Productivity in Mass Customization: an Initial Essay
Based on Current Literature

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Abstract
Considering the gap related to the measurement of productivity in the context of mass customization, it is proposed a possible joint use of measuring productivity in manufacturing and services in the context of mass customization, so you can balance the goal of mass production considering the needs and desires of the consumer and their interaction in the process. Thus, the work is structured from a literature review considering the concepts that encompass studies on productivity (profitability, quality, efficiency, effectiveness, etc.) and mass customization process, followed by an analysis of the data resulting from this review, and concluding with final remarks and recommendations for future research.

Key words: Mass customization; Productivity, Productivity in Manufacturing, Productivity Services, Consumer Interaction.

INTRODUCTION
The need for companies to improve their competitiveness in recent decades has led them to innovate and reconceptualize their traditional products and processes, resulting in an effort to increase the elements in the products offered regarding its functionality, attractiveness, technology, sustainability, and implementation of concepts of mass customization (CARULLI et al., 2013).

Twenty-five years ago, leading companies have turned to mass customization to improve their levels of customer satisfaction, increase their market share and success of their organizations (SMITH et al., 2013b).

The objective of mass customization is to create individually customized with volume, cost and efficiency of mass production, combining client integration settings, modular design, flexible manufacturing systems, and supply chain management (SMITH et al., 2013a).

In this context, the practice of mass production is proving to have more disadvantages in the fierce competition today, particularly as the environment in which this kind of system can not respond quickly to the demands of individual consumers (LIN et al., 2012).
The current competitive environment is such that customers have at their disposal various products to meet their personal needs. For businesses, the challenge is to meet the specific needs of its customers as much as possible (AGARD et al., 2009).

However, it is believed that further research is necessary to create individually customized products to meet the affective and cognitive needs of customers, keeping the volume, cost and efficiency of mass production products (Smith et al., 2013b).

To do so, companies need new techniques for mass customization, systems and methods for creating customized products individually, produced with the flow characteristics of mass production (SMITH et al., 2013b).

It is considered that, client integration is an important principle of mass customization compared to mass production, and that, over time, systems of mass customization will be successful only if they can adequately manage the balance between the benefits and client integration costs in the production process (PILLER et al., 2004).

From a managerial perspective, economies of integration with consumer demand conceptualize and implement strategies in new ways. Managers have, also, to understand the processes within this context integrator and try to identify potential areas for improvement in efficiency and economy (PILLER et al., 2004).

Piller et al. (2004) claim that there is an important trend for the future, which is quantitative empirical evaluation of mass customization considering the integration of the consumer in the process. The authors also claim that the empirical research in the field of mass customization are dominated by case studies and small samples, or too broad approaches, including all types of flexible production systems.

With increased interest in mass customization and its implementation in various industries, sufficient data must be available in the near future to embark on research that quantifies the factors of cost and value addition in mass customization. Systems in current mass customization has failed to demonstrate the economic benefits of customer integration into your process, ensuring the features and cost efficiency of mass production (PILLER et al., 2004).

Taking into account that the concept of productivity encompasses the concepts of quality, profitability, cost, efficiency, effectiveness, etc., and the gap related to the measurement of productivity in the context of mass customization research, the aim of this work is to develop an essay on the measurement of productivity in processes of mass customization, considering its goal to produce products in quantity and costs characteristic of mass production, but customized to each client (ZHao et al., 2003) and propose a way of measuring integrated productivity in MC.

This integrated form of productivity measurement considers the possibility of a mixed use of measuring productivity in manufacturing and services because of consumer interaction in the customization of the product (JOHNSTON & JONES, 2004) process.

Therefore, the article goes on to describe the methodology used for this research. The following topics are structured starting with a literature review, followed by an analysis of data resulting from this review and it is concluded by describing the final considerations and recommendations for possible future developments in the field of productivity in mass customization.

**METHODOLOGY**

Considering the gap related to the measurement of productivity in the context of mass customization is proposed a possible joint use of measuring productivity in manufacturing and
services in the context of mass customization, so you can balance the goal of mass production considering the needs and desires of the consumer and their interaction in the process.

For the present paper an exploratory literature review of studies published in the database Web of Science data on "Mass Customization" (MC) and on "Productivity" was performed, considering only the full articles related to research in Operations Management and Production areas. The search resulted in ten articles that did not deal directly with productivity in MC.

Thus, it was decided to do a search on mass customization with terms related to productivity as profitability, quality, efficiency, effectiveness, etc. This second search resulted in more than seven hundred thousand results, because of the generality and scope of the terms used.

