Analysis of sales demand and production capacity to determine the need for direct labour

Análise da demanda de vendas e da capacidade de produção para determinar a necessidade de mão de obra direta

Análisis de la demanda de ventas y la capacidad de producción para determinar la necesidad de mano de obra directa

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Abstract

This study consists of meeting the sales demand using the existing production capacity in an electronic goods industry and thus determining the amount of direct labor (MOD) necessary to meet the needs of customers. Since obtaining the correct number of operators on a production line is extremely important in the pursuit of productivity and cost reduction. Therefore, using concepts such as takt time, cycle time and line efficiency and other information related to the product or products that will be assembled on a production line, it will be possible to quickly and assertively determine the number of operators that must serve directly the client's demand, thus guaranteeing productive efficiency and the correct application of labor resources using as assumptions the capacity and equipment already existing in the production line. Thus, based on the company's sales projection, it will be

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possible to determine month by month the number of operators, number of shifts and the appropriate volume to be produced to meet the requested demand.

**Keywords:** Demand. Capacity. Efficiency. Labor. Production.

**Resumo**
Este estudo consiste em atender à demanda de vendas usando a capacidade de produção existente em uma indústria de bens eletrônicos e, assim, determinar a quantidade de mão de obra direta (MOD) necessária para atender às necessidades dos clientes. Uma vez que a obtenção do número correto de operadores numa linha de produção é extremamente importante na prossecução da produtividade e da redução dos custos. Portanto, usando conceitos como tempo takt, tempo de ciclo e eficiência de linha e outras informações relacionadas ao produto ou produtos que serão montados em uma linha de produção, será possível determinar de forma rápida e assertiva o número de operadores que devem atender diretamente a demanda do cliente, garantindo assim a eficiência produtiva e a correta aplicação dos recursos de mão de obra usando como pressupostos a capacidade e o equipamento já existentes na linha de produção. Assim, com base na projeção de vendas da empresa, será possível determinar mês a mês o número de operadores, o número de turnos e o volume adequado a ser produzido para atender à demanda solicitada.


**Resumen**
Este estudio consiste en satisfacer la demanda de ventas utilizando la capacidad de producción existente en una industria de bienes electrónicos y, por lo tanto, determinar la cantidad de mano de obra directa (MOD) necesaria para satisfacer las necesidades de los clientes. Dado que obtener el número correcto de operadores en una línea de producción es extremadamente importante en la búsqueda de la productividad y la reducción de costos. Por lo tanto, utilizando conceptos como el tiempo de toma, el tiempo de ciclo y la eficiencia de la línea y otra información relacionada con el producto o productos que se ensamblarán en una línea de producción, será posible determinar de manera rápida y asertiva el número de operadores que deben atender directamente la demanda del cliente, garantizando así la eficiencia productiva y la correcta aplicación de los recursos laborales utilizando como supuestos la capacidad y el equipo ya existente en la línea de producción. Así, en función de la proyección de ventas de
la empresa, será posible determinar mes a mes el número de operadores, el número de turnos y el volumen adecuado a producir para satisfacer la demanda solicitada.

**Palabras clave:** Demanda. Capacidad. Eficiencia. Laboral. Producción.

### Introduction

Analysing demand and production capacity is an essential step in determining an organisation's direct labour needs, especially in the business context. This process allows companies to assess the relationship between forecast sales and their production capacity, in order to identify whether more workers need to be hired to meet forecast demand. This introductory chapter will cover the main concepts related to analysing demand and production capacity, as well as the importance of carrying out this analysis effectively. In addition, bibliographical references from scientific articles published as of 2019 will be presented in order to substantiate the writing and provide a solid basis for the development of the research.

Demand analysis consists of assessing consumer behaviour in relation to a particular product or service in order to identify their needs and preferences. This analysis is extremely important for companies to be able to project future demand and thus make appropriate strategic decisions.

Demand analysis allows companies to identify market trends, consumer behaviour and seasonal fluctuations, among other factors relevant to forecasting demand. This requires the use of appropriate tools and techniques, such as market studies, data analysis and statistical modelling. Production capacity, in turn, refers to the maximum quantity of products or services that an organisation can produce within a given period. This capacity is determined by factors such as available resources, the technology used, the efficiency of production processes and the availability of labour.

Production capacity is a fundamental variable for operations management and strategic decision-making in companies. It is necessary to assess whether current capacity is sufficient to meet forecast demand or whether it needs to be increased, either by increasing available resources, implementing more efficient technologies or hiring more employees. Once the analysis of demand and production capacity has been carried out, it is possible to determine the need for direct labour to meet forecast demand. This need is calculated based on indicators such as average worker productivity, average production time for each product or service and
the length of the working day.

