and do not specifically analyse the evaluation and relevance of the decision to interna tionalize in depth. Thus, we have based our investigation in the GLOBOPE framework, by going directly to the proposed literature in the analysis stage of NFI and GSND. The objective of this paper is to set up an initial set of measures that, quantitatively, provides the elements needed to develop a decisional model for the analysis of the pertinence of inter nationalization of operations.

3. RESEARCH METHODOLOGY

Errasti (2011) defines GLOBOPE as a framework for the design and configuration process of a global production and logistic network that can be a useful management tool for SMEs, strategic business units (SBUs) and steering committees that are responsible for making global operations effective and efficient. According to Martínez et al. (2013), GLOBOPE bearsin mind the key decisions of the operations' strategy that need to be made about a global production and logistic network configuration and design in the internationalization process. The framework considers three core challenges relating to operations configuration: NFI, GSND and multisite production network configuration. All the previous problems must be dealt with according to five main stages: analysis, set up, stability, improvement, and excellence. In this paper, based on the proposal of principles, methods and tools to aid during the decision-making process for the analysis stage of NFI and GSND by Martínez et al. (2013), we review the scientific literature related to these principles, methods and tools for the analysis stage in order to identify the key quantitative parameters allow the detailed evaluation of strategic,

tactical and operational key decisions for NFI and tactical and operational key decisions for GSND that must be made before devising the internationalization plan.

4. KEY PARAMETERS FOR THE GLOBOPE-BASED ANALYSIS STAGE

Martinez (2013) proposes different principles, methods and tools to evaluate the key internationalization of operations' decisions made in the analysis stage. Here we reviewed all these principles, methods and tools, as well as the reference literature proposed. Several parameters were identified, which can be quantifiable to evaluate each key decision. The objective is to obtain an initial basis of the evaluation parameters for the internationalization of operations process analysis. These could, a posteriori, be interpreted using mathematical programming models, analytical formulations simulation models based on system dynamics. Tables 1, 2 and 3 provide the results of the review conducted, which was based on Martinez's initial proposal (2013). Key decisions and bibliographic sources according to the GLOBOPE framework were included, and the key parameters, which were identified to evaluate the key decision for both NFI and GSDN, were also directly included.

Table 1. Key parameters for the analysis stage.

NFI strategic decisions

Key decisions/ sources	Key parameters
Manufacturing facility location (MacCarthy and Atthirawong, 2003; Abele et al. 2008)	* Cost per square meter of construction * Land cost * Technology cost * Government restrictions cost * Total production cost * Total transport cost * Capital cost * Material cost * Labour productivity * Capital productivity * Distance from relevant markets * Freight rates * Potential restructuring and closure costs
Facility strategic role (Ferdows, 1997)	* Availability of subsidies * Access to low-cost production * Qualified and specialised personnel * Market proximity
Integration or fragmentation of productive and logistics operations: Make or buy decisions (Fine et al. 2002; Abele et al. 2008)	* Economic value added * Total costs * Assets * Revenues * Competitive cost structure * Strategic value added * Customer importance * Technology clock speed * Competitive position * Capable suppliers * Architecture * Procurement cost

Service delivery strategy • Supply strategy (Poler et al. 2002)	* Quality in information or decisions * Strategic quality factor of human resources * Tactic quality factor of human resources * Operational quality factor of human resources * Yearly cost per human resources * Interruptions in decision making * Total quality of the decision system
• Manufacturing strategy (Miltenburg 2009, 2005; Martinez, 2013)	* Currency cost savings * Logistic costs by geographic area * Local production cost * Material cost * Labor cost * Overhead cost * Other production costs * Product quality * Delivery time * Flexibility * Innovativeness * Accessibility * Effectiveness of learning curves * Learning * Cost savings due to offshore factories * Mobility * Reliability in due date achieving * Thriftiness
• Purchasing strategy (Trautmann et al. 2009; Gelderman et Semeijn, 2006)	* Activity of competence * Relevant supply market * Purchase difficulty * Purchase complexity * Supplier performance * Strategic partnership * Ordering cost * Supply assurance * Dominant suppliers' conditions * Safety stocks * Knowledge and volume of purchases * Flexibility * Added value of purchased product * e-procurement * Degree of aggregation of purchases * Cost savings * Profitability of the final product purchase * Supply risk
Global Operations Network • Distribution network (Abele et al. 2008; Waters, 2003)	* Technology cost * Government restrictions cost * Total production cost * Total transport cost * Material cost * Distance from relevant markets * Freight rates * Potential restructuring and closure costs
• Manufacturing network (Martinez, 2013)	* Manufacturing network type * Innovativeness * Local production cost * Material cost * Other production costs * Overhead cost * Logistic costs per geographic area * Labor cost * Scope of the manufacturing network * Delivery time * Cost savings due to offshore factories * Product quality * Delivery reliability in due date achieving * Flexibility

• Suppliers network (Meixell et Gargeya, 2005; Kraljic, 1983)	* Profit * Market penetration * Facility utilization * Export/import levels * Non trade-tariff barriers * Currency exchange rate * Worker skill availability * Corporate income tax * Fixed and variable costs * Time horizon * Functional efficiency * Bottleneck items * Establish local/global suppliers * Decentralization * Abundant variety of suppliers * Scarcity supply * Leverage, bottleneck and strategic items * Losses * Robustness across pre-defined scenarios * Sales * Production and purchase costs * Tariffs/duties * Commodities and special materials * Investment * Cost management and reliable short-term sourcing * Global sourcing, suppliers quantity and technology

Table 2. Key parameters for the analysis stage. NFI tactical and operational decisions

Key decisions/ sources	Key parameters
Plant and factory construction or adaptation (Martinez, 2013)	* Greenfield: New facilities from the ground * Brownfield: Acquisition of existing resources
Technological level of the facility and automation level of the process (Ferdows, 1997; Corti et al. 2009)	* Availability of subsidies * Labour force characteristics * Infrastructure * Proximity to suppliers * Competitors activity * Quality of life * Legal context * Macroeconomic factors * Political factors * Local managers availability * Access to low-cost production * Training facility * Proximity to markets/customers * Costs * Proximity to headquarters * Site competence * Availability of qualified and specialized human resources

Facility material flow design and planning process (Errasti, 2006; Muther et al. 1981; Tompkins, 2010)	* Supply price * Variety of suppliers * Transport cost in supply * Production stability * Production sequencing * In transit stock * Finished product stock * Service level in delivery * Reordering point * Customer satisfaction * Return of assets (ROA) * Supply chain profitability * Equipment effectively * Space and energy effectiveness * Return on investment * Security safety * Job satisfaction * Environmental responsibility * Sustainability and resilience * Housekeeping * Inventory levels of raw materials * Material control * Partnership and communication * Personnel effectiveness * Economic Ordering Quantity * Material handling * Stock level in regional distribution centres
Facility layout design (Muther et al. 1981; Hayes et Wheel-wright, 1984; Lluís, 2009)	* Space requirements * Size of packages (in/out) * Material handling cost * Cost of direct labor * Setup costs * Accessories costs * Depreciation costs * Total cost of the generated layout * Capacitation costs * Workstations type * Production lifecycle * Required machinery * Production quantity and rate * Materials flow * Product design and specification * Initial investment * Human resources (person/hours) * Material costs * Movements of materials and products * Product type * Average weight per shipment (in/out) * Operational costs * Seasonal variation of shipments * Installation costs * Daily variation of shipments in products * Operating times * Quantity and variety of materials and product * Services * Average and maximum number of trucks per day (in/out) * Average and maximum number of packages issued (in/out)

	* Similarity in operations, process and materials of products
Areas and workstation detailed design (Lluís, 2009)	* Amount of required equipment * Required surface * Distribution of equipment and work-stations
Procurement, distribution, installation and location of equipment and machines (Knoepfel, 1983)	* Total income * Land cost * Depreciation * Interest rate * Operations' expense * Salaries * Total profit * Risk level
Procurement tools and jigs (Yurdakul, 2004)	* Process quality * Setup time of an activity * Depreciation on machinery * Direct material cost * Material handling and storage * Production planning * Machine maintenance and supply * Selling cost * Direct labour cost * Administrative cost * Time between order and delivery * On-time shipments * Shipment accuracy * Material utilization * Manufacturing lead time * Scrap and rework * Variety of part types manufactured * Inventory * Actual machining time of a typical part * Lot size * Number of operations that can be performed with the machine tool.
Shop floor management design (Szulanski, 1996)	* Eventfulness of knowledge transfer * Degree to which the donor of the best practice is perceived as reliable * Degree to which the organizational context supports the development of transfers.

Table 3. Key parameters for the analysis stage. GSND decisions

Key decisions/ sources	Key parameters
Link between business and purchasing strategy (Slack et Lewis, 2002)	* Location * Supply network configuration * Organizational structure * Suppliers * Standardization and improvement * Quality * Responsiveness in time, volume, variety flexibility, cost.
Make or buy (Fine et al. 2002)	* Economic value added * Total costs * Assets * Revenues * Competitive cost structure * Capable suppliers * Customer importance * Strategic value added * Technology clock speed * Architecture * Competitive position
What and whom to buy? (Kraljic, 1983; Martinez, 2013)	* Functional efficiency * Bottleneck items * Establish local/global suppliers * Decentralization * Abundant variety of suppliers * Scarcity supply * Commodities and special materials * Time horizon * Leverage, bottleneck and strategic items * Cost management and reliable short-term sourcing * Global sourcing, suppliers quantity and technology
Purchase policy for each category (Sarkar et Mohapatra, 2006; Kauffman et Leszczyc, 2005)	* Quality systems at the supplier * Performance history * Financial capability of the supplier * Profitability of the supplier * Technological capability of the supplier * Supplier's proximity * Reputation for integrity/honesty/ image * Conflict resolution * IT standards/communication systems * Communication openness * Bidding procedure compliance * Price of products * Management and organisation * After sales support * Contribution to productivity * Ability to meet delivery * Production facilities and capacity * Promise/delivery lead time * Labor problems at supplier's place * Number of optimum suppliers * Sensitivity to buyer's requirement

	* Product quality/reliability * Decision cost to evaluate suppliers * Ability to supply items * Search cost to find and qualify suppliers. * Probability to find better suppliers * Business volume/amount of past business
Supplier selection process (Al-Harbi,1998)	* Contractor`s new fee * Total profit of the project * Total Cost * Expected utility value (EUV)
Contract management (Al-Harbi, 1998; Turner and Simister, 2001; Holt, 1998)	* Cost of changes in product specification * Total cost * Variations cost of the process specification * Price of contract * Aggregate score for contractor * Uncertainty in the product * Euclidean distances of clusters * Uncertainty in the process * Multiple Regression of variables * Total profit of the project * Membership functions for uncertainty * Contractor`s new fee * Predictive contractor performance * Expected utility value * Cost of product specification in the tender documentation * Cost specification of the working methods in supply documentation
Purchasing strategic objectives for product category (Martinez, 2013)	* Quality of products * Productivity cost * Delivery exactness * Security * Moral * Product type * Acquisition per volume
Procurement strategy (Martinez, 2013)	* Supply characteristics * Demand characteristics * Raw materials characteristics * Material requirement planning (MRP)

5. DISCUSSION

Table 1, Table 2 and Table 3 show the resulting set list of KPI identified in the literature referenced in the analysis stage for NFI and GSND. We have identified several indicators for each decisional level, and inside of each decisional level, for each specific key decision. Now, we have found that, many of the indicators are participating, simultaneously, in several key decisions along of NFI and GSND. This fact means that, the list could be refined by identifying all these relationships among indicators with the key decisions they could support. Due to that, in order to set a initial basic list of KPIs to develop decisional

mathematical models, a refin ing steps must be conducted to eliminate redundant infor mation by considering that one same KPI could contribute to multiple key decisions. Then, the resulting list of this work is a valuable starting point because it states a global set of information, containing all the main parameters to be taken into account.

It is important to highlight that in the set of the indicators identified,some of them could be modelled and, mathemat ically, formulated but in other cases, these indicators seem to be rather linguistic variables. In this case, the use of fuzzy

TOPSIS tools could be useful in order to complement quanti tative mathematical models with other qualitative variables or models. Future research steps must be oriented to struc ture, summarise and formulate them.

6. CONCLUSIONS

This work reviewed the GLOBOPE framework as a suitable means to analyse the internationalization of operations pro cess because the literature on this matter is disperse. This analysis was carried out specifically in the analysis stage of the GLOBOPE model. Here, key decisions were evaluated before implementing and setting up the internationalization of operations process. Then, an analysis of the literature review related to the principles, methods and tools for the decision-making process of these key decisions was done in order to identify and propose a set of key parameters. These key parameters can be employed as a basis to quantitatively evaluate these key decisions. Tables 1, 2 and 3 summarise the possible parameters for each GLOBOPE framework, NFI and GNSD possibility, along with their strategic, tactical and operational decisions. This series of parameters must act as a basis for future research lines in which the most relevant decisions are identified, and duplicities are refined and elim inated to comprehensively measure each decision. This is done to establish future mathematical or dynamical evalu ation models based on empirical or historical data of stan dards, and on information about the company interested in being internationalized, in order to objectively determine the quantitative criteria of the relevance, or not, of extending operations to other latitudes.

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ANALYSIS OF INDIVIDUAL MICRO-ENTREPRENEUR VISION FROM THE PERSPECTIVE OF FINANCIAL MANAGEMENT

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A B S T R A C T

In the business world, the management of an organization calls for the development of information to support decisions. However, this is not a reality for a significant part of micro and small enterprises in Brazil, as several studies have shown. On this theme, with a focus on individual micro-entrepreneurs1 , the present study investigated how these businesspeople manage their finances and development. Methodologically, the study was supported by field research with 21 entrepreneurs in different business segments from the city of Volta Redonda (Rio de Janeiro state). Results indicated that 19% of respondents do not control cash flow and 76% do not analyze their financial results. Of those that use some kind of control, 67% monitor their finances by handwritten notes in notebooks. Regarding the sales forecast, less than half of the surveyed people do this type of control. Therefore, the surveyed micro-entrepreneurs need to develop financial and ac counting management systems, focusing on a better financial control of their businesses. Although not conclusive, we believe the results obtained are related to the respondents' low level of education.

Keywords: Individual micro-entrepreneur; Micro and small enterprises; Entrepreneur ship; Financial and accounting management.

1. INTRODUCTION

According to Toma et al. (2014), entrepreneurship is a multifaceted phenomenon that can be analyzed as a pro cess, action or state of being. According to these authors, through the Schumpeterian view, where new technologies destroy old business models while creating new opportuni ties, the entrepreneurial process is one of the key factors in the economic development of a country/region.

Economists, sociologists and management scholars have proposed various entrepreneurship definitions and conceptual frameworks for the entrepreneurial process. Entrepreneurship study can be defined as "the study of sources of opportunities; the process of discovery, evaluation and exploitation of opportunities, and the set of individuals who discover, evaluate and exploit them" (Leyden et al., 2014).

In Brazil, most firms are informal: about 75% of compa nies are not registered with the National Register of Legal Entities (CNPJ) and do not contribute to the pension system. This feature is even more pronounced among micro-enterprises with up to one employee (Corseuil et al., 2014).

According to the Brazilian Institute of Geography and Statistics (IBGE, 2005), in a survey conducted in 2003, 53% of informal businesses did not keep any accounting records. This could be linked directly to

the fact that only 2% of micro-entrepreneurs had college diplomas, which in part can accentuate the difficulty of keeping satisfactory accounting records (IBGE, 2005).

In late 2008, through Complementary Law 128, individual micro-entrepreneurship (MEI) list was created (Costanzi et Barbosa Ribeiro, 2011). An individual micro-entrepreneur is defined as having gross income in the previous calendar year of up to R$ 60 thousand opting for the "Simples Nacional" tax regime and those who are not disqualified from opting for the system described in Article 966 of Law No. 10,406/2002 (Brasil, 2006).