Due to the large number of articles were selected for full reading the 25 most cited articles of the list resulting from the second search. Among these items were discarded again those which did not discoursed directly on productivity (or on their adjacent concepts) and mass customization and added items that were referenced in these selected papers for a more specific reading in the proposed issue.

Thus, after the disposal of the scientific articles outside the scope of this research and the addition of articles referenced in those who were not discarded, 29 articles were analyzed and summarized in this paper in order to arrange sufficient information for future developments of the subject proposed: productivity in mass customization.

LITERATURE REVIEW

Productivity

In recent years, the pressure of global competition has forced companies to focus on strategies to improve productivity in order to improve internal efficiency and thus competitiveness of a business unit (HANNULA, 2002).

It is universally recognized that most organizations, including businesses and nonprofit organizations, are input and output systems. This is also true of subsystems organizations, since any process can be viewed as an input-output system (HANNULA, 2002).

Most models and definitions of productivity intend to evaluate the efficiency of these types of systems, either directly or indirectly (HANNULA, 2002) and, despite extensive research on the concept, new and alternative measures of productivity and efficiency are required to reality current (DORFMANA & KOOP, 2005). Thus, the understanding of productivity and its measurement is of vital importance not only for organizations, but also for national and global prosperity (BERNOLAK, 1997).

Productivity means how much and how well the organization produces from the resources used. If it is produced more or better products (outputs) from the same resources (inputs), increase productivity. Or if the same goods are produced with fewer resources also increase productivity (BERNOLAK, 1997).

The same applies to the service, but with the addition of the interference of the consumer in the production process (JOHNSTON & JONES, 2004). If services are provided more or better services from the same resources, productivity increased. Or also, if you provide the same services from fewer resources, will also improve productivity (BERNOLAK, 1997).

By "resources" or "inputs" means all human and physical resources, i.e., the people who produce the goods or provide the services and goods that people use to produce goods or provide services (BERNOLAK, 1997). The features considered include land and buildings, fixed machinery and furniture, equipment, tools, raw materials, inventory and other current assets (BERNOLAK, 1997).
We must also bear in mind that is not productivity. The sales increase due to inflation, not increased productivity because the productivity increase means real, not just a nominal monetary increase. If volume increases sales but also increase the resources used, does not necessarily mean increased productivity as well. Improved productivity is given by the ratio between the production of goods or services by resources (BERNOLAK, 1997).

All elements of society benefit from the gain of productivity improvement (BERNOLAK, 1997): employers benefit through increased sales, improved profitability, increased competitiveness, a more stable and growing business, less waste, etc., benefit because workers become more productive, successful companies offer more stable jobs, better wages and working conditions, better career opportunities and better relations management of labor, customers benefit through better quality products and best services with cheapest prices, the general public benefits (e.g. governments) provide improved public services without increasing taxes.

One of the most important requirements for improving productivity is the measure of output (products and/or services), human and physical resources used, and their relationships. No measures of productivity do not know where the organization is and how it can improve.

Productivity (and profit) can be analyzed in two ways: comparisons with competing or other variations of patterns at a point in time or the change in yield (or return) with time as an index. Thus, in general, measurements indicated that the specific aspects of a company's operations should be reviewed and what kinds of actions can be considered to improve deficient areas (BERNOLAK, 1997).

It is important to emphasize that improving the productivity does not mean more work, but work smarter. This means improvements in various areas of an organization, performing various types of organizational changes (Table 1).

<table>
<thead>
<tr>
<th>Table 1 - Scopes that organizational improvements can be applied (source: adapted from Bernolak, 1997)</th>
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<tr>
<td><strong>Human Resources</strong></td>
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<tr>
<td>Better education, training, better working conditions, better communication of what is expected and feedback on performance rates, greater employee involvement in issues that affect them and how they improve productivity; incentives.</td>
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<td><strong>Organization</strong></td>
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<td>Clear definition of objectives - in writing; better planning, scheduling, meetings shorter, lighter presentations.</td>
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<td><strong>Focus on productivity</strong></td>
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<td>Select specific people to improve productivity in an organization. In larger organizations, a small group of 1-5 people is usually enough. In smaller organizations, the business owner or manager needs to set aside a few hours a week to focus on improving productivity.</td>
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<td><strong>Cutting Waste</strong></td>
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<td>Reduction or elimination of unnecessary duplication, waste of materials, energy, etc., identification and elimination of outdated requirements that are no longer needed.</td>
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<tr>
<td><strong>Remove Barriers to Productivity</strong></td>
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<td>Many problems are caused by well known productivity barriers. For example, resistance to change, fear of the unknown, ignorance about the productivity of its importance and its methodology; apathy; limitations in the areas of the neck, the lack of management support.</td>
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<tr>
<td><strong>Appropriate Use of Technology</strong></td>
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<td>The operation must first be simplified, standardized, restructured, and only then necessary to consider whether the existing technology is adequate or new technology should be introduced. Otherwise, it ends up with an automated system and expensive, but inefficient. The acquisition of new technologies should be coordinated with the training of operators, and new</td>
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technology should be fully utilized. It is important to make the maximum possible use of capital goods.