It is important to consider factors such as the availability of skilled labour, the costs of hiring and training, and the company's ability to manage a larger team. In summary, this introductory chapter has covered the importance of analysing demand and production capacity to determine an organisation's need for direct labour. This analysis allows companies to identify market demands, project future demand, assess production capacity and thus make appropriate strategic decisions. The bibliographical references used in this text were selected on the basis of the relevance and topicality of their content. Throughout the dissertation, these scientific articles will be analysed and discussed in greater detail in order to provide a solid theoretical basis and support the proposed conclusions and recommendations.

The contribution and relevance of this analysis are numerous. Firstly, it allows the company to plan accordingly, avoiding problems such as excessive stock or a lack of products to meet consumer demand. By analysing sales demand, the company can adjust its production capacity accordingly, avoiding wasted resources and unnecessary costs. In addition, analysing sales demand and production capacity helps determine the need for direct labour. If sales demand is above production capacity, this indicates a need to hire more workers to increase production and meet market demand.

In short, the analysis of sales demand and production capacity is fundamental to determining the need for direct labour in an organisation. It contributes to the company's strategic planning, avoiding problems such as excessive stock or product shortages, as well as helping to plan human resources. Therefore, this analysis is essential for a company's success and efficiency. Some essential manufacturing concepts are highlighted, such as: Takt time, Cycle time, Efficiency, Down time, Availability, Quality and OEE.

**Literature Review**

This section discusses the literature review, focusing on the most important topics for the study in order to understand the concepts needed to analyse capacity and meet sales demand.
2.1 Productive Capacity Management

Capacity management is the process of planning, monitoring and controlling a company's production capacity. It refers to the organisation's ability to respond effectively to customer demand and capacity management corresponds to these adjustments, matching production capacity with market demand. Inadequate management of production capacity can lead to exorbitant costs, lost business opportunities, customer dissatisfaction and reduced operational efficiency.

2.2 Installed Capacity

Installed capacity is important for companies to respond to market demands efficiently and quickly. According to Hasan and Gray (2019), companies with more production capacity than their competitors are more likely to achieve a greater market share and increase their profitability. However, it is important to emphasise that productive capacity must be correctly determined based on the internal and external needs of the enterprise. A study by Nofal and Marufuzzaman (2018) shows that excess installed capacity can waste resources and reduce profits. While insufficient production capacity can cause delivery delays and loss of customers. In addition, installed capacitance is constant and cannot be assumed to remain the same over time. According to Correia and Milhomens (2020), installed capacity needs to be constantly monitored and updated to meet changing market needs and requirements. Installed capacity is also related to the organisation's efficiency and productivity. Waddell et al. (2017) argue that well-sized and efficiently utilised installed capacity can lead to higher productivity and lower production costs. In addition, external factors such as changes in the law, currency fluctuations, the economic crisis and problems with the supply of raw materials can affect the company's production capacity. Resources, be they human, financial or technological, must be managed efficiently and effectively to ensure that installed capacity is utilised in the best possible way, always aiming to meet demand.

2.2.1 Definition and fundamentals of installed production capacity

According to Heizer and Render (2019), the classic definition of installed capacity is the maximum number of product units that a production line or piece of equipment can
produce during a given period under normal operating conditions and useful life. In this sense, installed capacity is measured by the maximum production that can be achieved in a given period, usually expressed in units per hour, daily, weekly or monthly. However, installed capacity is not a fixed and constant measure. This can be adjusted, among other things, by investing in new equipment, hiring more employees and training direct labour. In the current circumstances, installed production capacity is even more important, given the complexity and competitiveness of the global market. The 2020 COVID-19 pandemic has forced some companies to reduce their production to meet demand for essential products such as medicals equipment and hygiene products.

2.2.2 Management of installed production capacity

Managing a company's installed capacity is a very important issue for modern organisations. In a highly competitive and constantly changing environment, companies must be prepared to effectively meet market demands and guarantee customer satisfaction. According to Gavetti (2020), installed production capacity refers to the maximum amount of production that a company can produce during the specified period. Managing this capacity involves planning and directing manufacturing activities, taking into account demand, available resources and organisational objectives. One of the most common management methods is the line balancing method. According to Barretta et al (2021), this method consists of a balanced distribution of activities between workstations to reduce bottlenecks and ensure continuous production. In this way, greater productivity can be achieved and waiting times between activities can be reduced.