The main goal of this law was to reduce informality in the Brazilian market, allowing the federal government to increase its revenue, as well as increasing people's access to benefits that only formal workers otherwise enjoy (Paiva et al., 2013).

A study by Borges et al. (2012) of individual micro-entrepreneur profile in a mining town, concluded that the surveyed individuals had low levels of education, were not always willing to acquire new knowledge and ended up missing opportunities to grow their businesses and enjoy all the benefits provided by law.

Morais (2014) evaluated individual micro-entrepreneurs and informal workers in the city of Araranguá and found that interest in legalization is related to social security benefits, access to credit and the possibility of expanding the business. It was also observed that the enhancement of individual micro-enterprises requires greater investment in professional training and business management capacity.

Micro and small enterprises (MSEs) and individual micro-enterprises are the two categories of small businesses in Brazil. According to SEBRAE-NA (2013), in Brazil there are 6.4 million such establishments. Of this total, 99% are micro and small enterprises (MSEs). MSEs are responsible for 52% of formal jobs in the private sector (16.1 million) (SEBRAE, 2014). According to SEBRAE (2007), a microenterprise (ME) is a legal entity that receives each year gross income equal to or lower than R$ 240 thousand. In turn, small businesses (EPPs) receive revenue from R$ 240 thousand to R$ 2.4 million.

Despite the large number of micro and small enterprises (MSEs), the situation of these companies, although is improving, remains worrying. According to data on the survival rate of companies in Brazil (SEBRAE, 2011a), of every 100 new companies, 27 close in less than two years.

According to Dolabella (1995), financial management plays an important role in managing a company, as it is responsible for providing data on the financial situation of the organization and allows managers to trace their strategies.

For to Azeredo et al. (2008), the accounts allow measurement and highlight particular aspects of the economic and financial situation of the company, providing a broad overview of the situation.

In Brazil, the first triennium of this decade saw a strong increase in the creation of new businesses opting for the Simples Nacional tax regime. In December 2012, there were 7.1 million companies

registered for the regime. This figure was 26% higher than in the previous December. In 2011, the expansion was already almost 30%. The survival rate is systematically higher in the Southeast region (78.2% for those created in 2007), the only region with survival rate higher than the national average (75.6% for those created in 2007). Next comes the South (75.3%), Midwest (74%), Northeast (71.3%) and North (68.9%) (SEBRAE, 2013).

Based on the relevance of micro and small enterprises for the generation of jobs, income and tax revenues, counterbalanced by the high failure rate, the main objective of this study was to investigate the financial management profile of individual micro-entrepreneurs (IME) in the city of Volta Redonda.In particular, we examine the following questions: I) Do IMEs perform some type of financial control of their businesses? ii) What instruments do they use for this control? iii)

Do IMEs analyze their financial results? iv) Do IMEs use debt financing? v) Do IMEs make sales forecasts? Located in the Southeast region, Volta Redonda was the city selected for this empirical study since it is has the largest number of micro and small enterprises in the Middle Paraiba Region (SEBRAE, 2011b).

Methodologically, the data were collected through a field study of 21 individual micro-entrepreneurs in the city of Volta Redonda, with the main objective of analyzing the vision of this segment of entrepreneurs regarding financial management.

In terms of organization, this paper is structured as follows: section 2 develops the theoretical reference on indi vidual micro-entrepreneurs, informality, municipal data of Volta Redonda and financial management. Section 3 pres ents the research method. Section 4 organizes and discusses the results. Finally, the conclusion ends the study with recommendations for future research.

2. THEORETICAL REFERENCE

This section presents the theoretical foundation of the research, starting with an overview of individual micro-en trepreneurs with emphasis on informality. Information on the city of Volta Redonda is presented, emphasizing the number of micro and small enterprises of the cities in the Middle Paraiba Region, focusing on the evolution of the number by size of establishments in Volta Redonda. The section concludes with comments on financial management and accounting.

2.1 Individual micro-entrepreneurs (IMEs) and informality

Since the end of last century, the economic environment has undergone a revolution, affected by phenomena such as globalization, volatility, convergence, technological inno vation, competitiveness and differentials (services). These changes require increasingly flexible attitudes, creativity, productivity, quality, and forecasting ability of managers to achieve their long-term survival goals (Ost, 2007).

The Law of Individual Micro-Entrepreneurs (Law No. 128/2008) was enacted with the aim of encouraging self-em ployed people in the informal sector to regularize their situ ations (Oliveira et Strong, 2014).

According to the Portal do Empreendedor (2014) individ ual micro-entrepreneurs are people working on their own and that have legalized small businesses. To be an individual micro-entrepreneur, the person must gain a maximum to R$ 60,000.00 per year and have no stake in another company as partner or owner. The IME can also have one employee, receiving the minimum monthly wage or prevailing wage.Companies with these characteristics are eligible for the Simples Nacional regime, which exempts them from federal taxes (income tax, PIS, COFINS, IPI and pension contribution) and simplifies the process of paying municipal and state taxes and reduces the rates (Brasil, 2008)

Informal companies include economic units that produce some type of service or good that generates employment and income (Pathak et Muralidharan, 2016), traditionally characterized by small-scale production, low administrative costs and without clear separation of business and personal assets (Pochmann, 2005).

Likewise et al. (2005) consider that informal work can be characterized by small-scale production, reduced use of technology and unclear separation between capital and labor, in addition to engaging, in some cases, in economic activities outside the law and devoid of protection or pub lic regulation.According to Silva et al. (2010), the large Brazilian infor mal market arises due to the complex and costly regulation of formal work that results in the loss of economic dyna mism and unemployment, also caused by technological in novation or recessive economic times. However, informality emerges as an alternative for income generation and sus tainability for excluded groups, either by technical backwardness or surplus labor in the market.

In turn, according to the Ministry of Labor and Employ ment (2002), the high informality in the Brazilian labor market has three explanatory factors:

1) The new forms of labor relationships and business organization, which increase the number of self-employed people;

2) Loss of labor from traditional sectors (manufacturing) to sectors with higher degree of informality, such as services and commerce, and to outsourcing;

3) Finally, factors associated with the system of social security and labor laws, encouraging the establishment of many informal working relationships by companies and their employees.

Allied to these factors above, Fucs (2010) points out that the national tax system in Brazil is not only burdensome, but also complex, composed of a welter of taxes, contributions, fees and other levies. According to Pereira (2010), a company needs to have good tax planning, since today the tax burden is

the most negative element affecting businesses.

For these and other reasons, the number of enterprises in the informal sector in 2003 surpassed ten million (IBGE, 2005). With the enactment of Complementary Law No. 128/2008, establishing the legal form of the individual mi cro-entrepreneur, the government expected this number to steadily decrease.

The individual micro-entrepreneur category gives an op portunity for growth and development for those who are informal, offering means to stay in the market and thus leverage their enterprise and generate new jobs and opportunities (SEBRAE, 2010).

Among the advantages offered for establishing a formal company, by means of the registration on the National Register of Legal Entities (CNPJ), is the ability to open bank accounts and obtain loans. This comes with the obligation to issue invoices and pay the corresponding taxes.

In addition, the individual micro-entrepreneurs are enti tled to various benefits, such as sick pay, maternity aid and retirement (from the National Social Security Institute – INSS), among others. Individual micro-entrepreneurs must satisfy the following requirements (Brasil, 2006; Brasil, 2008):

• Have no obstruction according to Complementary Law 123/06;
• Opt for taxation under the Simples Nacional regime;
• Do not receive gross revenue of more than R$ 60 thousand per year or the proportional limit shown in Table 1

Table 1. Time in business proportional upper revenue limit for IMEs.

Time of activity (in months)	Proporcional limit (in R$)
12	60,000.00
11	55,000.00
10	50,000.00
9	45,000.00
8	40,000.00
7	35,000.00
6	30,000.00
5	25,000.00
4	20,000.00
3	15,000.00
2	10,000.00
1	5,000.00

Source: Ministry of Labor and Employment (2012).

According to the data of the Urban Informal Economy Survey (IBGE, 2005), conducted by IBGE in 2003, the informal economy generated US$ 17.6 billion in revenue in that year and was responsible for a quarter of non-agricultural workers in the country. In October 2003 there were 10,525,954 small non-

agricul tural workers in the country. In October 2003 there were 10,525,954 small non-agricultural enterprises, of which 98% were in the informal sector. Among the states, São Paulo, Minas Gerais, Rio de Janeiro, Bahia and Rio Grande do Sul concentrated together 57.6% of enterprises in the informal sector (IBGE, 2014a).

2.2 The city of Volta Redonda

The state of Rio de Janeiro is composed of 92 municipal ities1 cities in eight regions: Metropolitan, Northwest Fluminense, North Fluminense, Serrana (mountain), Baixada Litorânea (coastal lowlands), Middle Paraíba, South-Central Fluminense and Costa Verde.

Volta Redonda is situated on the banks of the Paraíba do Sul River, where Companhia Siderúrgica Nacional (CSN, or "National Steel Company") was established in 1946 (Klein, Araujo et Leal, 1985).

According to the IBGE (2014b), the city of Volta Redonda belongs to the Middle Paraíba Region, along with Barra do Piraí, Barra Mansa, Itatiaia, Pinheiral, Piraí, Porto Real, Quatis, Resende, Rio Claro, Rio das Flores and Valença. It has an estimated population of 262,259 inhabitants, with a land area of 182,483 km2 and a Municipal Human Development Index (IDHM, 2010) of 0.771.

Based on data extracted from the Annual List of Social Information (RAIS, 2010), released by the Ministry of Labor and Employment, Figure 1 shows the number of micro and small enterprises of the cities of the Middle Paraíba Region. Volta Redonda has the highest number (SEBRAE, 2011b).

Figure 2 shows the evolution of the number of establish ments from 2009 to 2010, in Volta Redonda. Micro enter prises represented 91.0% of the total formal establishments in Volta Redonda and the highest concentration of these companies was in the retail sector (SEBRAE, 2011b).

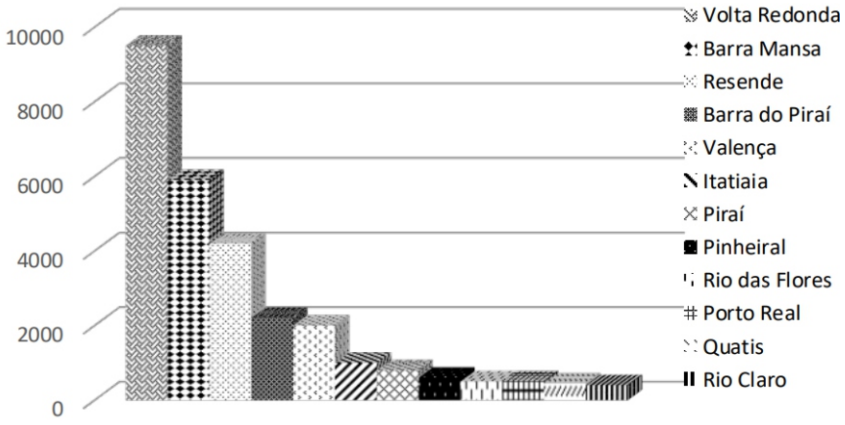

Figure 1. Number of MPEs in cities of the Middle Paraiba Region.
Source: SEBRAE (2011b).

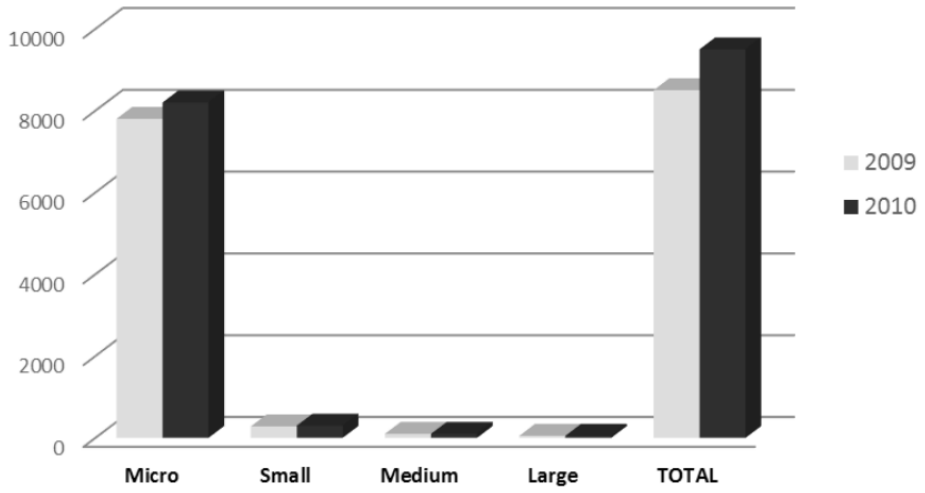

Figure 2. Evolution of establishments in the city of Volta Redonda.

Source: SEBRAE (2011b).

Financial management and accounting

Financial management can be defined as the management of monetary flows from operating activities of a com pany in terms of their respective occurrences in time. It aims to find the balance between "profitability" (maximization of returns) and "liquidity" (ability to honor financial commit ments within contracted deadlines). Thus, financial manage ment is necessary to balance generating profits and maintaining cash (Cheng et Mendes, 1989).

According to Dolabella (1995), a company's management system can be analyzed in three interrelated dimensions: operational, economic and financial, and the last one aims to ensure the company's liquidity.

As explained by Vaz et Menezes (2006), among the man agement challenges are those related human resources, production process and financial affairs, among others. The working capital management is extremely dynamic, requiring daily attention of executives. Any failure in this area can compromise the solvency of the company or impair its profitability.

n recent decades, management accounting has increasingly gained importance within organizations, as a funda mental tool for the pursuit of efficiency and cost contain ment (Macinati et Anessi-Pessina, 2014).

Accounting is responsible for providing information, meeting the new challenges, seeking data that meet the needs of stakeholders (concerned parties) (Daneberg, et al., 2014; Gill et al., 2017).

According to Carneiro et al. (2008), among the many pur poses of accounting is to act as a disclosure channel with society, allowing the identification, measurement and anal ysis of economic, financial, social and environmental events.

For Marion (1998) "Accounting can be considered as an information system designed to provide the

data to users to help them make decisions". Dolabella (1995) affirms that the financial function comprises a set of activities related to the management of funds handled by all areas of the company. This function is responsible for obtaining the necessary resources and the formulation of a strategy to optimize the use of these funds, since financial functions play an important role in the development of all operational activities, contributing significantly to the success of the enterprise.

3. RESEARCH METHOD

This paper addresses the practices of individual micro-en trepreneurs in Volta Redonda regarding financial manage ment. The method is qualitative, descriptive and explorato ry, based on literature review and primary data from a field survey.

The published data came basically from four sources: a) Scielo; b) Web of Science (WoS); c) studies conducted by SE BRAE; and d) laws related directly and indirectly to IMEs. The data from the academic literature were obtained by using the following search expressions: "micro e pequenas em presas", "micro empreendedor individual" and "pequenas empresas" (Scielo); and "microentrepreneurship", "microenterprise" and "small firms" (WoS).

The field survey involved the application of a question naire composed of eleven closed questions. It was previously validated through a pilot test with three other micro-entrepreneurs in the same field, but separately.

The questionnaire contained simple questions to facili tate the understanding of respondents, and covered issues on financial planning, result analysis, loans, cash-flow con trol, control of accounts payable and receivable, and sales forecasting, among others. Twenty-one micro-entrepreneurs in different business segments took part in the survey, conducted at a marketplace in the city of Volta Redonda.

