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Operations Management in the competitiveness of the Clusters

Generation of a material derived from sotol bagasse for developing products

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Abstract

This article presents an overhaul of the techniques of Operations Management (OM), which given its impact on the management of production processes, can affect the competitiveness of clusters. In the Colombian case there is clear evidence of a level of static productivity in the field of operations, so it is essential to define a theoretical structure that links the techniques in operations with the possibilities of competitiveness of the clusters. This article presents various instruments of operations management such as: forecasts, aggregate planning, inventories, learning curves and the deployment of the quality function that minimize the gaps to achieve an approach of educational institutions and their research processes to the objectives priorities of productive firms identified as clusters. In addition to the theories, models and practical cases, a reflection is presented on techniques or instruments in processes that impact on the priority objectives of cluster initiatives.
Key-words: Operations Management, Gaps, Cluster, Competitiveness, Productivity.

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Introduction

Currently in Colombia, there are about 87 active Cluster Initiatives (C.I.), [1], 25 of public origin, 46 of private origin and 16 of other origin, which present various limitations such as: lack of performance measurement indicators, little approach to the academic sector and low levels of productivity.

A review of Operations Management techniques is necessary given that one of the ways to improve productivity and organizational competitiveness is in the sophistication of company operations [2], where competitiveness is an element of local and global development [3], representing the effectiveness of organizations in a market of open economies [4], [5], [6], in order to minimize or eliminate internal impositions due to limited information or inflexibility in operational processes [7].

Menciona [8], que algunas de las tendencias claves son: la relación a las estrategias de producción – operaciones, la flexibilidad para adaptarse a los cambios en la demanda, el enfoque en calidad para asegurar la satisfacción del cliente, la reducción de los tiempos en ciclos de manufactura y la velocidad para la introducción de nuevos productos.

En este aspecto, [9], orientan este proceso de las tendencias en operaciones, mediante la ilustración de decisiones de operaciones mostradas en la Figura 1:

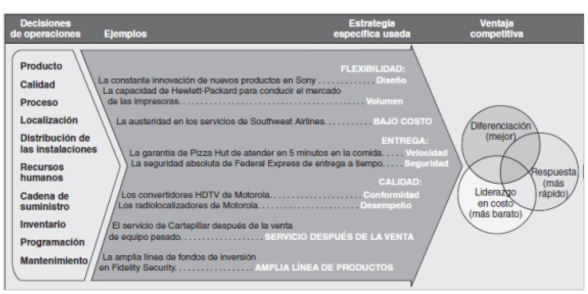

Figure. 1: Operations Decisions. Source: Taken from [9].

He mentions [8], that some of the key trends are: the relationship to production strategies - operations, the flexibility to adapt to changes in demand, the focus on quality to ensure customer satisfaction, the reduction of times in manufacturing cycles and the speed for the introduction of new products. In this regard, [9], guide this process of trends in operations by illustrating operational decisions shown in Figure 1:

Translated with www.DeepL.com/TranslatorPor lo tanto, de acuerdo a los intereses de estudio por objetivos en los Clusters y en consideración a técnicas específicas, se tienen un total de cinco técnicas (ver figura 2), que se describirán a profundidad de contenido.

Figure 2: Content review for some techniques in Operations Management. Source Own Elaboration.

Then, the reflection on the growing impact and acceleration of business practices towards Clusters, are addressed in this article, from the adoption of operations in Cluster initiatives in a framework of reflection that considers the main theories, to the incorporation of models and frameworks of reference in the Operations Management to consolidate its relationship with the techniques selected in consistency to the priority objectives of the Clusters.

Operations in Cluster initiatives (IC)

An alternative to increase the levels of productivity and business competitiveness, consists in the conformation of the Clusters. [5], [15], [16] indicate that clusters are one of the four types of agglomerations. These authors make a difference between Cluster and Cluster Initiative (CI), in which the first term is interpreted as the geographic concentration of companies in particular areas that compete and in turn cooperate; while the second term is identified as an effort by a region or group connected to the public sector, the private sector and the academic sector, to increase the growth and competitiveness of the companies attached to the Cluster.

For the Cluster initiative (IC), one modality is the approach of Clusters through models. 17], calls the GAP model (Gaps), as a model that visualizes the Clusters as a set of actors of different types, as shown in Figure 3, incorporates in the core the companies that make up the Cluster and in four edges involves government actors, research institutions, educational institutions and capital providers.