According to Ahmed et al. (2020), implementing a demand management system can bring multiple benefits to organisations such as cost reduction, productivity and customer satisfaction. These and management software include the use of advanced technologies to help analyse demand, plan production and implement lean management practices.

2.3 Available Production Capacity

Available capacity is a very important operations management concept for organisations in all sectors. It refers to the maximum capacity that an organisation can achieve in a given period of time, taking into account the appropriate allocation of resources and the
effective use of these resources. In this concept, we highlight the importance of available productive capacity and its relationship with improving the efficiency and competitiveness of organisations, as shown in Equation (1).

\[ AC = \frac{DWH}{PSTP} \quad (1) \]

Where:

\[ AC = \text{Available Capacity} \]
\[ DWH = \text{Daily Working Hours} \]
\[ PST = \text{Product Standard Time} \]

2.3.1 Factors influencing available production capacity

Several factors can influence an organisation's available capacity. These include the level of utilisation of available resources, the quality of production processes, the technology used and the efficiency of operational management. According to a study by López-Cotarelo et al. (2020), it is important to constantly work on identifying and eliminating production bottlenecks that jeopardise available production capacity.

2.3.2 Methods for calculating available production capacity

There are various ways of calculating available capacity in an organisation. Some of the methods commonly used by managers are based on periodically reviewing the potential for meeting demand through available production capacity. According to a study by Noran et al. (2019), the time-capacity analysis method is widely used to assess the available capacity of manufacturing companies. This method measures the time required to manufacture a given product, taking into account the availability of production resources, where the availability of labour and the simulation of equipment occupancy in the production process are analysed.
Table 1

Method for calculating available production capacity

<table>
<thead>
<tr>
<th>Available Capacity (DC)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One shift</td>
<td>A daily shift of 8 hours five days a week. CD = 8 x 5 x 4 = 160 hours per month.</td>
</tr>
<tr>
<td>Two shifts</td>
<td>Two shifts per day DC = 2 x (8 x 5 x 4) = 320 hours per month.</td>
</tr>
<tr>
<td>Three shifts</td>
<td>Three daily shifts DC = 3 x (8 x 5 x 4) = 480 hours per month.</td>
</tr>
<tr>
<td>Four shifts</td>
<td>Four daily shifts of 8 hours each, seven days a week (teams take turns to maintain uninterrupted work, respecting weekly rest). DC = 3 x (8 x 7 x 4) = 672 hours/week.</td>
</tr>
<tr>
<td>Overtime Hours</td>
<td>Each hour worked beyond the normal working day is added to the available capacity.</td>
</tr>
</tbody>
</table>

2.3.3 Measuring available production capacity

Once you have determined the available production capacity, you need to measure it accurately. These metrics are necessary for making strategic decisions to optimise resource allocation and maximise the efficiency of production processes. According to the study by Alves et al (2021), it is important to measure available capacity based on physical capacity and lead time. Physical capacity refers to the amount of output a company can produce in a given period of time. On the other hand, production capacity includes not only the quantity of products produced, but also the quality considered, the resources and the related technologies.

2.3.4 Strategies for optimising available production capacity

In order to make efficient use of existing production capacity, it is essential to use strategies to increase the production performance of the operation. Various methods can be applied to this end, such as improving the quality of operations, adapting advanced technologies and using good management practices. According to Wang et al. (2020), an effective strategy for optimising existing production capacity is to use the systems and tools available in Lean Manufacturing. These systems aim to eliminate waste and increase the efficiency of production processes, resulting in more efficient production capacity.

2.4 Effective Production Capacity

Effective production capacity is an important concept for companies in all sectors because it specifies the maximum quantity of a product or service that can be produced during a given period, taking into account existing limitations and restrictions. Effective production capacity is essential to ensure that the necessary demands made by the market are met and to
guarantee competitiveness. According to Howes et al. (2019), effective manufacturing capacity is a company's ultimate ability to produce a product or service, taking into account factors such as the availability of resources, the efficiency of the production process and the use of advanced technologies. Consequently, it is important for a company to be able to use its resources efficiently and optimally, always seeking to maximise production capacity. According to Shah et al. (2020), a lack of sufficient resources can create a bottleneck in production capacity and thus limit the quantity of products and services that can be produced. Consequently, it is important for companies to be able to identify and manage their resources in order to maximise their production capacity. Furthermore, the efficiency of production processes has a major impact on the company's actual production capacity. As Hinson et al. (2019) pointed out, poorly planned or inefficient manufacturing processes can lead to lost production, rework and delays, as well as reduced production capacity. It is therefore essential that companies endeavour to continuously improve their processes by eliminating redundant steps and adopting more efficient methods. One way to increase the efficiency of your plant is to invest in technology and automation.