The micro-entrepreneurs were chosen based on the following three parameters: i) diversity of products and ser vices typically sold by micro-entrepreneurs in the city; ii) their presence in this marketplace, which has a privileged geographical location; and iii) ease of access to micro-en trepreneurs by one of the researchers, since the majority of the people surveyed are customers of Banco do Brasil, where this researcher is the Corporate Relationship Manag er. Thus, we used an intentionally non-probabilistic sample of 21 small businesses from a total of 24 located in that marketplace. It should be mentioned that the marketplace has adequate infrastructure and is supported by the municipal government of Volta Redonda.

4. RESULTS AND DISCUSSION

Based on the data collected by this survey, it was observed that only 5% of respondents had completed higher education, while 52% had not finished 9th grade. Therefore, a general low level of education

was evident, which can be directly related to the results. This is not a conclusive find ing, but an assumption that the elements are related to, since it is reasonable to assume that the level of education has a direct influence on financial management issues and their control.

One result that stood out was the method used by the respondents to keep track of their finances. About two-thirds of them control this through figures written in notebooks and 19% do not perform any kind of control. Figure 3 illustrates these results.

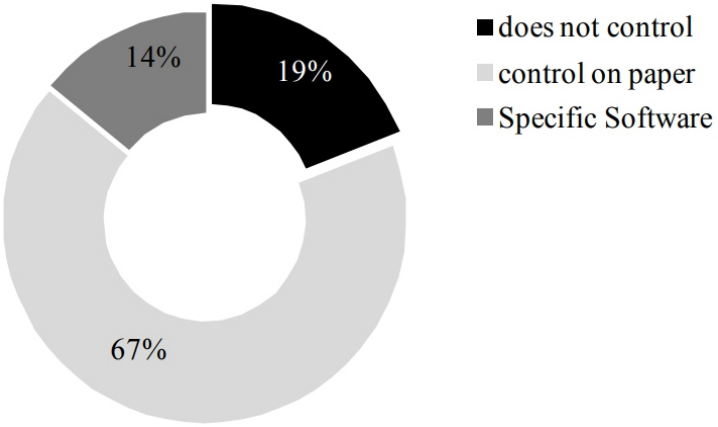

Figure 3. Cash flow control by micro-entrepreneurs.
Source: Prepared by the authors.

According to Rikhardsson et Impgaard (2004), successful management requires having relevant information to guide decision making. Dolabella (1995) points out that financial management has an important role in managing the compa ny, as it is responsible for providing data on the financial sit uation of the organization and therefore, it allows managers to trace out their strategies.

We believe that it is not the lack of resources that pre vents the use of electronic spreadsheets in managing cash flow and financial matters in general, but the existence of a culture characterized by resistance and/or technical inability to use new technologies. The low use of Microsoft Excel, as shown in Figure 4, is a clear example, in line with the scenario presented by the previous figure.

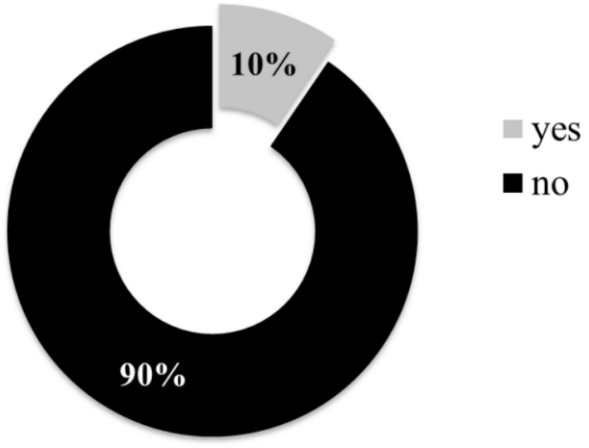

Figure 4. Use of Excel spreadsheets to control cash flow

Source: Prepared by the authors.

The use of this program does not require great technical knowledge; thus, it is the best program for financial record-keeping in micro-enterprises, since typically these companies do not have financial means to invest in specific software. This reinforces the observation of the previous paragraph, i.e., the lack of computer knowledge and the lack of interest and resistance to change of micro-entrepreneurs.

During the literature review, it was noted that cash flow is one of the most effective tools of financial planning and control, thus becoming a basic element for administrators to assess the financial position of the company in the long term (Quintana et Saurin, 2008). A precise cash flow forecast is essential for successful management and is especially important in volatile market and uncertain credit conditions (Tangsucheeva et Prabhu, 2014). Without an accurate prediction of cash flow, the company may fail to meet its short-term obligations and may be in danger of bankruptcy.

If the forecast cash flow is not accurate, the company can be limited by a number of factors, including changes in macro economic conditions that influence liquidity in the economy, varying customer payment behavior and dynamics of the supply chain.

According to Batista et al. (2012), in their study of the mortality of micro and small enterprises in Sousa, Paraíba state, small business owners have resistance to implementing a planning process and creating a database. These micro-entrepreneurs believe that strategic planning is an issue faced only by large companies with expensive projects, high amounts of customers and many managers.

Table 2 identifies the financial management activities carried out by the micro-entrepreneurs in the city of Volta Redonda, including analysis of financial results, planning of financial resources, monitoring of accounts payable and receivable, recording of costs and expenses, as well as the classification of costs into fixed and variable.

Table 2. Activities undertaken by Volta Redonda individual microentrepreneurs

Activities	Results (n=21)	
	Yes	No
Analysis of financial figures.	24%	76%
Financial resources planning	71%	29%
Monitoring of accounts payable and receivable, through payment flows	62%	38%
Recording costs and expenses	86%	14%
Classification of costs into fixed and variable	52%	48%

Source: Prepared by the authors.

According to Table 2, in general, financial management among the micro-entrepreneurs surveyed in Volta Redonda is inefficient: 76% of them do not analyze their financial results. This demonstrates the unpreparedness and lack of interest of most micro-entrepreneurs analyzed. It also shows a lack of

in terest of most micro-entrepreneurs analyzed. It also shows a lack of control in the structuring of business data, to enable measurement and comparison with past patterns.

On the positive side, most micro-entrepreneurs in this study (71%) plan the use of financial resources while the minority of them (29%) does not (Table 2). According to Chan et Chen (1991), companies in financial difficulties, such as those that have lost market value because of poor perfor mance, are inefficient producers and are likely to have fi nancial problems with cash flow. They also tend to be more sensitive to changes in the economy and are less likely to survive adverse economic conditions.

Table 2 shows that 62% of respondents monitor their accounts payable and receivable. This is good for the financial health of the company; however, it is not enough to ensure some security for the business. On the other hand, 38%, which is a very high percentage for an item of prime impor tance for the financial health of companies, do not do this, putting them at the mercy of "luck", and increasing the possibility of failure.

According to the data from Vaz et Gomes (2011), many companies are created every day in Brazil; however, many of them cannot survive and end up closing their doors within five years time. Among the various factors that lead these companies to close are the lack or incorrect management and control of inventories. This particularly affects small and medium-sized enterprises, as they do not often have quali fied people to perform such function or have one person to perform several functions, such as buyer, manager, financial controller, and shop attendant, etc.

Most of the studied micro-entrepreneurs (86%) know what costs and expenses are, while 52% of them understand the definitions of fixed and variable costs. These items are important for planning the company's budget, and the control of these costs is very important for the health of the company (Table 2).

High efficiency and total management of costs are fundamental to the success of any economy. These qualities are the only way to stay competitive, control costs and maintain the quality of products in an intensely competitive environment with decreasing profit margins and market shares (Assaf Neto et al., 2001).

Figure 5 shows the use of loans by the micro-entrepreneurs. Most of the respondents (76%) stated they have no loans while 24% have some type of loan or financing. These percentages are related to the lack of planning for compa ny's growth, where resources such as working capital and investments are not being used, or the entrepreneur fears expanding the business (Figure 5).

Kevane et Wydick (2001) said that the previous two decades had witnessed an unusual proliferation of micro-cred it programs throughout the developing world. The granting of credit to micro companies seeks to stimulate economic growth in the informal sector by promoting better capitalized companies, job creation and growth of long-term income.

Goulart (2013) investigated the profile and characteristics of individual micro-entrepreneurs who were

customers of a bank in the city of Criciúma (Santa Catarina) and found out that most had obtained loans, which helped to promote the business, noted in the reported increase of sales. The sales forecasting of micro-entrepreneurs is shown in Figure 6, revealing the majority (52%) forecast their sales.

This is a good practice for planning the future of the company in the short term and focusing on the way they want to follow. However, 48% do not do this forecasting, which can contribute to the premature mortality of the company, demonstrating once again the lack of business planning and direction (Figure 6). The lack of sales forecasting prevents companies from making financial projections in medium and long term.

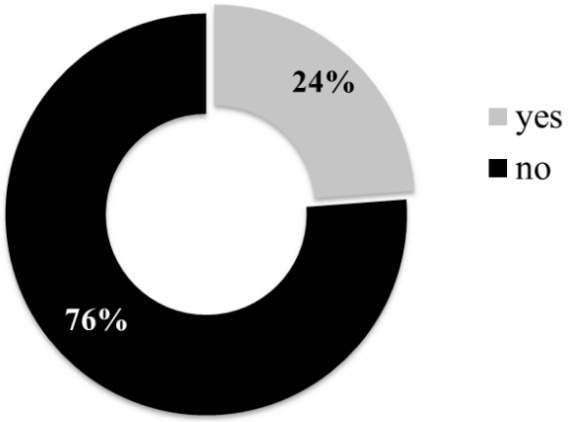

Figure 5. Use of loans by micro-entrepreneurs

Source: Prepared by the authors.

This result demonstrates a lack of business vision (myopia) and a lack of interest in business growth, as well as bad budget management by the majority of micro-entrepreneurs, who seem to be satisfied with their current situation.

According to Acquaah (2013), in contemporary competitive, complex and globally changing business environment, companies are challenged to adopt business models that enable them to meet strategic uncertainties and face risks in their business environments. Simons (2000) and Widen er (2007), accounting management researchers, argue that one of the ways in which companies can continuously reju venate to survive and succeed in these complex and uncertain environments is to understand the role of management control systems in creating competitive advantages.

A study conducted by SEBRAE (2014) evaluated the MSE purchasing system set up by the U.S. government and found out that, under the regulation of the Small Business Act, 1953, federal agencies are required to purchase at least 23% of their supplies from small businesses. The most notewor thy example comes from NASA, which, despite its high quality and technology requirements, spends 31% of its budget purchasing goods and services from American MSEs, when the law requires it to buy only 8%. Meanwhile, the Brazilian MSEs account for only 2% of exports. In Italy this percentage exceeds

50%, the result of a vigorous policy of incentives and protections, which for decades has driven micro and small businesses in that country. In Spain and France, there are similar mechanisms (SEBRAE, 2014).

Figure 7 shows the evolution of the assets of the compa ny, necessary to know the bottom-line profitability. The largest contingent (48%) of the surveyed micro-entrepreneurs does not monitor the evolution of the company's assets. This can cause false impressions of performance, and, in extreme situations, even bankruptcy

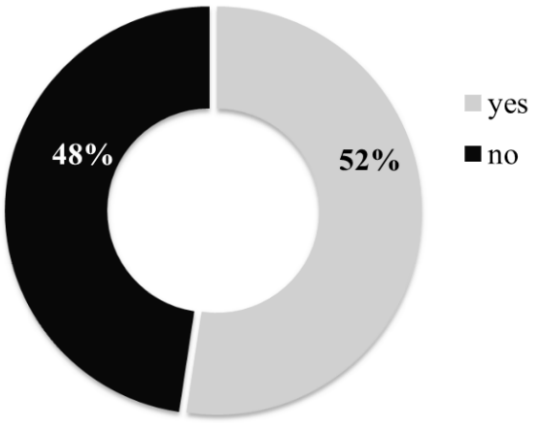

Figure 6. Micro-entrepreneurs that make sales forecasts

Source: Prepared by the authors

Deberry-Spence et Elliot (2012) described a number of factors that restrict micro-entrepreneurship, such as lack of financial capital and cash reserves, poor management skills, inadequate advice, deficiencies in technology, insufficient support services, ineffective rights or property protection, lack of access to credit and the difficulty of access to export markets. Factors include deficiencies in terms of learning and knowledge development, social networks and infrastructure.

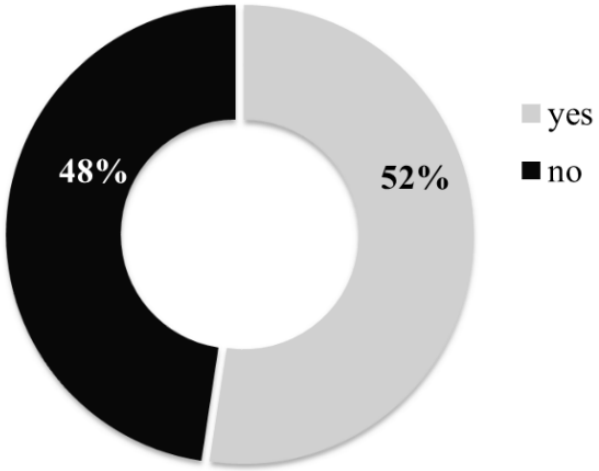

Figure 7. Monitoring evolution of business assets and profitability

Source: Prepared by the authors.

In a globalized scenario, in which information can be found more quickly and easily, many small entrepreneurs are unresponsive or unmotivated to improve and/or unpre pared to manage their businesses. The results found here reveal that many of micro-entrepreneurs are not ready to face challenges effectively and make their businesses grow and prosper, for the simple lack of interest in the search for knowledge and preparation to manage a microenterprise.

Figure 8 condenses and organizes all results found.

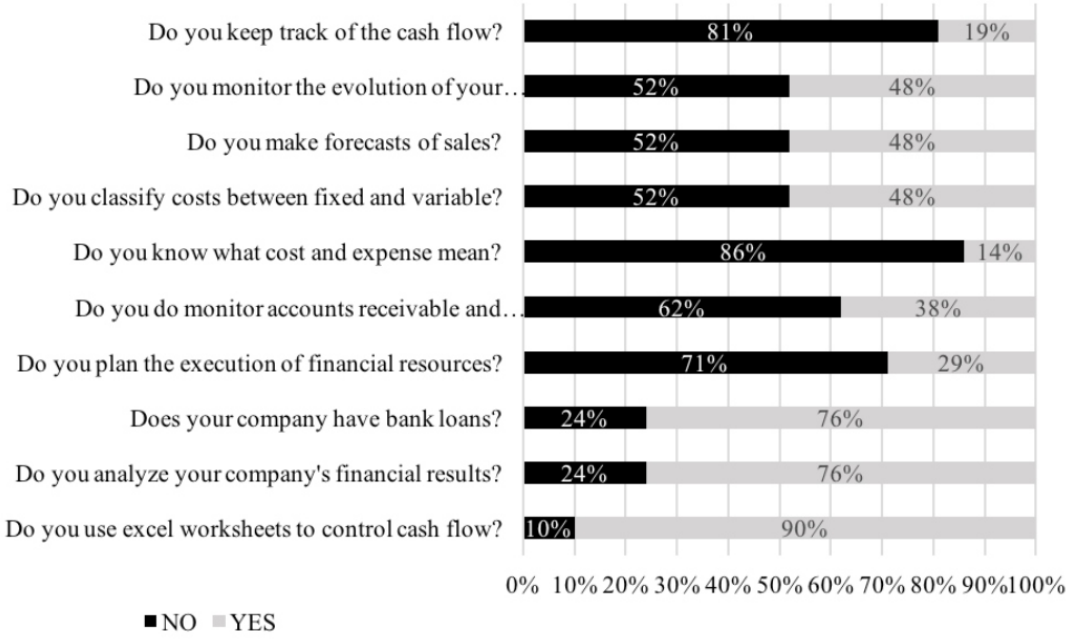

Figure 8. Summary of results

Source: Prepared by the authors.