A new organizational approach needs to be developed, in which everyone asks himself regularly questions as: Does this operation is necessary, and why? This work could be done in a better way? This operation could be standardized or simplified? I have a set of measures that show how I'm doing my job? I'm doing the "right thing"? I'm doing it the "right way"?

Thus, it is considered essential the understanding and measurement of the productivity for organizations that want and need to be competitive in today's market. The inclusion of the concept of productivity in a company can analyze and evaluate the organization in a systematic and effective way, when followed specific methodologies related to the measurement of productivity, enhancing performance and providing products and better services to its consumers.

Mass Customization

Although mass production can provide customers with good quality and low cost, this approach to traditional manufacturing has difficulty in meeting the specific needs of different customers today. With advances in computer technology, many design and manufacturing activities are automated by computer tools. To further enhance the competitiveness of products to manufacture customized products based on the individual needs of consumers was introduced, maintaining the quality and efficiency of mass production (TSENG & PILLER, 2003).

The mass customization is a new manufacturing approach to produce customized products based on the individual needs of each client, while maintaining the quality and efficiency of mass production. Due to large variations of customized production, traditional methods of planning production resources based on the volume of mass produced products are not effective for mass customization (DEAN et al., 2009).

The mass customization is usually conducted through the development of sophisticated software systems to handle various activities of design and manufacturing, including the capture of customer needs, identifying and modeling of product design, planning and control of manufacturing processes, etc (TU, 1997).

The mass customization aims at satisfying individual customer needs, trying to maintain the efficiency of mass production. With mass customization, each customer can specify the characteristics of a product, resulting in a wide variety of manufactured products as well as a wide variety of information arising from these customers (JIAO et al., 2000).

Mass customization is an emerging concept in the industry designed to provide customized products or services through flexible and in large volumes and at relatively low cost processes. This is an important strategy for customer satisfaction with unique reasonably priced (FRUTOS et al., 2004) products.

The main objective of the systems of mass customization is to provide products and services that better reflect the expectations of individual customers based on their needs and preferences. This type of system is a step ahead of conventional flexible systems where customer choices are anticipated, offering wide varieties (FRUTOS et al., 2004).

The implementation of a system of mass customization is a complex task that involves producing at a rate of mass production, specific products for each customer, which makes consumer participation in the process of product development is extremely important as the involvement customer in specifying types of products and its modularity allows mass customization can be fully realized in practice (FRUTOS et al., 2004).
The customer engagement provides customization while modularity provides the basis for repeatability in production in mass customization. It is how the knowledge related to product configuration is shared between customers and manufacturers that really determines the success of this type of production system (FRUTOS et al., 2004).

This process is basically dependent on the effective flow of information across all parties involved, and how customer needs, preferences and restrictions are collected, stored and processed. Thus, the integration of client processes that have traditionally been developed within organizations implies a process of enormous knowledge exchange (FRUTOS et al., 2004).

The MC exploits the capabilities of the modular design, the efficient production and market intelligence to translate customer needs into profitable products, individually tailored (FULKERSON, 1997).

Companies that fail to understand, anticipate customer preferences and respond quickly with appropriate products have a commercial advantage over competitors who are less flexible and less focus on the customer (FULKERSON, 1997).

Methodologies and computational tools have been developed through extensive research in the last decade to support the activities of mass customization (TSENG & PILLER, 2003). These studies have focused primarily on the three most important aspects of mass customization: the capture of customer requirements, modeling product families and customized products, and planning and control of production processes for mass customization.

Despite advances in research on mass customization, planning production resources such as materials, equipment and personnel, has not been well studied. Due to large variations of customized products, methods of resource planning traditional manufacturing used in mass production are not effective for solving problems in mass customization. Therefore, a new approach to resource planning needs to be introduced in this context (DEAN et al., 2009).

**PRODUCTIVITY IN MASS CUSTOMIZATION**

A lot of research on manufacturing resource planning (entries) for mass customization has been performed. One is the Wadhwa & Rao (2000) who studied the role of flexibility in advanced manufacturing, including mass customization systems. In this research, they found that flexibility is the most important factor to allow customization that is emerging as the main source of competitive advantage today.