According to Anand et al. (2019), a company must be able to predict and manage demand for its products or services in order to adjust its production capacity to market demands. Managing limited demand can lead to shortages and surpluses and this affects effective production capacity, and we must consider other important aspects such as the adaptability and flexibility of companies. According to Hajiheydari et al. (2019), companies must adapt quickly to market changes and customer demands and so production capacity must also change. As a result, companies invest time and resources to analyse and improve the efficiency of their production capacities according to Equation (2).

\[
CE = \frac{AWH}{TPP}
\]  

(2)

Where:

- \(EC\) = Effective Capacity
- \(AWH\) = Available Working Hours
- \(PST\) = Product Standard Time

\[\begin{align*}
CE &= \frac{AWH}{TPP} \\
\end{align*}\]
2.5 Realised Production Capacity

Realised production capacity is an important indicator for companies and reflects how efficiently they can produce a product in a given period of time. This concept is fundamental for strategic planning and decision-making, since companies need to know their production capacity in order to correctly size their resources. Realised capacity is the quantity of products or services that an organisation can make available in a given period, but not forgetting that the efficiency of the production process must be taken into account, so the maximum capacity that the company can produce efficiently in the production process takes into account factors such as the availability of resources, direct labour and the technology used, among others (Smith, 2020). Knowing the realised production capacity is fundamental for companies to plan their operations and avoid wasting resources. Proper calculations of production capacity avoid problems such as delays in delivering products to customers or under-utilisation of company resources, which leads to unnecessary costs and losses.

A company's production capacity can also be affected by external factors such as demand and market dynamics (Brown, 2020). There are various indicators that can be applied to measure realised production capacity, among which we can mention the capacity utilisation rate (CUR), which measures the ratio between utilised capacity and total available capacity. When a company identifies that its realised production capacity is below its maximum potential, certain strategies can be adopted to increase it. These include optimising the production process, investing in staff training, using technological resources, secondary outsourcing, etc (Peterson, 2020). The COVID-19 pandemic has brought many challenges that directly affect the productive capacity of companies, among them the decrease in demand and the scarcity of resources due to the restricted movement of people, these are some of the main challenges that companies face, resulting in the reduction of production capacity in many industries (Gupta, 2020).

Simulation is an important tool for estimating realised capacity and allows companies to assess different scenarios and make decisions based on the greatest amount and assertiveness of information. Through simulation, it is possible to identify bottlenecks and areas for improvement, as well as study the impact of changes in the production process, as shown in Equation (3).

\[ RC = \frac{AWH - UDT}{PST} \] (3)
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Where:

\[
\begin{align*}
RC &= \text{Realised Capacity} \\
AWH &= \text{Available Working Hours} \\
UDT &= \text{Unplanned Down Time} \\
PST &= \text{Product Standard Time}
\end{align*}
\]

2.6 Sales Demand Management

Sales demand management is an essential activity for organisations seeking to optimise their production processes and maximise their financial results. To achieve this, many companies are turning to advanced manufacturing systems, which use technologies such as artificial intelligence, machine learning and automation to analyse and forecast sales demand more accurately and efficiently. We will also analyse the importance of sales demand management and its relationship with advanced manufacturing systems. In addition, we will present mathematical formulas to show how these technologies can contribute to optimising the demand management process.

To highlight the importance of advanced manufacturing systems, we can use a simple mathematical formula. The sales demand formula can be expressed as Equation (4):

\[
SD = PC \times AFP \times AQB
\]

(4)

Where:

\[
\begin{align*}
SD &= \text{Sales Demand} \\
PC &= \text{Probability of Purchase} \\
AFP &= \text{Average Frequency of Purchase} \\
AQB &= \text{Average Quantity Bought}
\end{align*}
\]

By using advanced manufacturing systems, it is possible to estimate each of the factors in this formula more precisely. The probability of purchase can be calculated by taking into account the characteristics of the target audience, such as age, gender, geographical location, etc. The average frequency of purchase can be determined by analysing past customer behaviour and identifying consumption patterns. Finally, the average quantity purchased can be estimated by analysing historical sales data. Another relevant piece of research to support
our argument is the work by Smith et. al. (2020), which concluded that automating tasks related to sales demand management can increase the productivity of sales staff by up to 30 per cent. This is because advanced technologies allow professionals to dedicate themselves to strategic activities, such as developing new marketing strategies and identifying sales opportunities.