5. CONCLUSION

Financial management involves a set of actions and procedures related to monitoring certain indicators, which have the objective of maximizing the economic and financial re sults of a company. These results, being positive or negative, end up influencing all other areas of the organization; and this is no different in micro and small enterprises (MSEs).

Since this type of organization is considered one of the main pillars of the Brazilian economy because of its ability to generate jobs, the utility of this study is justified and its goals achieved, i.e., to investigate the individual micro-entrepreneur profile.

The research in question was able to identify relevant is sues such as low educational level, lack of control of cash flow and the low use of effective tools to control it, such as Excel worksheets. It is important to highlight, though, that the percentage of entrepreneurs who control their finances through written notes in notebooks was not expected to be so high, (67%). In this respect, only 14% of the respondents keep track of financial flows with the use of some type of software. In terms of long-term

sales forecasting, for exam ple, we found that 48% do not make any kind of prediction. Thus, by induction, it is believed that this combination of results is one of the reasons (or the main reason) that the mortality rate of MSEs is high (around 27%), as shown in the literature review of this study.

As positive results, it was observed that, apparently, 76% of the entrepreneurs surveyed are not indebted. It is "ap parently" because it could mean a lack of vision in the use of credit, which would leverage aspects related to this type of organization.

Finally, despite this empirical study was conducted with a sample of only 21 micro-entrepreneurs, it is believed that this type of result is common in the business world. However, due to the impossibility of generalization of our findings; and since the selection of the companies surveyed was non-probabilistic and intentional, further research based on statistical models is recommended, aiming at random se lection of an adequate number of companies from this segment, so that the result of the sample may be more reliably attributed to the entire population.

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INDUSTRY 4.0: GLITTER OR GOLD? A SYSTEMATIC REVIEW

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ABSTRACT

Publications on the fourth industrial revolution have skyrocketed since its establishment in 2011, both in academic and non-academic channels. Even though their measurable results have been published in non-academic material, especially among industry and business reports, within the academia it is still unclear how they are shown. This study aims to review and analyse the presence of industrial results within the academic context in a systematic manner by using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) methodology. The findings indicate an increase trend of this type of publication within the academia and further directions are suggested.

Keywords: Industry 4.0; outcome; results; PRISMA

1. INTRODUCTION

The manufacturing industry context has been taking big steps towards innovative advances leading to paradigm shifts. Starting from the use of mechanisation (the so-called 1st industrial revolution in the 18th century), going through the intensive use of electrical energy (the so-called 2nd indus trial revolution in the 19th century), and culminating in the widespread digitalisation (3rd industrial revolution in the 20th century) (Lasi et al., 2014).

In the early 2010s, Germany has taken the lead in what has been called "The 4th industrial revolution". Kang et al.(2016) take this movement as a revolution and summed it up as a "collection and a paradigm of various technologies that can promote strategic innovation of the existing convergence of humans, manufacturing industry through technol ogy, and information". However, no universal agreement on what constitutes an "industrial revolution" has been met yet (Maynard, 2015).

Whether the recent technological advances can be taken as a revolution or not, it triggered several different innova tions such as: the development of new business models, an application-pull and a technology-push in industrial practice (Lasi et al., 2014). It is relevant to emphasise that this pathway of new technologies has a sustainable engineering bias embedded within it. For instance, Siemieniuch, Sinclair etHenshaw (2015) made a collection of 'global drivers' (such as population demographics, food security; energy security; community security and safety) to pose a direction of think ing when deploying such actions.

Governments and industries worldwide, aware of this trend, have been taking actions to benefit from what this set of advances can provide. Table 1 shows a list of programs by country (Liao et al., 2017).

Even though many countries have been joining efforts towards this "revolution", the

academia/industry bonding is still hard to stablish. In recent years, there has been an increase in publication on this topic; however, the state of knowledge is still relatively fragmented and tentative (Perk mann et al., 2013). One possible explanation for why such framework exists is the challenge in linking tangible and in tangible inputs and outputs and capturing their relationship and value. This relationship is especially intractable when one tries to link intangible inputs (knowledge and skills) with tangible outputs (money or another measurable ROI) (Carayannis et al., 2014).

This lack of systematisation hinders both research and cross-sectional studies.Because of this weak link between the academia and the industry, the tangible results coming from the Industry 4.0 might not be placed in a systematic way among indexed databases. Looking at this context as well as the different technologies that they encompass a question arises: Within the academic database SCOPUS, what is the current status of the measurable results from the industry?

Therefore, in order to provide an appropriate answer to the stated research question, the objective of this paper is to review and analyse the presence of industrial results within the academic context in a systematic manner.

The rest of this paper is organised as follows. Section 2 presents the fundamental review principles and the systematic literature review method. Section 3 illustrates the obtained results via charts and tables. Section 4 contains the discussion of the findings, aiming to answer the research question. Section 5 concludes this paper and suggests next steps.

2. PRINCIPLES AND METHODS

A literature search of internet-based bibliographic data bases was completed identifying research that had looked at tangible outcomes within the possible uses of Industry 4.0.

Table 1. Initiatives by country

Date	Country	Plan/Initiative	Source
2011	United States	Advanced Manufacturing Partnership (AMP)	(Reif; Jackson; Liveris, 2014)
2012	Germany	High-Tech Strategy 2020	(Henning; Wolfgang; Johannes, 2013)
2013	France	La Nouvelle France Industrielle	(Ministère du Redressement Productif, 2013)
2013	United Kingdom	Future of Manufacturing	(Government Office for Science, 2013)
2014	European Commission	Factories of the Future (FoF)	(European Commission, 2013)
2014	South Korea	Innovation in Manufacturing 3.0	(kang et al., 2016)
2015	China	Made in China 2025	(Li, 2015)
2015	Japan	The 5th Science and Technology Basic Plan	(Cabinet Office, 2015)
2016	Singapore	RIE 2020 Plan (Research, Innovation and Enterprise)	(Ministry of Trade and Industry, 2015)

Source: Compiled from Liao et al. (2017)

Table 2. Inclusion and exclusion criteria and their explanations.

I/E	Criteria	Criteria explanation
Exclusion	Search engine reason (SER)	A paper has only its title, abstract, and keywords in English but not its full-text
	Without full-text (WF)	A paper without full text to be assessed or invalid DOI
	Non-related (NR)	There is no measurable result from the application of 'the fourth industrial revolution' tools
Inclusion	Partially related (PR)	A research about the outcomes of the fourth industrial revolution without mentioning Industry 4.0 or using it as background/keyword
	Closely related (CR)	The research efforts of a paper are explicitly and specifically dedicated to the results produced by the deployment of the Industry 4.0

Source: The authors' own (2017)

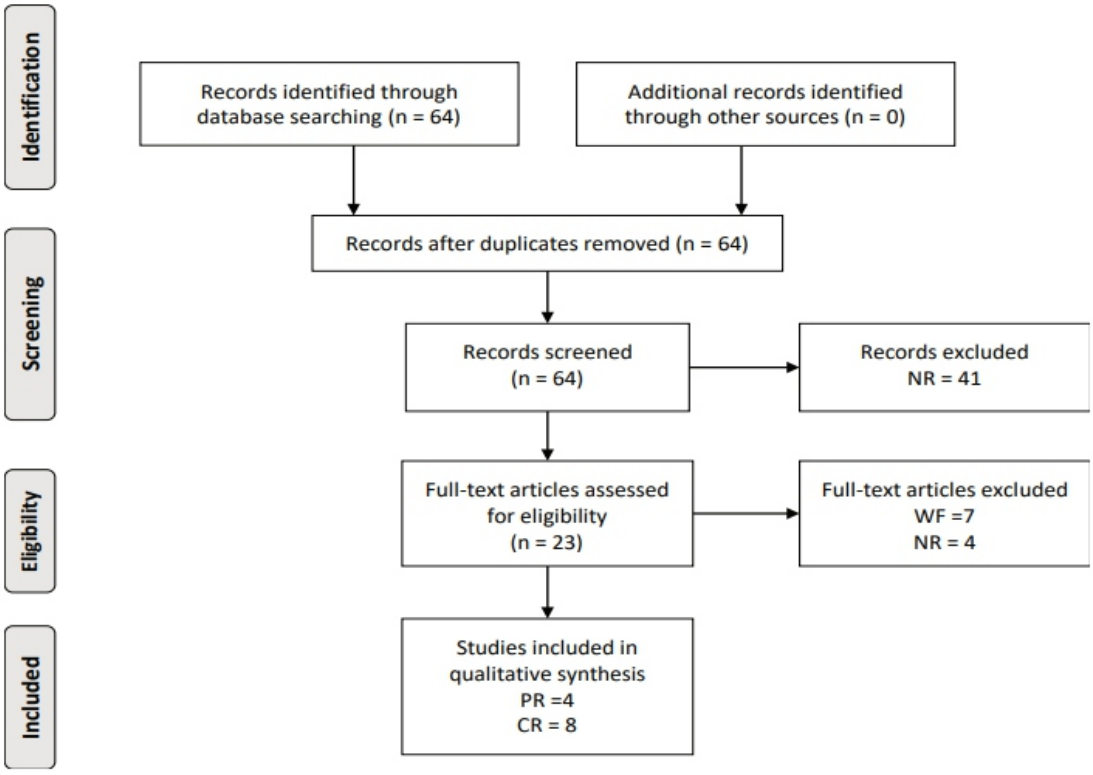


Figure 1. The PRISMA flow chart that reports the different phases of the systematic literature review

Source: The authors' own (2017)

The search was conducted using the Scopus database. All searches were limited to the following conditions:

1. Document type: Academic article
2. Language: English
3. Year: From 2011 to 2017

In order to define the search terms, three post-gradua tion researchers on the topic discussed and reached a consensus1. Then, the terms were tested in the databases to check whether they would fit the purpose. The final search was made by using the following terms: "Industry 4.0" AND (outcome OR

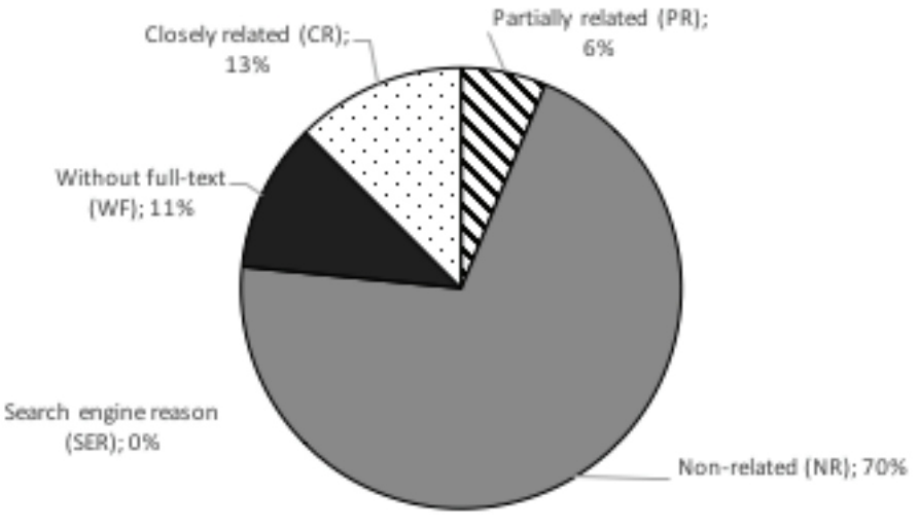
result).

In order to reduce the subjecti vity when analysing the select ed papers, two fundamental review principles were defi ned:

• Explicit inclusion and exclusion criteria: As shown in Table 2, there are fi ve outlined criteria for including or excluding collected papers, as well as their subsets.

• Reducing subjecti ve judgement: Each paper with unclear link between Industry 4.0 and its outcomes should be reviewed by a second examiner (researcher with enough knowledge in the area and able to discuss a bett er placing within the categories from Table 2.

The search was carried out using the guidelines of PRIS MA, which stands for Preferred Reporti ng Items for Sys temati c reviews and Meta-Analyses (Moher et al., 2009). This methodology was developed based on the defi niti ons used by the Cochrane Collaborati on (The Cochrane Collaborati on, 2011), a global healthcare network focused on the way health decisions are made. The main ideas embedded in PRISMA are the iterati ve process and the eff orts towards the reducti on of assessment bias. The PRISMA framework is presented in Figure 1 and a simplifi ed pie chart of the classifi cati on is shown in Figure 2.



F igure 2. Proporti on of papers in each category

Source: The authors' own (2017)

2.1 Paper Collection

The systemati c search used SCOPUS as database to collect academic research that (1) were published online before the beginning of September of 2017; (2) contained at least one of the identi fi ed terms in

either the abstract, ti tle and keywords; (3) were published in academic journals; (4) were writt en in English.

The fi rst screening process was carried out to exclude ar ti cles where their abstract did not contain measurable results coming from the applicati on of 'the fourth industrial revoluti on' tools (NR). Then, all papers that passed the initi al screening process had their full texts downloaded and analysed in order to exclude papers where there was no access to their full texts (WF). Some papers could not provide a clear judgement from the abstract screening and were fully read to be categorised according to whether the arti cle has no applicati on of any measurable result from the use of Industry 4.0 tools (NR); whether the research talks about the outcomes of the fourth industrial revoluti on without menti oning Industry 4.0 or using it as background/keyword (PR); and whether the research eff orts of a paper are explicitly and specifi cally dedicated to the results produced by the deployment of the Industry 4.0 (CR).

3. RESULTS

According to the fi ft h inclusion and exclusion criteria presented in Table 2, the number of papers in the last stage of the PRISMA fl ow chart (Figure 1) accounted for 12 papers out of 64 that were used for the qualitati ve/quanti tati ve analysis. These papers are listed in Table 3.

The applicati ons presented in the papers from Table 3

were clustered according to their profi le: related to the con text or related to a specifi c item. General informati on about the technology applied by the author as well as the area and the paper classifi cati on according to the inclusion and exclusion criteria were also listed. The result is shown in Table 4.

4. DISCUSSION

The abstract screening process was performed looking for values or indicators that could suggest the presence of measurable results of the research within the full text. During the screening process, several words or expressions were found not to have a strong link with measurable results when taken by their own, such as: "potenti al", "feasibility", "can lead the way for the development", "theoreti cal simulati on", and "promising". All these expressions were used either as indicators of possible uses or results obtained into a simulated environment.

The selected papers (those classifi ed as Parti ally related or Closed related) represent 19% of the total. It is curious to note how recent they are; all of them were published within two years of the research date (2016-2017). This might indicate a more advanced stage in the Industry 4.0 maturati on process, where there are enough studies with tangible results being published. It is important to stress that these results are among non-indexed papers, what could be seen as a research limitati on.