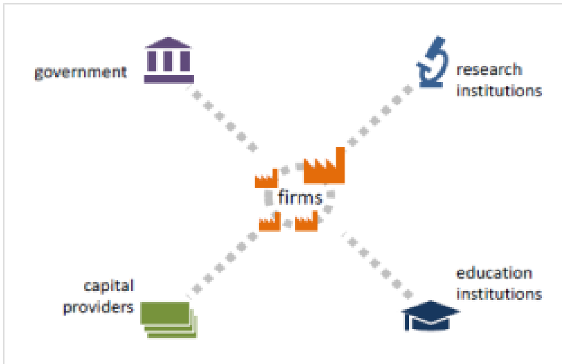

Figura 3: Modelo GAP. Fuente: Tomada de [17].

For 2016, [1], carries out a study on the performance and management of Clusters in 19 departments, publishing in March 2017 the results of the first assessment that incorporated 61 IC, with the participation of 308 companies and 115 entities. The study included nine value chains, including the textile chain. In general, the results for the country are related to low sophistication, a low level of diversification of the productive apparatus and a level of static productivity.

Another basic point in the orientation of geographic concentrations is the conformation of objectives that quantify the efforts of the Clusters, [5], [17] analyze four scenarios in the definition of 10 priority objectives for the Clusters. The result of this analysis is shown in
Figure 4:

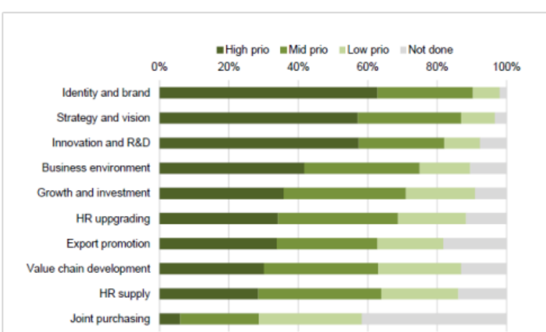

Figure 4: Priority level in ten objectives. Source: Taken from [17].

To achieve some of these objectives, process management is important and is achieved through Operations Management (OA) [18].

In relation to strategies and vision we have: forecasting models and the deployment of the quality function; learning curves that have important contributions towards innovation; the possibilities of research and development and the measurement of the updating of human capital; aggregate planning that functions as an element of human resource planning at the supply level (HR supply), and inventory systems with the possibility of contributing directly to joint purchasing.

Framework for reflection

The AO in the competitiveness of the Clusters has the following constructs: the techniques in operations management and competitiveness Cluster, focused on the processes for the production of goods and services. Due to the context, it is important to take into consideration the Clusters and Cluster initiatives, together with the theories that support their creation and development. Figure 5 gives a summary of the conformation of the theoretical concepts.

Figure 5: Theoretical concepts of AO and Competitiveness Cluster. Source: Own Elaboratio

Theory of the Firm

The Firm's Theory proposes an increase in production, leveraging on current unused or optimized capacity in order to minimize its cost structure [19], [20]. However, there is a plant size that optimizes the average cost, which can be represented by Figure 6, which shows that the average cost curve is optimized in a plant size "y" (third curve that obtains the lowest average cost "AC"), and from the fourth size (fourth curve), an inverse process is observed.

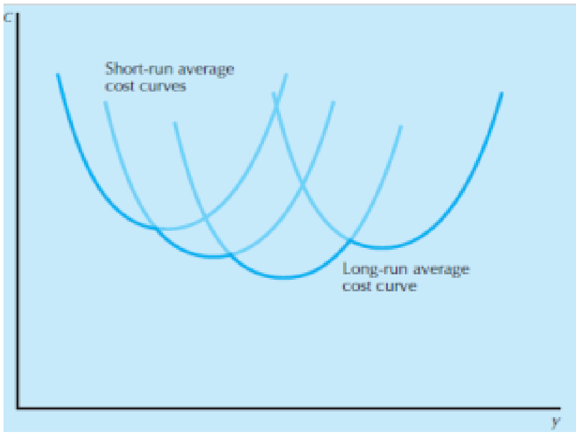

Figura 6: Niveles discretos de tamaño de planta. Fuente: Tomada de [19].

Firm Theory in Markets

According to [21], the Firm's Market Theory, based on Coase studies, proposes to coordinate production with a third company (subcontracting or outsourcing) when transaction costs in the market are high.