2.7 Methodology for Synchronising Capacity x Demand

The efficient synchronisation of production capacity with sales demand is a challenge faced by many companies. Inadequate management of this relationship can result in problems such as excessive stocks, financial losses and low customer satisfaction. It is therefore essential to develop methodologies that enable production capacity to be properly synchronised with sales demand in order to optimise operational efficiency and meet customer expectations. One widely adopted methodology for synchronising production capacity with sales demand involves the use of advanced manufacturing systems. These systems encompass various production techniques, such as Just in Time (JIT), Lean Manufacturing, Theory of Constraints and Six Sigma, which are combined to achieve a flexible and optimised operation.

The proposed synchronisation methodology includes the following steps:

1. Analysing historical sales data: it is essential to collect and analyse historical sales data in order to understand past demand and identify seasonal patterns or future trends. This will provide a basis for estimating future demand and determining the production capacity required.

2. Forecasting sales demand: based on the analysis of historical data, it is possible to use demand forecasting techniques, such as moving average, exponential smoothing or regression models, to estimate future demand. These forecasts can be refined using additional information, such as new product launches, changes in customer preferences or seasonal events.

3. Establishing production capacity: based on projected demand, it is necessary to determine the production capacity required to meet this demand. This involves the appropriate allocation of resources such as labour, machinery and physical space, taking into account operational efficiency and actual production capacity.

4. Stock sizing: as part of synchronising capacity and demand, stock must be managed appropriately. It is important to establish optimum stock levels to avoid shortages or
excesses. Techniques such as calculating the resupply point and using kanban systems can be employed to optimise this management.

2.7.1 Stages of the Synchronisation Methodology

2.7.1.1 Demand forecasting

Sales demand forecasting is a fundamental process for companies in all sectors, as it allows us to estimate the quantity of products and services that customers will purchase in a given period. This forecast is essential for the strategic planning of organisations as it directly influences production, stock management and the definition of marketing strategies. Various sales demand forecasting methods are used, some of which employ statistical and mathematical analysis. Among these techniques, linear regression stands out, as it seeks to establish a functional relationship between demand and explanatory variables such as price, promotions, climate, among others. Table 2 shows the data used in this analysis, including monthly sales and the explanatory variables considered.

Table 2

Sales demand forecast data

<table>
<thead>
<tr>
<th>Month</th>
<th>Sales (Units)</th>
<th>Average Price (R$)</th>
<th>Promotion (%)</th>
<th>Weather (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan/19</td>
<td>100</td>
<td>500</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Feb/19</td>
<td>120</td>
<td>450</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>Mar/19</td>
<td>110</td>
<td>480</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Apr/19</td>
<td>130</td>
<td>470</td>
<td>8</td>
<td>22</td>
</tr>
</tbody>
</table>

By analysing linear regression, the following sales demand forecast model was obtained. Equation (5):

\[ D = 15 + 0.1 \times P - 2 \times Pr + 3 \times W \]  \hspace{1cm} (5)

Where:

\[ D = \text{Demand} \]
\[ P = \text{Price} \]
\[ Pr = \text{Promotion} \]
W = Weather

Using this model, it is possible to forecast demand for the coming months based on the respective explanatory variables. For example, for the month of May/19, considering an average price of R$490, a promotion of 7% and a temperature of 24°C, the demand forecast is Equation (6):

\[
DM = 15 + 0.1 \times 490 - 2 \times 7 + 3 \times 24 = 50
\]  

(6)

Where:

\begin{align*}
DM &= \text{Demand May/19} \\
P &= \text{Price} \\
Pr &= \text{Promotion} \\
W &= \text{Weather}
\end{align*}

This forecast allows the company to plan more assertively, adjusting production and stock levels in line with expected demand. It also makes it possible to develop more effective marketing strategies, directing efforts towards the months when demand tends to be highest, for example. It is important to emphasise that the sales demand forecast must be constantly reviewed and updated, since factors such as changes in the economy, competition and customer preferences can have a significant impact on the results obtained.

2.7.1.2 Determining production capacity

One of the main benefits of determining production capacity is the ability to accurately forecast and plan production volumes. This avoids problems of overproduction or underutilisation of resources, as well as guaranteeing customer satisfaction and operational efficiency. In order to calculate production capacity, it is necessary to consider three main factors: available time, quantity of labour and production efficiency. As stated by Brown (2020), available time is the number of hours the company is operating on a daily, weekly or monthly basis.
2.7.2 Tools for synchronising production capacity x sales demand

ERP systems are integrated systems that allow the management of information from various areas of the company, such as sales, production, stock and finance. They provide a complete, real-time view of business operations, making it easier to identify bottlenecks and gaps in production capacity, as well as greater precision in forecasting demand. ERP systems can also support decision-making through management reports and analyses.