Table 3. Selected papers

#	TITLE	AUTHOR	YEAR
1	Energy Optimization of Robotic Cells	Bukata L., Sucha P., Hanzalek Z., Burget P.	2017
2	Performance Improvement of Kinect Software Development Kit-Constructed Speech Recognition Using a Client-Server Sensor Fusion Strategy for Smart Human-Computer Interface Control Applications	Ding I.-J., Lin S.-K.	2017
3	Large-Scale Online Multitask Learning and Decision Making for Flexible Manufacturing	Wang J., Sun Y., Zhang W., Thomas I., Duan S., Shi Y.	2016
4	Dynamic reallocation and rescheduling of steel products using agents with strategic anticipation and virtual market structures	Neuer M.J., Marchiori F., Ebel A., Matskanis N., Piedimonti L., Wolff A., Mathis G.	2016
5	A computer vision assisted system for autonomous forklift vehicles in real factory environment	Syu J.-L., Li H.-T., Chiang J.-S., Hsia C.-H., Wu P.-H., Hsieh C.-F., Li S.-A.	2017
6	Equipment utilization enhancement in photolithography area through a dynamic system control using multi-fidelity simulation optimization with big data technique	Hsieh L.Y., Huang E., Chen C.-H.	2017
7	From sensor networks to internet of things. Bluetooth low energy, a standard for this evolution	Hortelano D., Olivares T., Ruiz M.C., Garrido-Hidalgo C., López V.	2017
8	A feasible architecture for ARM-based microserver systems considering energy efficiency	Xu S.S.-D., Chang T.-C.	2017
9	Autonomous Channel Switching: Towards Efficient Spectrum Sharing for Industrial Wireless Sensor Networks	Lin F., Chen C., Zhang N., Guan X., Shen X.	2016
10	PLCs as Industry 4.0 components in laboratory applications	Langmann R., Rojas-Peña L.	2016
11	A Cloud-based Architecture for the Internet of Things targeting Industrial Devices Remote Monitoring and Control	da Silva A.F., Ohta R.L., dos Santos M.N., Binotto A.P.D.	2016
12	A Smart Maintenance tool for a safe Electric Arc Furnace	Fumagalli L., Macchi M., Colace C., Rondi M., Alfieri A.	2016

Source: The authors' own (2017)

Table 4. Classification of the selected papers

#	Profile	Technology applied	Area of application	I/E criteria
1	Context	Power Optimisation - Algorithm	Car factory	PR
2	Item	Kinect sensor-SDK: Algorithm	Kinect sensor	PR
3	Item	Algorithm	Online platform	PR
4	Context	SOA (service-oriented architecture)	Plant of ArcelorMittal	PR
5	Context	Adaptive Structural Features (ASF) and Direction Weighted Overlapping (DWO)	Pallet factory	CR
6	Context	Abnormality Detector and the Dynamic Photo Configuration	Foundry	CR
7	Item	Bluetooth Low Energy	Chips	CR
8	Item	ARM-based Server Cluster Board (SCB)	Computer processor	CR
9	Item	Industrial wireless sensor networks (IWSNs)	Industrial wireless protocol	CR
10	Item	Reference Architectural Model Industry 4.0 (RAMI 4.0)	Programmable logic controller (PLC)	CR
11	Item	Cloud-based architecture for IoT	Industrial exhauster	CR
12	Context	Smart Water Monitoring	Furnace - Tenaris Dalmine	CR

Source: The authors' own (2017)

Regarding the profile of the selected articles, they are almost evenly split between context (5 papers)/item (7 papers) application. Such division brings to light the evolution profile present in the algorithms/sensors and the joint efforts to apply them in an industrial context. It is also possible to be

understood as the conjoint development of both tools and applications, instead of a division in two phases: developing tools and then applying them to a context. Another alternative is to take this process as a cycle, where the tools are tested in real life and then improved on demand.

Among the algorithms shown by the papers, there is a prevalence of the operational research (usually Mixed Integer Linear Programming) as optimisation tool. Mostly to improve an energy grid or reduce the power consumption of a specific device.

Moving back to the overall results, the low percentage of academic research that present measurable results might have two possible interpretations (stated by the light of this paper's proposal):

As the "Industry 4.0" is a trend term, many papers that have their main topic within the electronics or computing fields are using the term to suit the stream. Such practice ends up jeopardising the use of "Industry 4.0" as search string, as the filtering process turns into a harder task.

Another possible reason why such low percentage of the results was obtained is the lack of standardisation about the topic. This idea goes along with the first topic; however, the difference lays on the publication profile, that does not fo cuses on the results that were already provided. Instead, the authors emphasise the possible applications or results com ing from simulation into a controlled environment.On the other hand, it is possible to exist published papers that are partially/closely related to the topic approached in the present study that do not identify themselves as being part of the Industry 4.0 movement.

5. CONCLUSION

The purpose of this article is to review and analyse the academic presence of measurable outcomes of the fourth industrial revolution in a systematic manner. This review provided support to identify the profile of results presented in academic articles within the Industry 4.0 context as well as to explore possible explanations for the findings.

The study was conducted based on a research question that could be answered to the extent of its limitations (mainly the search string used by the authors). However, as stated by the discussion's last paragraph, it is possible that some measurable applications of Industry 4.0 tools have been suppressed by the lack of consensus among academia and practitioners.

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OPTIMIZATION OF MACHINING PARAMETERS DURING DRILLING BY TAGUCHI BASED DESIGN OF EXPERIMENTS AND VALIDATION BY NEURAL

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ABSTRACT

Drilling is a hole making process on machine components at the time of assembly work, which are identify everywhere. In precise applications, quality and accuracy play a wide role. Nowadays' industries suffer due to the cost incurred during deburring, especially in precise assemblies such as aerospace/aircraft body structures, marine works and automobile industries. Burrs produced during drilling causes dimensional errors, jamming of parts and misalignment. Therefore, deburring operation after drilling is often required. Now, reducing burr size is a serious topic. In this study experiments are conducted by choosing various input parameters selected from previous researchers. The effect of alteration of drill geometry on thrust force and burr size of drilled hole was investigated by the Taguchi design of experiments and found an optimum combination of the most significant input parameters from ANOVA to get optimum reduction in terms of burr size by design expert software. Drill thrust influences more on burr size. The clearance angle of the drill bit causes variation in thrust. The burr height is observed in this study. These output results are compared with the neural network software @easy NN plus. Finally, it is concluded that by increasing the number of nodes the computational cost increases and the error in nueral network decreases. Good agreement was shown between the predictive model results and the experimental responses.

Keywords: Drill Thrust; Burr Size; Aluminium 2014 Alloy; Taguchi Design of Experiments; Neural Network.

1. INTRODUCTION

Drilling operations usually produce burrs on both the entrance and the exit surfaces of the work piece. It is formed as a result of plastic deformation, which depends in large measure on the ductility of the material. Drilling burrs are the main handicap to reach the automation of assembly processes because of the necessity of deburring operations. Burrs are a source of dimension al errors, jamming and misalignment. They may cause short circuits in electrical parts, reduce the fatigue life of components or act as a crack initiation point (Gillespie, 1999; Aurich et al., 2009). For these reasons, the reduction of quality in drilling processes is a critical problem for the aeronautics and aerospace industries. Small burrs are allowed, but they have to be below a certain height. Therefore, deburring operation after drilling is often re quired. In aeronautics assembly, the components to be joined are drilled in stacks (multi-layers). Once the holes are made, components have to be separated in order to deburr and remove the remaining lubricant or chips. This means an additional work which can reach 30% of the to

tal machining costs in precision operations (Aurich et al., 2009). Most of these problems are related to exit burr because it is much larger than that in the drill entrance. Hence, most research on this topic is often focused on the development of strategies to minimize exit burr.

1.1 Neural Network

An Artificial Neural Network (ANN) is: "an information processing paradigm, such as the brain, is the pro cess information. The key element of this paradigm is the structure of the information processing system. It is composed of a large number of highly interconnected processing elements called neurons working in unison to solve specific problems. ANNs can be used to identify patterns and trends from complex or vague data that are very complicated to recognize by human being or other computer techniques. The ANN has to be trained using a learning process. The trained network can then be used to gain insight into new situation and to answer "what if" questions. Because of their immense ability to identify patterns or trends in data they have been greatly used in many applications, including forecasting, industrial process control, customer research, data validation, and risk management, etc. There are various types of neural networks available, such as feed forward neural network with single- and multi-perceptron, Adaline, radial basis function, and Kohenen self-organizing map. Among them, the feed forward networks are the most simple and are used in prediction by training input data to obtain the desired output. The basic architecture of feed-forward networks with multi-layer perceptron is as shown in the Figure. The first layer is called the input layer, and the last layer is the output layer. The intermediate layer is called hidden layer and it can be more than one. The information is fed forward from the input layer to output layer through the hidden layers in a simple feed-forward neural network model. Thus, in the back propagation neural networks, the output value is compared to the desired value and the difference is back propagated through the network. The back propagation algorithm adjusts the weights of the neural network such that the output of the network matches the desired output. This cycle is repeated until the desired value is obtained with minimum root mean square error and is basically called training the neural network (Raymond, 1998).

1.2 Burr formation

A burr is a body created on a workpiece surface during the manufacturing of a workpiece, which extends over the intended and actual workpiece surface and has a slight volume in comparison with the workpiece, undesired, but to some extent, unavoidable. The presence of burrs on the edges of parts after machining, which may bring about a number of problems, turns deburring into a necessary part of the production process.

Burr removal is a non-value added process and might represent as much as 30 percent of the cost of fin ished parts (shown fig.1) (Berger, 2002). As deburring is non-productive and costly finishing process, it

should be minimized or avoided. Any material leading to limited burr formation is therefore advantageous. Recent stud ies and literature have pointed out tremendous issues related to burr formation and deburring operations, including:

• Small finger injuries for assembly workers

• Source of debris (bits of burrs) during operation, thereby reducing the life time of the machined part

• Changing parts resistance and reduction of tool life and efficiency

• Presentation of hazard in handling of machined parts, which can interface with subsequent assembly operations;

• Burrs that are adhered to the work part may become loose during operation, and consequently cause difficulties and damage.

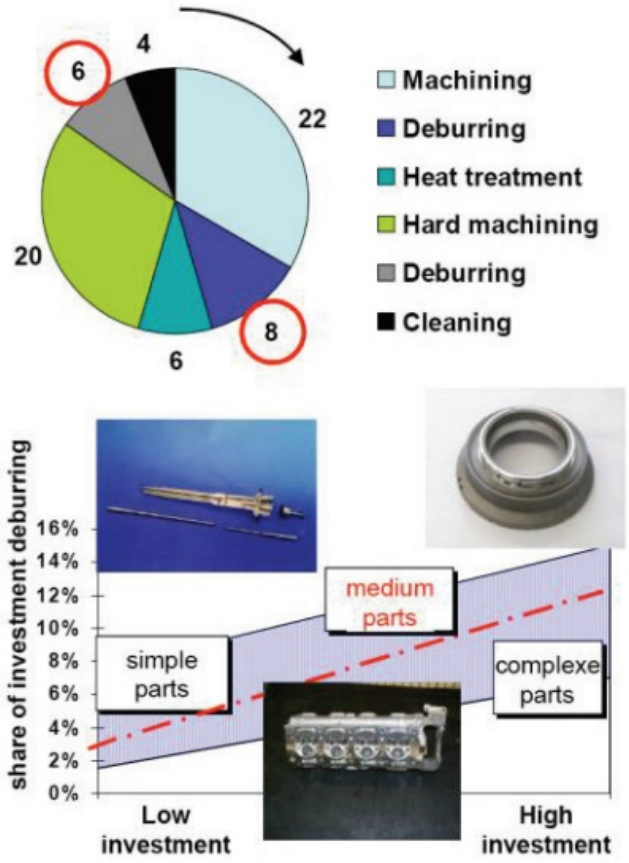


Figure 1. Investment in deburring systems as a function of part complexity in manufacturing [4]

2. BACKGROUND LITERATURE

A lot of research has been conducted using neural networks in the field of machining. However, very few studies have used neural networks to predict burr height. The review of past studies carried out in drilling using neural networks is described below: Sudhakaran (1999) proposed a neural net work model to identify the effect of drill geometry, specifically lip height and point angle on burr height in the drilling of aluminum 2024-T3. Feed, lip height and point angle were inputs to the model with output

being burr height. The best architecture was 4-6-4 and showed good consensus with the experimental result. It was noted that burr height increases with the increase in lip height irrespective of any point angle. Sokolowski et al. (1994) proposed a neural network model to predict the burr height by considering the effect of cutting velocity, feed, depth of cut, work piece material and exit angle on burr formation. A feed forward back propagation neural network was used with a structure of 5-10-3. The output was classified into three types of burr, namely small medium and large based on the height of the burr. The developed model successfully predicted the burr height in face milling. It was also evident that neural network could act as a universal tool to model burr formation and it would also be very important from practical application standpoint because of their relative use of small data sets. Hambli (2002) developed a neural network model to predict burr height in blanking process. The input to the feed forward neural network model was tool die clearance and punch–die clearance and wear state of the tool and the corresponding output was burr height. The model showed good agreement with the experimental results with an error of less than 0.1% for any point. Karri (1999) predicted thrust and torque in drilling operations using neural networks. Eight inputs were considered and the result showed an aver age percentage deviation of less than 2% at the testing stage. Both thrust and torque were predicted to targeted accuracy with the help of neural networks, which was very difficult to achieve using conventional mechanics of cutting approach for prediction of thrust and torque. Sanjay and Jyothi (2006) proposed a back propagation neural network model to pre dict surface roughness in drilling. Drill diameter, feed, speed and machine time were used as input to ANN model. Further neural network model was more consistent for different combinations of speed and feed compared to mathematical model developed to predict surface roughness. Singh et al. (2006) developed a neural network model to predict flank wear. Various process parameters, such as speed, feed, thrust force, torque force, and drill diameter were considered as inputs and the corresponding maximum flank wear was measured. The network parameters, such as momentum coefficient, number of hidden layers, and learning coefficient were determined on trial and error. The best network architecture was considered to be 5-4-1, depending on the mean square error. Out of 49 data values, 34 were used for training the net work and 15 were used for testing. The output showed good agreement with the experimental results. Therefore, neural network was considered as an important tool for prediction of drill wear. Dini (2003) developed a neural networks model to predict delamination in drilling of glass fiber reinforced plastic (GFRP). The delamination was measured at both entry and exit sides of the tool. Peel–up and push-out damage were measured at entry and exit side respectively as a function of feed rate, tool size and cutting forces. Two types of neural network model were developed to analyze and predict the delamination. The Use of the first network delamination was categorized into 4 groups, namely no damage, and low, medi um and high damage, while the second network was used to predict the damage. The developed model showed very good agreement with the experimental results. Mahfouz (2001) proposed a neural

network model to monitor tool wear. Vibrations and acoustic emissions were measured for 0.5 diameter HSS twist drills. Based on the experimental results, wear was classified into four types of categories. The wears were classified as chisel wear, rake crater, edge fracture, and corner wear. This information was fed into the neural network. The network correctly identified the chisel and corner wear up to 80% accuracy and edge and crater wear to around 70% accuracy. Chao and Hwang (1997) proposed a neural network model for the prediction of cutting tool life. Experiments were conducted to collect tool life data on lathe for turning opera tion. Each experiment is performed until a flank wear reaches a maximum of 0.7mm. The tool life is obtained by summing up the total cutting time. The results of this experiment were used in the development of a neural network model. The results were then compared against backward stepwise regression model and the artificial neural network model made the most accurate prediction. Karri et al. (2002) proposed a three layer neural network model to determine the internal surface roughness in drilling. Three types of neural network model were developed and the one that had the lowest RMS error was selected for prediction. The input to the model was frequency, speed, thrust, feed, tool type, diameter, and torque. The experiments were tested for 15 different conditions and out of which 12 exhibited an error of less than ± 0.7μm, show ing considerable prediction capability.

3. MOTIVATION OF THE PRESENT WORK

3.1 Methodology

The orthogonal array forms the basis for the experimen tal analysis in the Taguchi method. The selection of orthogonal array is concerned with the total degree of freedom of process parameters. Total degree of freedom (DOF) associated with five parameters is equal to 10 (5X2). The degree of freedom for the orthogonal array should be greater than or, at least, equal to that of the process parameters. There by, a L27 orthogonal array having degree of freedom equal to (27-1) 26 has been considered, which is used to optimize the drilling parameters for burr size, thrust force, surface roughness, and roundness error using S/N ratio and ANOVA for machining of Al 2014 alloy. By means of the taguchi techniques, industries are able to greatly reduce the product development cycle time for design and production, thus reducing costs and increasing profit. Moreover, the neural network (NN) technique has been applied to compare the predicted values with the experimental values and compare the error between the experimental values. Finally, a confirmation test has been carried out to compare the predicted values with the experimental values, and confirm its effectiveness in the analysis of the measured responses.