There are important elements that differentiate between the purchase of production factors and the sale of goods and/or services, in [22], called transaction costs, which are given by realities such as: the search for information or agents for negotiation, the communication process for negotiation, the definition of terms, the execution of negotiation, the development of agreements or the fulfillment of commitments, these being some of the elements that translate into transactions required in terms of time, effort and money.

Theory of Space Economics

Added to the previous concepts, we have the Space Economics, developed in function of the basic concept of Agglomeration Economics. In this regard, [23], offers a semantic representation on the theories related to local and regional development according to location or space.

In any case, all the theories related to the economy of space or localization seek to dictate a spatial principle for the organizational activity that allows to visualize the access to a market or center, measuring among other aspects the costs. As for this theory, [24], it mentions that the spatial dimension arises in response to globalization, which possesses new geographic structures with specific variables of production location according to its environment.

Framework y modelos

Based on the works of [25], it is necessary to use a Framework that consolidates the Cluster's performance within the currents and the macro-microeconomic environment for the competitiveness of the regions (countries or economic blocks).

[26], summarizes in a total of eleven recipes or models that try to address three relevant theoretical concepts: Strategies (Models: Railway, Radio, Stairway, Funnel, Multi Home - Based and Hourglass), Competition (Models: Radio, Archipelago, Stairway, Funnel, Multi Home - Based and Hourglass), Competitiveness and Cluster (Models: Trabant, Cluster and Inverted S, 7 Gaps, Hollywod, Multi Home - Based and Hourglass).

Casos prácticos

From a practical approach, there are several case studies:[25],[27],[28],[29],[30],[31], [32], are clear practical evidences that support development and its impact on greater economic activities given the development of clusters such as: Turkey Textile, California Wine, Wichita Vehicles and Aerospace Defense, Wichita Textile Plastic, Pittsburg Biotechnology / Pharmaceuticals, Pittsburg Information Technology, Pittsburg Production Technology, North Carolina Chemicals, Textiles and Plastics, North Carolina Communications Equipment, Kenya Flower Court and Australia Tourism in Cairns, among others.

These real cases demonstrate the quantification of medium and long term strategies that, in diverse economies, support the theories on the development and impact of Clusters in the phases of incipient, articulated, interrelated and self-sufficient Clusters [33], [34], affecting indicators such as the Grow Domestic Product (GDP) and in the export levels of goods and services [25]; clear evidence of improvements in competitiveness levels. To measure these scenarios, one of the most applicable models is Porter's Diamond [25], [35], using a four-point pattern: demand conditions, conditions of supply factors (human and natural), strategy, structure and rivalry, and related and supporting industries.

Operations Management (OA)

Every transformation system requires inputs to obtain the outputs, defined as products and/or organizational services. In Figure 7, a system approach can be observed

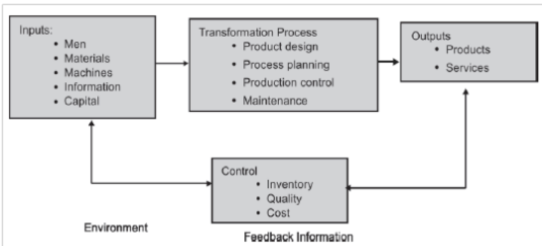

Figura 7: Sistema de producción. Fuente: Tomado de [36].

Under the systems approach, the AO is the part of the organizations in charge of the production of goods and/or services; that is, of the transformation of the inputs or resources required by a process into the outputs to be offered in a market, under levels of quality requirements; therefore, it deals with the management of resources for the production of goods and/or services [36], [37].

Técnicas en Operaciones

Among the main functions of organizations is the Operations function [12], in addition to the basic functions: Finance and Marketing (see Figure 8):

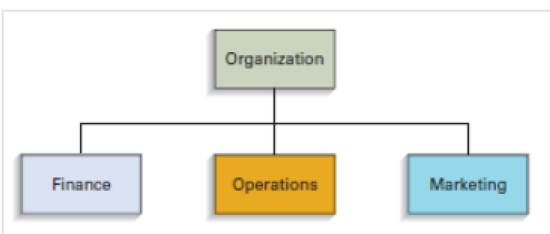

Figure 8: Basic functions of organizations. Source: Taken from [12].

Now, inside the operations, the techniques in operations selected according to the arguments by priority objectives in Clusters described in the section of operations in the CI are: forecasts, aggregate planning, inventory systems, learning curves and the deployment of the quality function. A detailed description of each technique is provided below:

Pronósticos

According to [38], time series methods work for the specific analysis of different patterns of historical demand by projecting them into the future.