Information Technology (IT) also plays a fundamental role in analysing and synchronising production capacity with sales demand. Technological advances have enabled the development of increasingly sophisticated tools to help in this process. For example, simulation software makes it possible to analyse different scenarios and assess the impact of changes in production capacity or sales demand. In addition, Supply Chain Management (SCM) systems allow for greater integration between the different partners in the chain, making it easier to synchronise production capacity with sales demand.

Another important tool is the use of performance indicators. Performance indicators are metrics used to monitor and evaluate an organisation's performance in relation to its strategic objectives. In the context of analysing and synchronising production capacity with sales demand, indicators such as the level of production capacity utilisation, the response time to orders and the customer satisfaction index are extremely important. By applying tools such as Just in Time (JIT), pull production and Kanban, it is possible to synchronise production capacity with sales demand, avoiding excessive stocks or product shortages and guaranteeing efficient production. In addition to the tools mentioned above, other strategies can be applied to help analyse and synchronise production capacity with sales demand. For example, collaboration with customers and suppliers can enable a greater exchange of information and a better understanding of market needs. The adoption of project management practices, such as the use of schedules and resource allocation techniques, can also help synchronise production capacity with sales demand.

2.8 Efficiency as a Competitive Strategy

Productive efficiency can be defined as an organisation's ability to use its resources in the best possible way to produce goods and services. In this sense, it is directly related to the efficient use of production factors such as labour, capital and technology. By achieving high
levels of productive efficiency, companies are able to reduce their production costs, increase production capacity and improve the quality of their products or services. One of the main competitive strategies that stems from productive efficiency is cost reduction. Organisations that manage to produce with high quality and speed are able to meet consumer demands more effectively than their competitors. In this sense, production efficiency can help create an image of excellence and reliability for the company, which generates significant competitive advantages.

2.8.1 Cost strategy

Firstly, it is essential to understand that cost efficiency is not just about cutting costs indiscriminately. It's about optimising processes, eliminating waste and finding smarter solutions to produce properly. This approach emphasises the importance of focusing on the added value and quality of the final product or service, while at the same time seeking to cut unnecessary expenses. One of the most effective ways to implement cost efficiency is through continuous improvement. By adopting a continuous improvement mindset, companies can reduce waste, improve productivity and consequently lower production costs. Technology also plays a key role in the quest for cost efficiency. Technological innovations allow companies to automate repetitive tasks and improve process efficiency. Implementing supply chain management systems, process automation and data analysis can lead to a significant reduction in operating costs.

2.8.2 Quality strategy

In today's highly competitive market scenario, where companies are constantly seeking to stand out and gain an edge, quality efficiency has emerged as an essential strategy for gaining competitive advantage. The ability to deliver high quality products and services efficiently and effectively becomes a source of value for customers, contributing to their loyalty and satisfaction. Quality efficiency is a crucial factor for the success of organisations in today's market. Quality, as well as being a basic requirement, has become a consumer expectation, and companies that manage to deliver top quality products and services, consistently and efficiently, come out ahead of the competition. One of the ways to achieve quality efficiency is through the application of tools and methodologies aimed at operational
excellence. The Six Sigma methodology is one of the most widely used approaches to improving quality and efficiency in organisations. This methodology is based on the use of data and statistical analyses to identify and solve quality problems, with the aim of reducing defects and variations in processes. The implementation of Six Sigma results in the optimisation of companies' operational performance, leading to efficiency in quality and, consequently, the achievement of a competitive advantage.

2.8.3 Flexibility Strategy

In today's business environment, organisations face a dynamic and uncertain environment where flexibility has become increasingly important. The ability to adapt quickly to change is essential for survival and success in the market. In this context, flexibility has been widely discussed as a competitive strategy capable of generating an advantage for companies. However, the rigidity of traditional strategies may no longer be enough to cope with the rapid changes and uncertainties in business. Flexibility is therefore gaining prominence as a way of adapting to new market demands and gaining competitive advantage.

Materials and Methods

Efficient manufacturing requires adequate planning of direct labour to satisfy production demand. To this end, it is crucial to use indicators that help calculate the number of workers needed to achieve the proposed objectives. In this case study, the expected result will be an understanding of the manufacturing indicators needed to accurately and objectively calculate how much direct labour will be needed to meet sales demand.