3.2 Schematic Machining:

In this study, the experiments were carried out on a Radial drilling machine (Make: Siddapura Machine

(Make: Siddapura Machine Tools, Gujarat, INDIA) to perform different size holes on Al 2014 alloy work piece (300x50x10mm) by altering the point and clearance angles on standard HSS twist drill bits and maintaining constant helix angle of 30 degrees. Furthermore, the speed (rpm), feed rate (mm/rev), and drill diameter (mm) are varied.

3.2.1 Measuring Apparatus

The burr size (thickness and height) is measured by tool maker's microscope and digital profile projector. During the drilling operation performed on material, thrust force was measured by kistler dynamometer.

Table 1. Experimental Planning as per Taguchi Method

LEVELS	FACTORS				
	CUTTING SPEED (rpm)	FEED RATE (mm/min)	DRILL DIAMETER (mm)	POINT ANGLE (0)	CLEARANCE ANGLE (0)
	A	B	C	D	E
1	465	18	8	1000	40
2	695	20	10	1100	60
3	795	26	12	1180	80

Table 2. Comparison of Experimental Results vs Neural Network Results

Experimental Results			Exp. No	Simulation Results		
Burr height (mm)	Burr thick (mm)	Thrust Force N		Burr heigt (mm)	Burr thick (mm)	Thrust Force N
R1	R2	R3		R1	R2	R3
0.324	0.278	262	1	0.3217	0.3033	247.417
0.283	0.316	288	2	0.3218	0.2649	294.845
0.342	0.282	241	3	0.3123	0.2846	233.883
0.285	0.278	235	4	0.2982	0.2673	194.220
0.378	0.268	335	5	0.3209	0.2747	297.164
0.284	0.297	252	6	0.3281	0.2547	305.349
0.438	0.349	241	7	0.4063	0.3907	230.635
0.345	0.291	335	8	0.3443	0.2791	371.287
0.312	0.254	395	9	0.2967	0.2239	333.818
0.338	0.443	232	10	0.3347	0.4133	219.314
0.262	0.359	248	11	0.3042	0.3316	284.637
0.328	0.248	265	12	0.3402	0.2368	313.215
0.528	0.296	316	13	0.5422	0.2853	321.184
0.291	0.232	286	14	0.3026	0.2361	261.305
0.387	0.264	202	15	0.3737	0.2121	208.967
0.314	0.411	208	16	0.4257	0.2161	242.604
0.429	0.347	265	17	0.4075	0.3371	237.603
0.541	0.320	265	18	0.5421	0.3311	255.738
0.314	0.289	316	19	0.3092	0.2783	287.987
0.269	0.331	286	20	0.3091	0.2821	287.286
0.326	0.238	252	21	0.3086	0.2453	258.758

0.354	0.212	241	22	0.3416	0.2142	248.665
0.281	0.252	135	23	0.2844	0.2122	147.946
0.396	0.223	395	24	0.3899	0.2123	343.792
0.386	0.252	186	25	0.3931	0.2776	184.177
0.423	0.319	252	26	0.4184	0.3299	254.664
0.541	0.248	316	27	0.5432	0.2538	313.309

4. RESULTS AND DISCUSSIONS:

4.1 Experimental Results

From main effects plot of S/N ratio for, the optimum pa rameters combination of all responses are A2B3C5D4E1, corresponding to the largest values of S/N ratio for all control parameters. From Table 3, it is observed that the clearance angle has more influence out of all parameters; feed rate has moderate influence; and cutting speed has less influence on all multi responses. For confirmation of significance of input parameters the analysis of variance is determined. The effects of input parameters versus output response graphs are drawn and the individual effects of input factors are analyzed. These factors are discussed in conclusions chapter. Finally, the interaction of individual factors over outputs found through the graphs obtained by design software was known.

Table 3. Response Table for Signal to Noise Ratios Smaller is better

	Spindle	Feed Rate(B) drill		Point	Clear-ance
Level	Speed (A)rpm	mm/ min	diame-ter (C) mm	Angle (D) degree	Angle (E) degree
1	-44.11	-43.92	-43.58	-43.93	-41.74
2	-42.05	-41.95	-42.09	-42.15	-42.53
3	-42.35	-42.64	-42.84	-42.43	-44.23
Delta	2.06	1.97	1.49	1.77	2.49
Rank	2	3	5	4	1

Table 4. Analysis of Variance (Burr height)

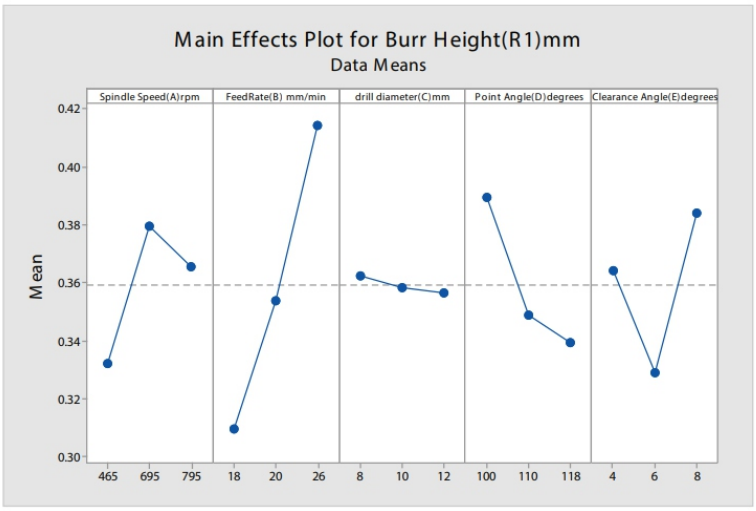
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed(A) rpm	2	0.010671	0.005335	1.05	0.373
Feed Rate(B) mm/min	2	0.049803	0.024901	4.89	0.022
Drill diame-ter(C)mm	2	0.000173	0.000086	0.02	0.983
Point Angle(D) degrees	2	0.012742	0.006371	1.25	0.313
Clearance Angle(E) degrees	2	0.014052	0.007026	1.38	0.280
Error	16	0.081427	0.005089		
Total	26	0.168867			

Table 5. Analysis of Variance (Burr thickness)

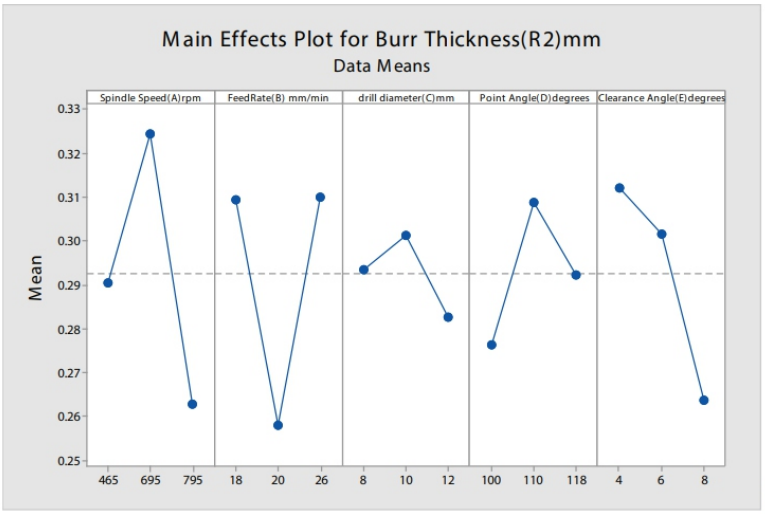
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed(A)rpm	2	0.017237	0.008618	4.89	0.022
Feed Rate(B) mm/min	2	.016054	0.008027	4.55	0.027
Drill diame-ter(C)mm	2	0.001581	0.000790	0.45	0.647
Point Angle(D) degrees	2	0.004737	0.002369	1.34	0.289
Clearance An-gle(E)degrees	2	0.011603	0.005802	3.29	0.064
Error	16	0.028213	0.001763		
Total	26	0.079425			

Table 6. Analysis of Variance (Thrust Force)

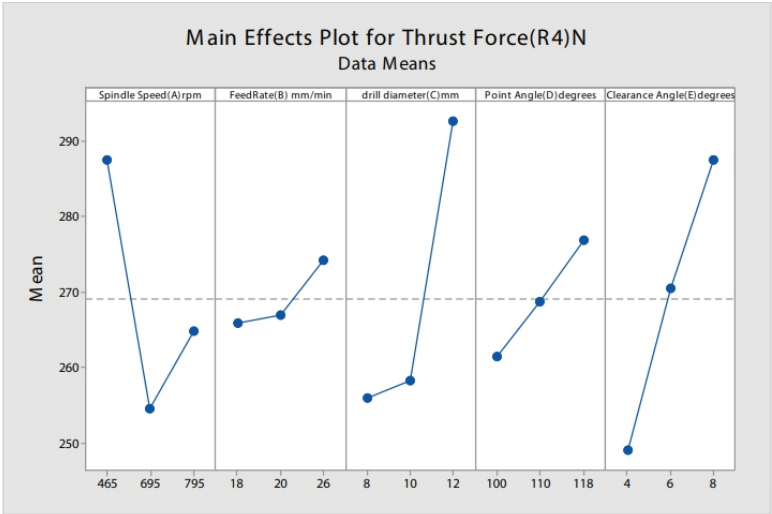
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed(A)rpm	2	5159.2	2579.6	0.62	0.552
Feed Rate(B) mm/min	2	366.9	183.5	0.04	0.957
drill diame-ter(C)mm	2	7589.5	3794.8	0.91	0.424
Point Angle(D) degrees	2	1066.7	533.3	0.13	0.881
Clearance An-gle(E)degrees	2	6710.7	3355.3	0.80	0.466
Error	16	66948.0	4184.3		
Total	26	87841.1			


Main Effects Plot for Burr Height(R1)mm
Data Means
Spindle Speed(A)rpm
FeedRate(B) mm/min
drill diameter(C)mm
Point Angle(D)degrees
Clearance Angle(E)degrees
Mean
0.42
0.40
0.38
0.36
0.34
0.32
0.30
465 695 795
18 20 26
8 10 12
100 110 118
4 6 8

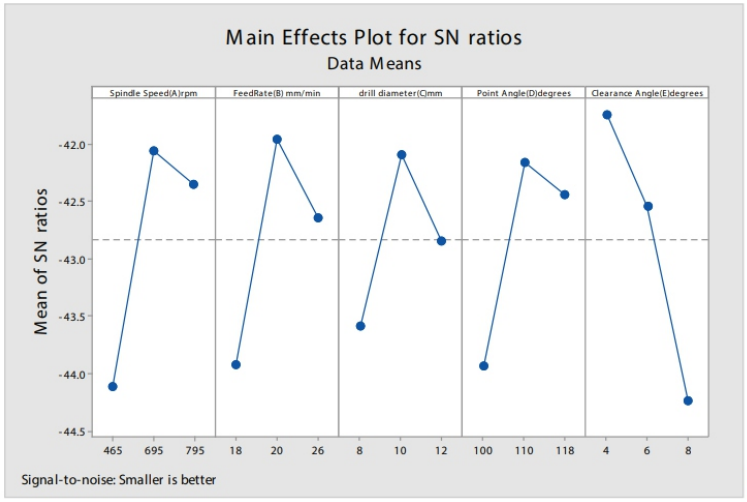
(a)


Main Effects Plot for Burr Thickness(R2)mm
Data Means
Spindle Speed(A)rpm
FeedRate(B) mm/min
drill diameter(C)mm
Point Angle(D)degrees
Clearance Angle(E)degrees
Mean
0.33
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
465 695 795
18 20 26
8 10 12
100 110 118
4 6 8

(b)

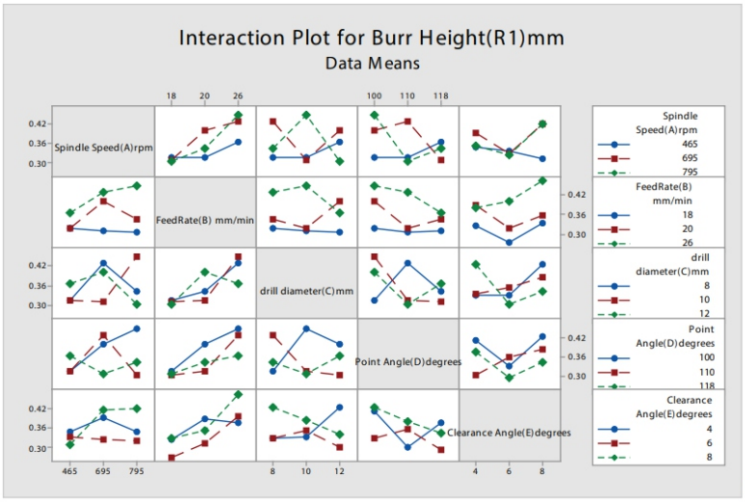

Main Effects Plot for Thrust Force(R4)N
Data Means
Spindle Speed(A)rpm
FeedRate(B) mm/min
drill diameter(C)mm
Point Angle(D)degrees
Clearance Angle(E)degrees
Mean
290
280
270
260
250
465 695 795
18 20 26
8 10 12
100 110 118
4 6 8

(c)

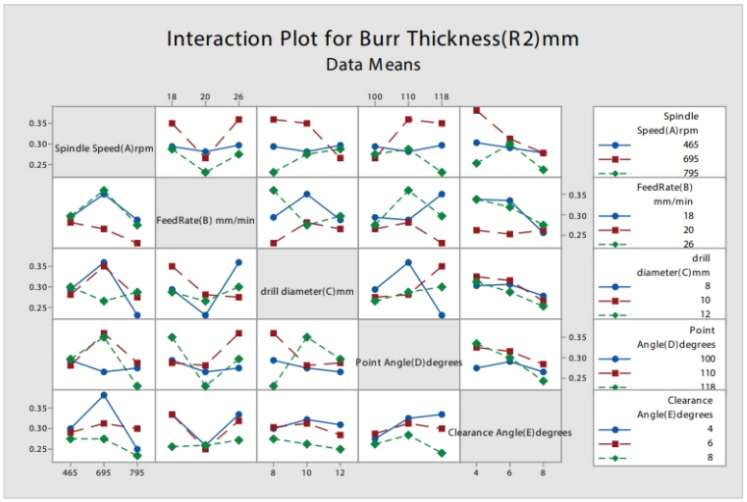


(d)

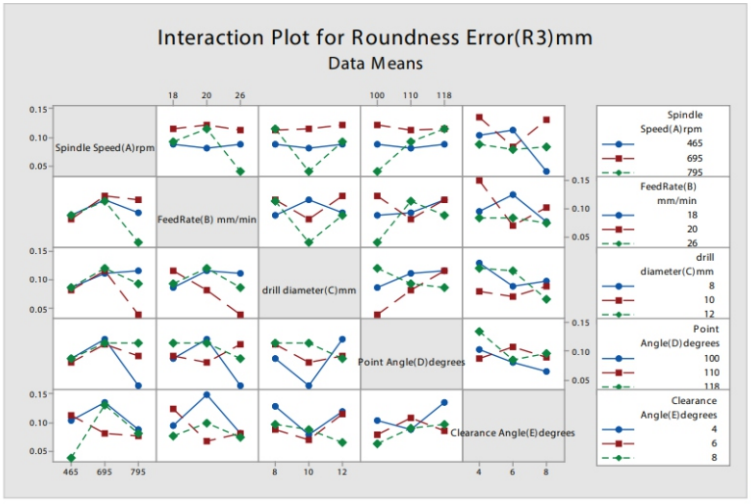
Figure 2. main effects plots for responses (a, b, c) and s/n ratios (d)