Manufacturing resource planning is a process of organizing materials, equipment and people to meet the business plan of an organization. Resource planning in manufacturing can shorten the production lead time, increase your flexibility, improve product quality and reduce the cost of production (DEAN et al., 2009), thereby improving process productivity.

Have Yao & Carlson (2003) studied a more specific case of the impact of lot size in the manufacture of upholstered furniture with a wide variety of styles and fabrics ordered by customers. Akkermans et al. (2003) investigated the impact of enterprise resource planning (ERP) to supply chain management (SCM). In this research they found that the offer of ERP was seen as a positive contribution to the mass customization of products and services. Aydin & Gungor (2005) developed an effective approach to dealing with product information in an environment of relational database systems for multi-product and multi-process production. This research aimed to reduce efforts in product definition to production systems of mass customization in order to generate Bill of Materials (BOM) and execution of Material Requirements Planning (MRP). Yao et al. (2007 a,b) developed a comprehensive system for production planning in mass customization systems of non-rotational parts. Production resources and their capabilities were considered in this production planning system. Moreover, the prediction of individual customer needs has also been investigated (TANG et al., 2005).
Among the analyzed studies that related mass customization concepts that concern with productivity, it was possible to identify some specific characteristics that influence the productivity of this type of system.

One such feature is the resource planning of production, the long-term plays an important role in mass customization to improve production efficiency and reduce production costs (DEAN et al., 2009), hence their productivity.

It was also possible to observe that large variations in the production of customized products with large production volumes, planning labor resources becomes essential to meet the deadlines for production and improve the utilization efficiency of labor (DEAN et al., 2009), which also affects the productivity levels of the production system.

Due to the large variation in customized mass customization systems products, future customer demands can not be modeled by specific customized products. One must consider that the estimated manufacturing capabilities are performed using uncertain customer demands (DEAN et al., 2009).

However, it is possible to understand the relationships between customer demands and resource requirements are provided when sufficient historical data. Future resource requirements can be predicted from the relations learned from previous demands of customers (DEAN et al., 2009).

Although flexible production technologies are often seen as the main facilitator of mass customization, it is argued that the information regarding the client technologies play an important role similar to an overall understanding of productivity in mass customization is possible.

The availability of information about the consumer integrated with production systems to allow coherent mass customization to be applied efficiently.

In addition to the applications of the concepts of productivity in manufacturing is important to understand that there is mass customization client integration in production processes. The customer is integrated into the value creation and influences the production of this type of production system process. The integration of the client can be an important asset to increase efficiency and can pave the way for a new set of potential cost savings (PILLER et al., 2004), thus influencing directly the productivity index of the system.

ANALYSIS

Considering the gap in research that directly relate the processes of mass customization and the concept of productivity of your measurement, an initial general review on mass customization and adjacent to productivity concepts already stated in previous research has been done.

This consideration allowed to identified no research that considered the direct measurement of productivity in mass customization systems, despite its importance and great potential for improvements in this type of process with the implementation of concepts of productivity.

Since mass customization consumer participation exists so that it interferes in various ways in the production process (Figure 1), it is not possible to consider the calculation of productivity only with measurements based on traditional manufacturing.

**Figure 1** – Characteristics of mass customization process
As the concept of productivity in services considers such participation interference consumer, but without considering the traditional manufacturing process, we propose a joint and integrated use of both types of productivity (as if they were a calculation of partial productivity) using the tools and methods of each so that you can an overview of the process of mass customization and a calculation of an index of total factor productivity from previous calculations (Figure 2).

![Diagram](image)

**Figure 2** – Integrating measurement of productivity in manufacturing and services for a total productivity index in mass customization

**FINAL CONSIDERATIONS**

Organizations today that use mass customization systems can not fully improve their productivity without having their productivity measured and analyzed, thus, needed to know the whole system to understand facts and what is influencing their results. There is a need for applying an integrated system for measuring productivity of interrelated measures of manufacturing and services that are meaningful, understandable and practical use to the productive systems of mass customization.

From literature review of the concept of mass customization and adjacent terms of productivity, it was possible to find existing research considering the possibility of improvements in the mass customization process, but not directly indicating productivity indexes. To this end, this paper proposed a possible initial joint use of measuring productivity in manufacturing and services in the context of mass customization, whereas the characteristics of the production process are achieving results of mass production but producing customized products according to the needs and desires of consumers, which directly interferes in the production process of this type of system.

This initial proposal allows ramifications for future applications in empirical research in order to assess whether this is the best way to address the productivity of mass customization. Also indicates the quantitative development using integrated methods of measuring productivity in manufacturing and services in order to demonstrate in a practical way how to proceed with this joint use of measuring productivity.
REFERENCES