3.1 Manufacturing Indicators

Manufacturing is one of the main sectors of the economy, and the continuous quest to improve production processes guarantees the competitiveness of companies in this constantly evolving market. In this context, manufacturing indicators play a crucial role, as they provide valuable information on the performance, efficiency and quality of production processes. The aim of this text is to discuss the most commonly used manufacturing indicators.
3.1.1 Productivity

The productivity indicator in manufacturing is a metric that makes it possible to assess the relationship between the quantity of resources used and the quantity of products generated in a given period. It enables a more precise analysis of performance, making it easier to identify bottlenecks and implement improvements in production processes. The calculation of this metric is Equation (7):

\[
P = \frac{UP}{T} \quad (7)
\]

Where:

- \( P \) = Productivity
- \( UP \) = Units Produced
- \( T \) = Time (hours or days)

3.1.2 Efficiency

The productive efficiency indicator in manufacturing is a metric used to measure an organisation's ability to transform inputs into products, taking into account the minimisation of resources used and the maximisation of production. It reflects the company's ability to optimise production processes and achieve superior results. The calculation of this metric is Equation (8):

\[
EF(\%) = \frac{UP}{PLU} * 100 \quad (8)
\]

Where:

- \( EF \) = Efficiency (%)
- \( UP \) = Units Produced
- \( PLU \) = Planned Units
3.1.3 Takt time

Takt time can be defined as the maximum time available to produce a production unit and, at the same time, meet customer demand. It is often expressed in seconds per unit. To calculate takt time accurately, three essential pieces of information are needed: available production time, customer demand and the number of products required. The formula for calculating Takt time is as follows, according to Equation (9):

\[ TT = \frac{PTA}{SD} \]  

Where:

- \( TT \) = Takt Time
- \( PTA \) = Production Time Available
- \( SD \) = Sales Demand

3.1.4 Production cycle

The production cycle is a fundamental concept when analysing industrial processes and their efficiency. It is a set of chained activities that are repeated over time, enabling the transformation of inputs into a final product. To better understand the production cycle, it is necessary to use mathematical calculations and analysis tools to measure and evaluate its efficiency. One of the main metrics used is cycle time, which represents the time interval between two successive operations within the production cycle. This value is calculated by dividing the total time spent in the cycle by the number of cycles carried out. To support our analyses, it is essential to use up-to-date scientific citations. In addition, it is necessary to emphasise the importance of quality control throughout the different stages of the production cycle in order to guarantee customer satisfaction. The calculation of this metric is Equation (10):

\[ PC = \frac{NPT}{UP} \]  

Where:
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PC = Production Cycle  
NPT = Net Production Time  
UP = Units Produced

3.1.5 Availability

Equipment availability refers to the proportion of time that a piece of equipment is available for use, in relation to the total time. It is an indicator of a production system's ability to meet its operational needs. To calculate availability, it is necessary to take into account scheduled and unscheduled downtime, as well as the necessary repair time. A common way of calculating equipment availability is using the following formula Equation (11):

$$PA(\%) = \frac{TPT- DT}{TPT} * 100$$  
(11)

where:

PA = Production Availability (%)  
TPT = Total Production Time  
DT = Downtime

Operating time refers to the time the equipment is available for operation, while total time is the total observation time. It is important to mention that, in addition to scheduled downtime, we must also take into account unscheduled downtime due to mechanical failures, unexpected maintenance, among other problems. For a better understanding of the concept of equipment availability, let's consider an example. Suppose a factory has a total observation time of 720 hours and the equipment has operated for 650 hours during this period. Using the formula mentioned above, we can calculate availability as shown in Equation (12):

$$PA(\%) = \left( \frac{650}{720} \right) * 100 = 90,28\%$$  
(12)

Where:

PA = Production Availability (%)
This means that the equipment was available for operation 90.28 per cent of the time. Equipment availability is fundamental to guaranteeing the continuity of industrial production and avoiding delays and losses. Through good preventive and predictive maintenance planning, it is possible to minimise failures and maximise equipment availability.

The importance of equipment availability in industrial production can also be seen in a study by Chen and Wang (2020), which investigated the impact of availability on Overall Equipment Efficiency (OEE) in an electronics industry. The results revealed that availability was one of the main determinants of OEE, highlighting the importance of keeping equipment available and in continuous operation to maximise the efficiency of the production process.

3.1.6 Down time

Down time is downtime that occurs during the industrial production process, resulting in an interruption in the production chain. Among the main causes of down time are mechanical failures, which can occur due to normal wear and tear on machines or a lack of proper maintenance; a lack of raw materials or inputs for production; logistical problems, such as delays in the delivery of components; and even a lack of operator qualifications. These causes can be grouped into categories to make it easier to understand their magnitude and plan corrective measures. To measure the impact of downtime on industrial production, it is necessary to carry out mathematical calculations that relate downtime to the industry's production capacity.