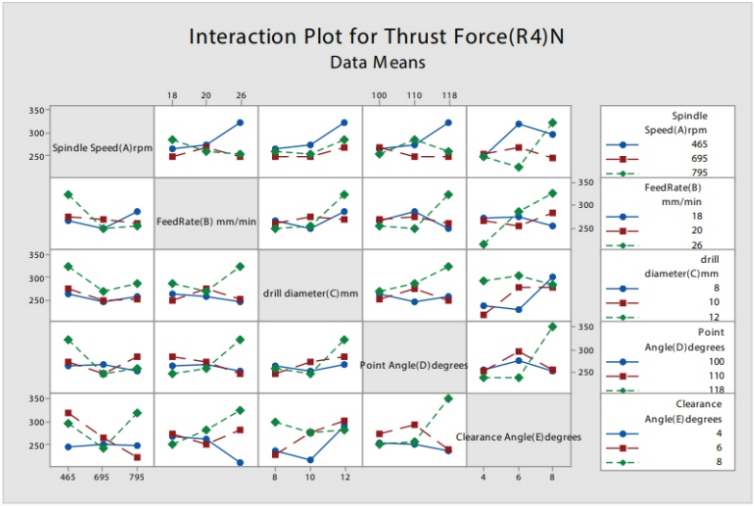
(g)



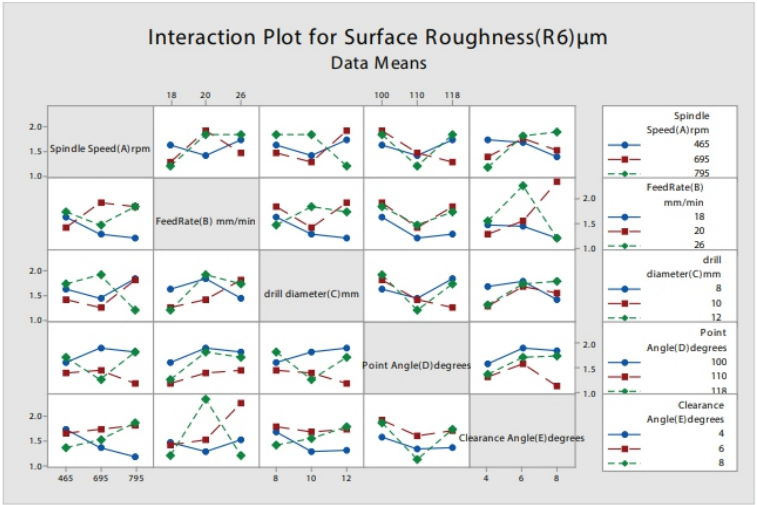
(h)



(i)



(j)

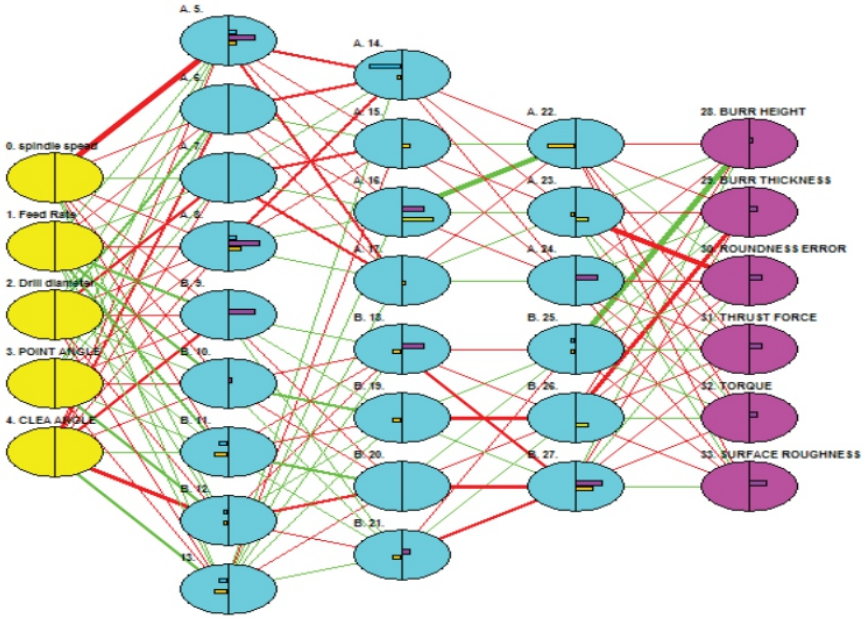


(k)

Figure 3. Interacti on plot for output responses (g, h, i, j, k)

4.2 Neural Net Work Results

Arti fi cial neural systems are physical cellular systems that acquire store and uti lize experimental informati on. Powerful learning algorithm and self-organizing rule allow ANN to selfadapt according to the requirements in a conti nually varying environment (adaptability property). The ANN architecture is a multi layer, feed forward back propagati on architecture. Multi layer percepti on (MLP) has an input layer, output lay er, and hidden layer. The input vector is an incident on the input layer and then on the hidden layer and, subsequently, on the fi nal layer/output layer via weighted connecti ons. A neural network is a machine that is designed to model the way in which the brain performs a parti cular task or functi on of interest. To achieve good performance, they employ a massive interconnecti on of machine that can be defi ned as a neural network, as it is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use.



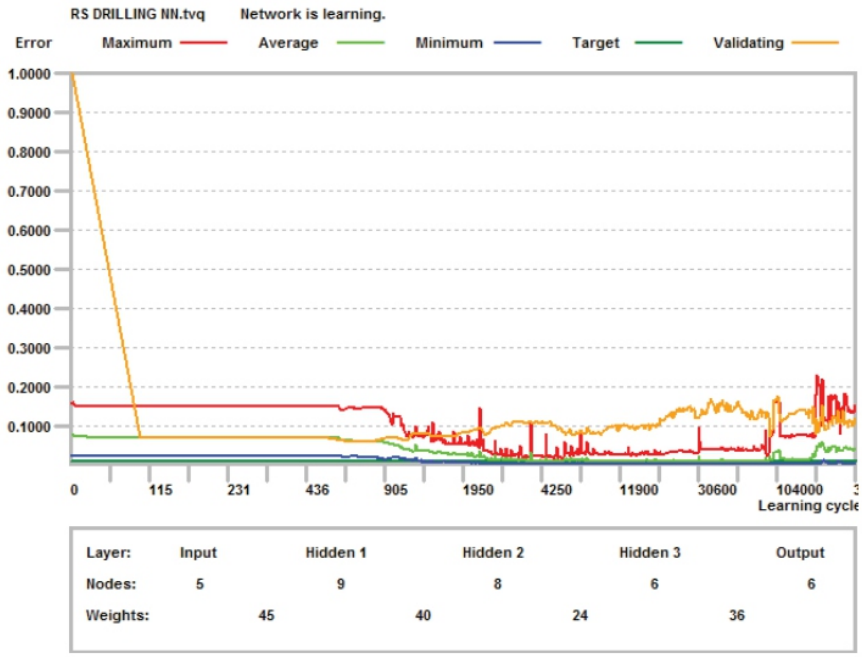
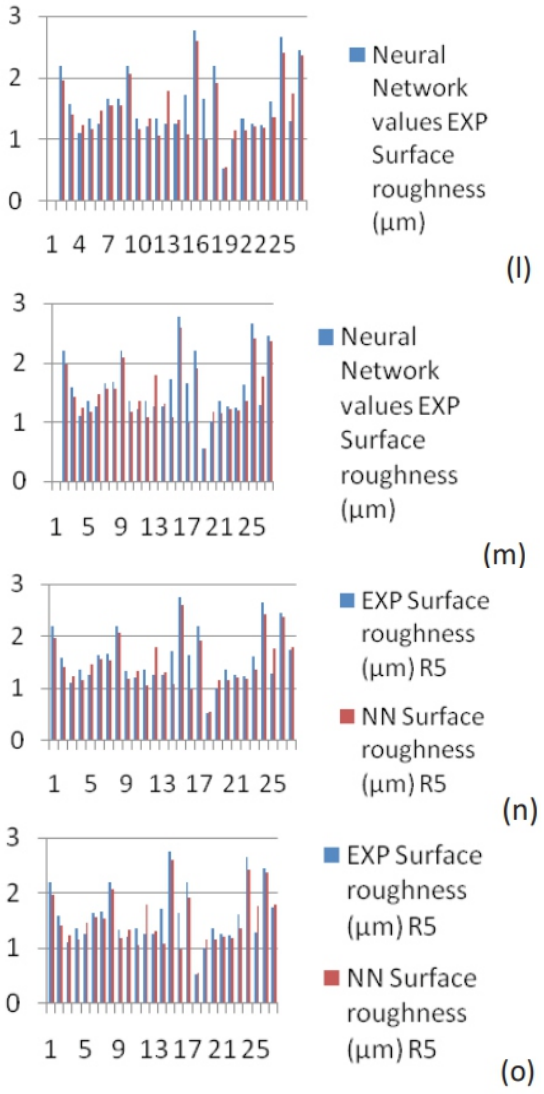


Figure 4. Feed Forward Neural Network block diagram and result



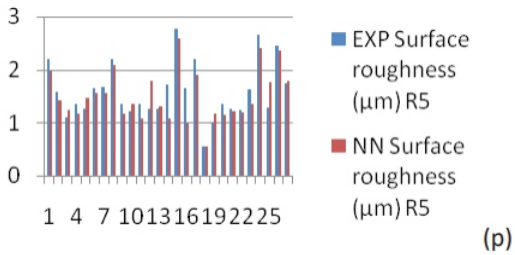


Figure 5. Validati on of experimental results with neural network

The experimental observations were incorporated into the NN model. A feed forward neural network was developed to predict all outputs. Predicted and experimental values of all responses are depicted in table 2.

5. CONCLUSIONS

The machining characteristics of Al2014 alloy have been stud ied. The primary machining characteristics, such as drill thrust, burr size, surface quality, and circularity deviation were studied. The results obtained from the experiments are the following.

• From S/N Ratio response graph, the combination of parameters having the values of A2B3C5D4E1 obtained for input parameters in an order.

• From S/N Ratio response table, clearance angle is the most influencing factor on burr size, during drilling of Al2014 alloy.

• From the results, ANOVA for feed rate is the most significant factor for almost all responses.

• From results of NN, it is concluded that the experiment No. 15 obtained relatively more errors than the remain ing. The deviation between the experimental values and the prediction values are found in the range of 3 to 4%. Finally, it is concluded that by increasing the number of nodes the computational cost increases and the error decreases. Good agreement was shown between the predictive model results and the experimental measurements.

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THE INNOVATION PROCESS IN HOSPITAL SERVICES: A CASE STUDY IN AN OCCUPATIONAL THERAPY

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ABSTRACT

The theoretical debates in the literature point to the need of innovations in hospital services. The objective of this article is to identify the conditions of services that facilitate or hinder the process for different types of innovation in hospital services. For this, case studies were developed that allow the identification of the types of innovation found in the physical rehabilitation outpatient clinics of the Occupational Therapy unit (OT) of the Orthopedics and Traumatology Institute (OTI) of the Clínicas' Hospital of the Faculty of Medicine of the University of São Paulo (HCFMUSP). The data collected reveal that the results of hospital services are related to the process of developing innovations in the various stages of the workflow, from the generation of ideas to the diffusion within the hospital unit. On the other hand, the review of the literature based on the reverse cycle of Barras and the complements of Gallouj and Djellal show that the paths of innovation in hospital services and innovations in industrial organizations are opposite. Therefore, the results of the analysis of the five cases selected for study reveal that, under the integrative approach, a process change leads to a product change. Thus, the article concludes that, in hospital services, innovations are born within the organizational structure as well as in external contact with professionals, researchers and surgeons.

Keywords: Innovation in hospital services; Types of innovation; Rehabilitation, Reverse cycle, Hospital services.

1. INTRODUCTION

Gallouj (1998) questioned the ability of firms to effectively innovate in services, arguing that changes in service organizations could be understood only as modified results and values of the manufacturing activities. In view of this, Gallouj and Windrum (2009) and Gallouj and Savona (2009), question the specific need to create a new theoretical approach to service innovation.

On the other hand, if the service sector has a major importance in the world economic scenario, another question arises: do manufacturing theories support the process of innovation in services or an integrated approach that supports goods and services would be more suitable? To answer this question, it is important to know the paths of innovation in services and the conditions of use of technical, operational and organizational resources that support or hinder the innovation process.

It is in this context that innovations in hospital services are relevant, because, as Salge and Vera (2009)

have shown, such organizations devote a great deal of atten tion to innovations, although they lack knowledge about its development. This lack is verified when analyzing the literature dedicated to hospital innovations, in which it is observed that the understanding of the innovation theme, in its majority, is directed towards medical innovations.

However, according to Djellal and Gallouj (2007), hospitals are complex service providers and health system hubs. Thus, according to the same authors, clients should be considered as consumers of a complex set of services to meet their particular and familiar needs.Thus, the understanding about innovations in services in hospital environments requires a holistic analysis of the hospital organization in all its aspects, that is, it should not only be limited to those directly related to medical activities, understood as techniques, but have other, re lated to support and organizational operations, such as rehabilitation, reception, hospitality, nutrition and communication.

This article investigates, through the study of cases of innovation, in the Occupational Therapy unit (OT) of the Institute of Orthopedics and Traumatology (OTI) of the Clínics's Hospital of the Medical School of the University of São Paulo (HCFMUSP). The ideas for innovations in hospital services are generated, converted into effective results and disseminated by its stakeholders. The objec tive of the research is to identify service conditions that facilitate or hinder the process for different types of in novation.

2. THEORETICAL BACKGROUND

Many authors have used examples of service innovation, showing a multiplicity of types of innovation requiring different theoretical approaches to understand their processes.

For Gallouj (1998), three are the most indicated ap proaches: technicist, service-oriented (differentiation), and integrative.

The first approach, the technicist, works on innovations in services such as manufacturing (tangible) technological conceptions and, according to Djellal et al. (2003), the in corporation of ICTs triggers non-technological innovations in organizations, requiring modifications in the organizational structure.

The main contribution to the understanding of this approach was elaborated by Barras (1986), with the "reverse product cycle" model, showing that the innovation in services runs in the opposite direction to that of technological innovation. Thus, Barras (1986) considers, in the first moment of the introduction of a new technology, the incremen tal process innovation aimed at improving efficiency, then radical innovation in processes, focusing on service quality, and, finally, the radical product innovation, resulting from new services or existing service recombination.

The second approach of Gallouj (1998) is service-oriented, and considers user-producer relations as the distinguish ing feature of services production from manufacturing; so much so that, for Gallouj and

Savona (2009), the first orientations for a Service-oriented innovation are the Knowledge Intensive Business Service (KIBS) and the ad hoc innovations.

The third approach of Gallouj (1998) is known as integrative and proposes the combination of goods and services to form a single theory of innovation. Therefore, the theory about the management of services puts the presence of the client and the intangibility of the results as operating conditions. The tendencies point to the concept that "product" is the end result, that is, the solution to the problem of the patient or client, be it a good (tangible) or a service (intangible), according to BRAX (2005), SPRING and ARAÚJO (2009), TUKKER (2004) and PAWAR, BELTAGUI and RIEDEL (2009).

According to Gallouj and Savona (2009), the integrative approach is one that offers the best conditions for the theoretical development of innovation in services; however, the authors emphasize that, if the specific needs of the customer are met by the consumption of goods, services or both, the distinction between both is unnecessary.

However, Gallouj and Weinstein (1997) show that the provision of a given service can be understood as the result of a final technical characteristics obtained from the combination of the technical characteristics that mobilize certain competencies. The authors emphasize that the participation of the client in co-production is one of the main characteristics of the provision of services when shared to the production of certain goods.