Historical data "in the past" is essential for the analysis of the behavior or pattern of demand to recommend a technique for forecasting into the future. 4],[39],[40] ,[41] indicate that the five basic patterns of demand are related to: the horizontal pattern, the trend pattern, the seasonal pattern, the cyclical pattern and the random pattern.

It is then on the basis of demand that the use or application of a particular technique, based on mathematical methods, can be recommended [42]. For the purpose of grouping them: 38],[40],[41], classify time series prediction techniques into: first level techniques (suggested for when the demand for a product has a horizontal pattern); second level techniques (suggested for when the demand for a product has a trend pattern), and third level techniques (suggested for when the demand for a product has an additional pattern to the previous ones of seasonality).

For the first group we have: the simple moving average: [11],[42] indicate that it happens when the demand for a product does not grow or decrease rapidly and if it does not include seasonality characteristics, the moving average will serve to eliminate random fluctuations from the forecasts. In mathematical terms, he proposes [40]:

$$F_{t+1}= (D_t + D_t\text{-}1+D_{t-2}+\ldots\ldots\ldots+D_{t-n}+1) / n$$

Where: Dt: real demand in period t.

n: total number of periods included in the average.

Ft+1: forecast for period t+1

Within the first level we also have the weighted moving average, for [11],[42], the weighted moving average allows us to assign importance to each element, as long as, of course, all values add up to 1. Translated into mathematical terms: 38],[41] express it as:

$$F_{t+1}=W_1{*}D_t+W_2{*}D_{t-1}+W_3{*}D_{t-2}+\ldots\ldots\ldots+W_n{*}D_{t-n}+1$$

con la condición $\sum W_i = 1$.

As a third alternative to the first level techniques, we have the exponential smoothing method, [40] considers it a very refined weighted moving average method, [38] establishes that exponential smoothing arises from the idea that it is possible to calculate a new average from an older average and, in turn, from the most recent observed demand. Therefore, this alternative is born from the study and improvement of the weighted average technique, in which the most recent forecast and demand are mixed using a weighting coefficient or softening parameter; [40] indicates that the equation corresponding to this forecast model is developed under the following relationship:

F_{t+1}=α*(Demand for the last period)+(1-α)*(Forecast calculated for the last period).
$F_{t+1}=\alpha * D_t + (1-\alpha) * F$

Where α: softener parameter, whose value fluctuates between 0 and 1.

As for second level techniques, forecasts with linear regression [11] are considered, where it is established that linear regression refers to a special type of regression (functional relationship of two or more correlated variables), where the relationships between variables form a straight line. This relationship is developed by obtaining the equation of a straight line under its theoretical relationship [38]:

$Y=a + b*X$
Where:
Y: dependent variable.
X: independent variable.
a: Intersection of the straight line with the Y axis.
b: slope of the line.

Within the second level there is also the Trend-Adjusted Exponential Smoothing Method [38], defined as the procedure by which a trend is incorporated into an exponentially smoothed forecast.
Finally, for the third level there is the triple exponential smoothing, but it is important to mention that these techniques, based on time series, are effective in applications for production scheduling, inventory management, pricing decisions and cost estimation [43].

Aggregate planning

Every organization must plan its production to respond to the forecasted demand of its customers; that is, operational planning to support the marketing plan (sales) [18], [42]. Therefore, the development of an aggregated production plan over a horizon of six to twelve months represents the connection between the sales forecast and the master production schedule (detailed production-level schedule) [44]. In addition in: 09], [42], [45] there are several options to manage the production capacity of a company, but they are consolidated between the demand monitoring strategy and the level production strategy, although other alternatives can be generated that fluctuate between these two, also called "hybrid plans".

In addition to pure and mixed planning strategies, [11], [46] develop the use of mathematical techniques, specifically, the application of the transportation matrix (special model of linear programming) in the area of knowledge of aggregate planning.

From the computational perspective [44],[47], linear programming in aggregate planning has an important potential when using some software for production decisions, having diverse production options in front of demand requirements, the scheme used is that of transport models.

Finally, from a statistical perspective, it is important to describe the measures of the aggregated plans using basic measures such as [48]: the average and the standard deviation, plus the representation of the data for analysis.

Inventory systems

For a variety of reasons, organizations need to store quantities of resources and/or products in the processes that occur in the different supply chains, ranging from handling raw materials, components, process work to managing finished products, so companies use different types of inventories [42],[47]. For [11],[45] an inventory system is the set of policies and controls that monitor inventory levels and determine those to be maintained, when it needs to be replenished and how large the orders should be.