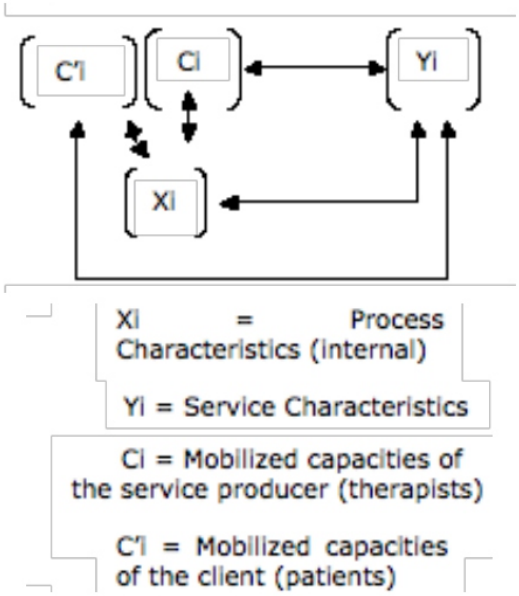

Figure 1. Representation of a product

Source: Gallouj and Welnstein (1997)

However, for Zuckerman et al. (2013), a particular importance shall be the recognition of user-led innovation, a concept that shows the innovation process made by a small but significant percentage of users. In this case, user-led innovation is very important because the health care professionals and

and patients have an intimate perception of problems, needs and of the possible solutions.

In figure 1, Xi represents a set of technical character istics with the following meanings: tangible technical characteristics of front-office; tangible technical back-of fice features and the intangible technical characteristics of front-office and back office, as well as organizational characteristics. Yi represents the set of final characteristics, obtained by a combination of technical characteristics Xi. Ck are the mobilized competencies of the service provider, while the term C'k represents the competencies of the customer.

On the other hand, Hansen and Birkinshaw (2007) em phasize that the integrative approach suggests that value creation for service organizations may be embedded in an innovation value chain, consisting of generating ideas, con verting them into products and disseminating practices and products obtained by the organization.

It is important to note that, for Sundbo and Gallouj (1998), there may be product, process, organizational or market innovation, and according to Gallouj and Weinstein (1997), if the product is a set of characteristics, innovation will be any change that has the potential to impact such characteristics. The intensities considered can be radical, improvement, incremental, ad hoc, recombination or for malization.

On the other hand, Djellal and Gallouj (2005, 2007) pro pose a more dynamic understanding of innovation in hos pital environments. They expand their definition to other forms, not only the techniques and technologies of medical practices, but also organizational with varying degrees of in tensity, such as radical, incremental or improvement. Thus, the outputs of the hospital services, for Djellal and Gallouj (2005), must meet the following variables:

a) Component of the services provided within the hospital organization (Si): the most important are the medical, hotel, and nutrition services, administrative and managerial services;

Table 1. Innovation value chain

	IDEA GENERATION			CONVERSION		DIFFUSION
	IN-HOUSE Creation within a unit	CROSS-POLLINATION Collaboration across units	EXTERNAL Collaboration with parties outside the firm	SELECTION Screening and initial funding	DEVELOPMENT Movement from Idea to first result	SPREAD Dissemination across the organization
KEY QUESTIONS	Do people in our unit create good ideas on their own?	Do we create good ideas by working across the company?	Do we source enough good ideas from outside the firm?	Are we good at screening and funding new ideas?	Are we good at turning ideas into viable products, businesses, and best practices?	Are we good at diffusing development ideas across the company?
KEY PERFORMANCE INDICATORS	Number of high-quality ideas generate within a unit	Number of high-quality ideas generated across unit	Number of high-quality ideas generated from outside the firm	Percentage of all ideas generated that and up being selected and funded	Percentage of funded ideas that lead to revenues; number of months to first sale	Percentage of penetration in desired markets, channels, customers groups; number of months for full diffusion

Source: Adapted for Hansen and Birkinshaw (1997)

b) Means of service delivery, corresponding operations or functions and associated technologies:
b.1) Material (M): material operations with corre sponding sciences and technologies, logistical and material transformation that involve the process ing of tangible objects, that is, transporting, trans forming, maintaining or repairing them;
b.2) Informational (I): informational operations with corresponding sciences and technologies, logis tical and information processing that involve the gathering and processing of codified information, that is, producing, capturing, transporting, archiving, and updating it;
b.3) Methodological (K): methodological operations with corresponding sciences and technologies, in volving the intellectual processing of knowledge, using codified methods and routines and intangi ble technologies;
b.4) Relational (R): contacting or relational service operation with corresponding sciences and tech nologies and service operations in which the principal medium is the customer and which consists of a direct service provided in contact with the customer and with a greater or lesser degree of interaction;
c) Competences mobilized of service producers © or clients (Ci): are the professional skills, individual or team that operates in the hospital organization and often are expressed tacitly, so difficult to identify. These competences are derived from various sources: initial education and training, continuing training, experience and, more generally, the various interactions that are sources of learning.
d) Final characteristics of the service (Y): this is the value generated to the customer and perceived by him; indicates the usefulness of a particular service component. It is the result of combining the means of providing services (M, I, K, R) and competences mobilized skills ©; Ci). In service activities the task of identifying and labelling them may vary in terms of difficulty, depending on the type of constituent service in question. If the hospital service, as a whole, is adopted as the unit of analysis, then it can be defined as a package type of service. In this case, a simple way of denoting the service characteristics is to represent them in terms of the various constituent services or functions that make up the package
e) Interorganizational and intraorganizational relationships: these are the relational aspects that involve the interactions between the stakeholders in different environments, both internal and ex ternal to hospitals, as Chesbrough (2003) points out in open innovation.

On the other hand, Lambooij and Hummel (2013) show that a service, including hospital service, can be understood as the result of a combination of technical characteristics obtained from the combination of operations and competencies of the service providers and the patient or client in its co-production.
However, according to Lambooij and Hummel (2013), many innovations applied to hospital services do not affect target groups; they are not applied in daily practice and do not provide benefits to the actors involved, because there is no policy and balance of power among stakeholders that consider a social deployment and not only technique of innovation, which creates negative impacts on the speed and

diffusion of innovations in the organization.

3. METHODOLOGY

In order to reach the objectives of the article, the research focused on the innovation process of the rehabilitation clinics of the Occupational Therapy units of the Orthopedics and Traumatology Institute (OTI) of the Clinics's Hospital of the University of São Paulo (HCUSP).

Because it is a Public University Hospital, HCUSP offers favorable conditions for the development of academic work and, by working with several specialties, enables the researcher to contact a variety of situations to enrich the research.

The proximity to IOT researchers allowed the identification of better working conditions and a space not yet explored for the discussion of innovation processes in hospital services.

On the other hand, the dynamics of the activities of the Occupational Therapy unit of the Orthopedics and Traumatology Institute, its proximity to the development of medical research and the interest of its professionals in the innovation processes coincided with the interests of this research.

The first step was the recognition of the field of research, that is, an attempt was made to understand the meaning, functions, differences, and importance of Occupational Therapy as support activities of orthopedic trauma or post-surgical treatments and in the rehabilitation of patients. Field research, at this stage, focused on the rehabilitation in outpatient clinics of the Occupational Therapy units of the Orthopedics and Traumatology Institute.

During the months of September, October and November of 2016 and January 2017, about 10 hours per week were devoted to field research.

From there, the research developed in two parts: a theoretical conceptual basis on innovation in hospital services and qualitative data collection in the respective outpatient clinics.

Field surveys were developed in three moments: the first was observational, the second was devoted to interviews with directors and coordinators of the unit, and the third was interviews with the therapists.

Among the innovations identified in the studied environment, five were analyzed under the integrative approach of Gallouj (1994) and Gallouj (1998). These cases are representative of the innovation value chain in different aspects, such as: where and how the generation of the idea occurred; if there was the participation of external professionals or patients, and how the idea was disseminated in the Occupational Therapy unit.

The final analysis of the information and data collected were shared and validated with the director responsible for the Occupational Therapy unit. In this way, each identified innovation process created potential for sharing and diffusion throughout the unit.

The bibliographical references found for the topic under study refer to classic articles that show the state of the art for innovation in hospital services. As the theoretical basis on innovation in hospital services is not fully consolidated, this article hopes to contribute through the analysis of the practical cases studied.

4. RESULTS AND DISCUSSIONS

Among the innovations identified in the studied environment, five innovations were selected, according to table 2. The analysis of these innovations will be discussed in light of the "reverse product cycle", a model proposed by Barras (1986), the framework developed by Djellal and Gallouj (2007), and the first theories of Gallouj (1998) for innovation in services.

Table 2. Innovation cases identified in the Occupational Therapy Unit

IDENTIFIED INNOVATIONS	DESCRIPTION
1) Ortheses laboratory	Interorganizational partnership: group of surgeons and OT team. Laboratory for confection of bracing in different materials, counts on software, 3D printer, and robots.
2) Process of care	Treats ambulatory care in the OT unit, rehabilitation processes and patient reception.
3) Ankle and Foot Orthosis (Weil) - (Surgery Technique)	It deals with a new field of knowledge within the surgical procedures of the ankle and foot. It was born of the partnership between orthopedic surgeons and operative therapists.
4) Clinical Research - post surgical treatment for Dupuytren's disease	After the surgical procedure, the occupational therapy unit should work on new rehabilitation techniques and verify how patients who undergo classical surgery and those who undergo stem cell surgery behave.
5) Annual Operations Planning	Annual meeting of the work team: therapists, health aides, coordinators, and unit director. It analyzes the current situation (successes and failures) and projects the future within the horizon of one year.

Source: prepared by the authors

1) Orthoses laboratory

Objective: to produce orthoses with different types of materials.

The material that requires higher processing temperatures in favor of greater flexibility, combination of materials, higher quality, longer durability, higher stiffness, and shorter processing time.

The laboratory is a good example of the application of technological innovation in services, reinforced by the evidences of the three phases of the reverse product cycle of Barras (1986): first, the efficiency improvement, obtained by training the team of therapists to characteristics of the new process; the mastery of the new process leads to the maturity of knowledge regarding 3D printing, that is, since it is a new and totally different process from the existing process. Finally, in a third phase, it will be possible to create a new material orthosis, which will result in a new way of providing orthotic services to patients, reduction in the time of manu facture and increase in the quality of the product, providing greater patient comfort, durability and flexibility of use.

2) Process of care

Objective: to adjust to the availability of specialized personnel to autonomy and functionality.

This innovation reveals the relational and patient char acter of the therapist, the co-production of the service, the particularity of being ad hoc, as well as highlighting the spe cialized knowledge-intensive service (KIBS) of occupational therapists. These are packages of services rendered directly to the patients, but demanded by the physicians of the outpatient clinic.

3) Ankle and Foot orthosis of Weil

Objective: Leverage medical outcomes and outpatient re habilitation for ankle and foot surgery. This innovation has an essentially technical surgical character. These are new therapeutic procedures for foot rehabilitation that require the use of orthoses to maximize treatment results, allow ing greater functionality and autonomy for patients. In this process, the expertise and competences of the therapists contributed decisively to the success of the surgical result. Therefore, as it was a new experience, generated from the partnership between the Occupational Therapy unit and the orthopedic surgeons, it can be considered as a radical, integrative, interorganizational innovation, the result of which is a new product of the hospital service offered to patients. It is a type of knowledge-intensive service (KIBS).

4) Clinical Research - post-surgical treatment for correction of Dupuytren's disease.

Objective: To compare the treatment and behavior of pa tients who underwent classical surgery and stem cell surgery.

Because it is a research order, it can be considered that this innovation is radical, with an integrative approach of Gallouj (1994) and interorganizational. On the other hand, the reverse cycle of the product of Barras (1986) is verified, as it seeks to improve efficiency in post-surgical rehabilita tion, followed by a new knowledge and reach of maturity, characterizing a radical innovation and finally the generation of a new product of the service applied, represented by the new protocols for the surgical process and for the post-surgical rehabilitation.

5) Annual Operations Planning:

Objective: To improve the critical processes of the Occupational Therapy unit.

It is an incremental and intraorganizational innovation, to improve the critical processes of the Occupational Therapy unit. The actions developed aim at the delivery of a new form for appointment scheduling or high patient clinics. On the other hand, therapists seek to be able to improve the per formance of the billing system through courses that generate revenues by disseminating knowledge to external clients.

Table 3 shows a framework of the functional and rela tional division of innovation for each of the innovations described in Table 2, with reference to the work of Djellal and Gallouj (2007).

Thus, from framework shown in the table 3 for this research:

Si is the services provided by the OT unit:

1) New process for orthoses conceived from the laboratory;

2) Process of care for rehabilitation and processes to receive the patient (reception);

3) Ankle and foot orthosis (Weil) a surgery technique and a new field of knowledge within the surgical procedures

Table 3. Framework functional and relational division of OT outputs

Organization Level	Service Components	Mobilized Skills	Means of service				Final Features
Oi	Si	Ci	Mi	Ii	Ki	Ri	Yi
1) External	Orthosis	Knowledge	New Materials	Software	Routines	Ad Hoc	New Orthosis Autonomy
2) External	Rehabilitation	New KIBS	Infrastructure	Infrastructure	New Routines	Coproduction	Functionality
3) Surgeons	Post-Surgery	New KIBS -	Infrastructure	Infrastructure	New Routines	Ad Hoc	Functionality
4) Surgeons	Post-Surgery	New KIBS -	Infrastructure	Infrastructure	New Routines	Ad Hoc	Functionality
5) Internal	Planning	Training	Infrastructure	Infrastructure	New Routines	Internal OT	Processes improvement

Source: adapted from Djellal and Gallouj (2005)

4) Clinical research a post surgical treatment for Dupuytren's disease; for the occupational therapy unit there will be new rehabilitation techniques;

5) Annual operations planning is a special meeting of OT work team for planning new routines and innovations.

Yi: are the expected results with innovation and they generate value for patients - Yi = f (Ci, Mi, Ii, Ki, Ri):

1) To produce orthoses with different types of materials;

2) To adjust to the availability of specialized personnel and allow greater autonomy and functionality to

the patients;

3) Leverage medical outcomes and outpatient rehabilitation for ankle and foot surgery;

4) To compare the treatment and behavior of patients who underwent classical surgery and stem cell sur gery;

5) To improve the critical processes of the Occupational Therapy unit.

Ci is the new knowledge acquired with innovation or mo bilized capacities of the service producer (therapists and patients):

Service means are operations: (Ii) methodological oper ations; **(Ki)** creation of new routines; **(Ri)** Relational operations; and **(Mi)** Materials and equipment used.

Organizational level (Oi) external/internal partnerships: therapist relationships among themselves or with patients and surgeons.

5. CONCLUSIONS

This article identified and analyzed five innovations in the Occupational Therapy unit of the IOT during the period studied. The studies pointed out that the processes of inno vation dealt with the integrative approach, according to Gallouj (1998) and Gallouj (1994), as well as the assumptions of the "Reverse cycle of the product" of BARRAS (1986). On the other hand, the development of research shows that inno vations are achieved according to the innovation value chain studies of Hansen and Birkinshaw (1997).

In the product and processes innovations evaluated, the relative effectiveness was observed and the patient, through o-production, contributed to the success of his own treatment. The interaction between therapists, patients, and surgeons was one of the success factors of the innovations analyzed.

The innovations were born from ideas to improve pro cesses, generated within the OT team and from external demands, such as those of orthopedic surgeons. For the OT team the innovations represented opportunities for professional growth and effectiveness in the treatments of each patient. For surgeons, however, innovations were opportunities for improving outcomes in post-surgical complications.

The main difficulty encountered during the research was to establish a criterion for identifying innovations, since the idea that innovation should be technological and that it would only make sense if innovation was radical prevailed.

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