In itself, for inventory management, there is a duality of options, the first referring to the management of inventory systems from a mathematical perspective posed by [45],[47] and another under the probabilistic approach defined by [09],[47], as a probabilistic model.

In addition, one of the key elements in inventory models is the management of the cost structure. There are four types of basic costs [49]: order, product acquisition or manufacture, inventory maintenance and breakage (deficit) because the product is not in the quantity and time requested by the client.

Therefore, the applicability of this probabilistic approach is based on three inventory systems that manage two management criteria: how much to order?

and when to order? [09], [11], [37], [38]. In the continuous review system (Q system or Q,R system), when the stock position falls below a predetermined order point or reorder point, an order is placed for a fixed amount [38]. In a nutshell:

Continuous Review System

If PI<=R (Order moment), then Q (Fixed order quantity) is ordered.
PI: Inventory stock item.
R=d*te+z*σ*√(te)

Q = √[(2*D*Co)/Cm] for a purchasing process (formula generated in function of minimizing the basic cost structure of an inventory system).
Q = √[(2*D*Co)/Cm*(1-d/p)] for a manufacturing process (formula generated as a function of minimizing the basic cost structure of an inventory system).

Where:

D: annual product demand.
Co: ordering cost.
Cm: cost of maintenance or storage.
d: demand in periods (annual, monthly, weekly, daily, etc.).
p: production rate in periods (annual, monthly, weekly, daily, etc.).
z: number of standard deviations desired to cover a level of service.
σ: standard deviation of the annual behaviour of demand.
Tee: delivery time of the supplier.

Continuous Review System: referenced in [09],[38],[42], [50].

For the periodic review system or fixed period system (P), the inventory item is not rigorously reviewed like the previous system, but is performed periodically or remotely. In this sense [38], it states that the revision carried out under this system immediately generates an order that is quantified by the difference between the predetermined target and the position of the existence of the inventory (PI). In a synthesised form:

Periodic Review System
Each review period P (response to when), a certain amount related to is requested: White (B) minus IP, that is,
Qt=(B - PIt)
P, calculation options. Option 1: Frequency preset by management or the given distribution system. Option 2: P= Q/D
P: frequency of review (weekly, monthly, etc.).
B=d*(te+P) + z*σ*√(te+P)
Qt: quantity to be ordered at the time of revision t.
Summary 2. Periodic Review System: with reference in [11], [38], [42].

However, for the third system known as the system of maximums and minimums or the optional resurfacing system, the systems previously seen are combined [11]. This system initially functions as a P system (when it is adjusted to a monthly, weekly, etc. frequency revision), but, given the revision, it is not always requested; that is, there is a conditioning for the order: If PI < = R, a quantity (how much) is requested Qt = M - PI, where M: is the maximum inventory level (M = Q + R).

Finally, it is important to point out that the systems proposed were designed for products with independent demand; that is, those that are affected by market conditions [38] and reinforced by what is explained in the section on forecasts, it can be mentioned that the products that are offered directly to customers or end users have the characteristics of products with independent demand.

Learning curves.

The learning curve functions as a premise that people perform their tasks better as they repeat them [09],[47]. They are sometimes called experience curves, since they imply that as experience is acquired in production, the process becomes more efficient.

Learning can be modeled through the learning curve, which is a line that shows the relationship between production time per unit and the cumulative number of units produced [11], [47], [50]. Such approaches are interesting if one thinks of the managerial usefulness of this tool or model, specifically in the area of human talent or intellectual capital in production processes. Then [11], they pose three assumptions of the learning curves:

1.The amount of time required to complete a task or product unit will be less each time the task is undertaken.

2.The time per unit will decrease at a decreasing rate.

3.The reduction in time will follow a predictable pattern.

In other words, the time required for manufacturing can be schematized under the mathematical perspective, in this sense,[09] proposes three approaches based on mathematical functions of learning curves: the arithmetic approach, the logarithmic approach and the learning curve coefficient approach. Each of them reaches the point of a formula that links the required production time with the worker's experience as a recursive element that affects the reduction of productive time.

Deployment of the quality function

Since the beginning of the Industrial Revolution, and during the development of managerial thinking, there has been a diversity of perspectives for the management of production, from the push of the market to the change of the dragging of the market in function of the needs of the clients. For this reason, a diversity of models have emerged to approach existing gaps by classifying two types of important gaps [49]: the customer gap, which is the difference or distance between the service expected by the customer according to standards (expectations) and the perceived service (perception), and the supplier gap, which is presented within the organization (knowledge, design and standards, performance and communication).

Furthermore, [38],proposes an inter-functional perspective, which maintains that the product must not only be adapted to the needs of the market but must also have a technical advantage; that is, not only must the aspects of the consumer's needs be addressed, but these must be transferred to the technical language of the production process. In this sense, the tool of the quality control area that has generated the possibility that the customer's voice has an opening in the technical aspects of the process is the Qfd: "Deployment of the quality function". In definition, [47], it establishes that with Qfd it is possible to link the needs of customers with the attributes of the product offered and/or the aspects of the process that generates the good or service produced.

A series of consecutive steps [38], [11], [50], named below, are used to deploy the quality function:

1.Development of the concept: stage in which the needs and expectations of the clients are transferred through a process in which the client is listened to and studied in order to determine the characteristics and attributes of the product ("good or service") to be offered. One of the techniques used in this phase is market research to determine customer requirements.

2.Once the requirements of the clients have been established, we enter a stage centered on their hierarchization, where one of the most frequently used tools is Pareto's analysis, which helps us to differentiate the hierarchy and sequence to meet the needs according to the clients' criteria..

3.After the information provided by the clients, the technical requirements of the process are developed that can meet and address the needs expressed by the client. This process is called: the construction of the quality house, and it recommends the use of an interdisciplinary team, which can convert the customer's requirements to the technical requirements for the process to fit them.

Once the house of quality is obtained, each client's need is related to the requirements of the process, for which they recommend a scale of four possible evaluations: 0, 1, 3 or 9 [50]. The value of 0 is added to the cell of the needs that have no relation with the technical requirements; the value of 1 when there is a low relation; the value of 3 when the relation is average, and the value of 9 when there is a strong relation between the need and the technical requirement of the analyzed process.

Using some software and even spreadsheets, once the input information is provided, the calculations are performed in an automated way, both for the hierarchization of customer requirements, process technicians and, additionally, the identification of existing gaps between the organization under study with respect to the competition. The first two calculations work to develop strategies in the context of the market and in the process priorities, while in the analysis of the gaps can be reflected strategies aimed at covering the aspects of competition.

Conclusions

By crossing general concepts, theoretical concepts and operational techniques, a structure is proposed that allows a synchronized execution of operational techniques and their impact on cluster objectives (See Table I):

TABLA I: Proposal of techniques for cluster objectives. Own elaboration.

TECHNIQUES	OBJECTIVES - CLUSTER
Prediction of cluster demands	Strategies and vision
Deployment of the quality function	Strategies and vision
Inventory Systems	Joint purchasing.
Production Planning	Human resource planning (HR supply)
Learning Curves	Innovation and research and development possibilities

In addition, a cascade effect is proposed that interrelates the outputs of products expected in each technique or block of techniques to the requirements of subsequent techniques (See Table II):

TABLE II: Proposal of phases between techniques. Own elaboration

DESCRIPCIÓN	
Pronóstico	Predicción de las demandas del clúster. Estrategias y visión.
Despliegue de la función de calidad	Brechas entre las expectativas/necesidades de los clientes.
Información del contexto externo como realidad del mercado real y potencial del clúster.	
Planeación de la Producción	Partiendo de las demandas previstas, planear las estrategias de la oferta.
Sistemas de Inventarios	Teniendo los escenarios de demanda, condiciones de producción y relación con proveedores, se puede proponer un sistema específico de inventarios para el cluster textil.
Información para dar respuesta a las necesidades de los clientes, planes agregados de producción y políticas en inventarios.	
Curvas de Aprendizaje	Tiempo de producción en función de la experiencia. Incidencia del ciclo productivo.

From the theoretical/practical perspective, the management of operations in the competitiveness of clusters represents an opportunity for the fulfillment of priorities in organizations that unite for the achievement of common objectives such as: the development of strategies and shared vision, research and development, updating of human capital and the development of joint purchasing.

For each one of the priority objectives of the clusters, there are diverse techniques of operations management that, at a tactical level, achieve the operation of the purposes by means of forecasting models, the use of the deployment of the quality function, the generation of the learning curves, the use of the aggregate planning and the implementation of the inventory systems, which in turn have an intrinsic relationship with the achievement of the objectives of the cluster initiatives.

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