3.1.7 Quality

Quality in industrial production is a constant concern for companies seeking to stand out in an increasingly competitive market and can be defined as the conformity of products or services with predetermined requirements, which meet customer expectations and offer safety, durability and efficiency. It is a broad concept that encompasses several dimensions, such as the quality of the design, the quality of the production process and the quality of the end product.

Quality control and assessment in industrial production can be carried out using mathematical calculations and statistical analysis. One of the main indicators used is the Sigma Index (Σ), which measures the ability of the production process to meet the established...
requirements. The higher the Sigma Index value, the closer the process is to achieving perfection.

3.1.8 OEE (overall equipment efficiency)

In today's competitive manufacturing landscape, companies need to optimise their production processes to stay ahead. A key performance indicator used to assess equipment effectiveness is Overall Equipment Effectiveness (OEE). OEE measures the efficiency of equipment utilisation and provides insights into possible areas for improvement. OEE is a metric that evaluates the performance of equipment by assessing its availability, performance and quality indices. It provides a holistic view of how efficiently a company's equipment is being utilised, allowing management to identify and rectify inefficiencies. OEE is derived from three fundamental components, namely Availability (A), Performance (P) and Quality (Q), as expressed by the following formula shown in Equation (13):

\[
OEE = AxPxQ
\]  

\(13\)

Where:

OEE = Overall Equipment Effectiveness  
A = Availability  
P = Performance  
Q = Quality

1. Availability (A): Availability represents the percentage of time that the equipment is available for production compared to the total planned production time. It includes planned and unplanned downtime and can be calculated using the formula in Equation (14):

\[
DA(\%) = \frac{(TPT-DT)}{TPT} \times 100
\]  

\(14\)

Where:

DA= Production Availability (%)
TPT = Total Production Time
DT = Downtime

2. Performance (P): Performance measures how efficiently the equipment performs during its available time. It is calculated by dividing the actual production rate by the maximum production rate under ideal conditions according to Equation (15):

\[ P(\%) = \frac{RPR}{MPR} \times 100 \]  \hspace{1cm} (15)

Where:

- \( P(\%) \) = Performance
- \( RPR \) = Realised Production Rate
- \( MPR \) = Maximum Production Rate

3. Quality (Q): Quality reflects the proportion of products produced that meet predefined quality standards. It is determined by dividing the number of good units produced by the total number of units produced according to Equation (16):

\[ Q(\%) = \frac{GUP}{TUP} \times 100 \]  \hspace{1cm} (16)

Where:

- \( Q(\%) \) = Quality
- \( GUP \) = Good Units Produced
- \( TUP \) = Total Units Produced

3.2 Planning Direct Labour

In the modern era of globalised industry, the efficient planning and proper allocation of human resources have become determining factors for an organisation's success. Specifically, direct labour planning plays a significant role in the production process, as the proper allocation of workers is crucial to ensuring efficiency, quality and meeting production deadlines. Labour planning refers directly to the process of determining the required number
of workers to carry out certain tasks in a given period of time. This process involves analysing several variables, such as expected demand, production capacity, worker skills and resource availability. Workload balance analysis (production line balancing) is a technique that allows work to be distributed evenly among workers, taking into account the amount of work available and the skills of each individual. This analysis is based on mathematical calculations that take into account the productive capacity of each worker and the expected demand for a given period of time. An example of a project that can be used is the project of the time needed to carry out a specific task for a single worker. The basic formula for this project is Equation (17):

$$TT = \frac{TST}{OE}$$  \hspace{1cm} (17)

Where:

- $TT$ = Task Time
- $TST$ = Task Standard Time
- $OE$ = Operator Efficiency

Results and Discussion

4.1 Analysing the Results

Analysing sales demand and production capacity is an essential stage in a company’s management process. It is through this analysis that organisations can determine the appropriate amount of manpower needed to meet market demands. In this context, a master's thesis was carried out to provide the appropriate knowledge of what information and performance indicators are essential for carrying out the calculation to determine the correct number of direct labour needed to meet a sales demand.

The main objective of this research was to analyse the relationship between a company's sales demand and its production capacity in order to determine the need for direct labour. To do this, data was collected on the company's monthly sales, its production capacity, as well as information on the number of employees and their respective roles.
Another important point identified in the research was the need for efficient human resources management. It was found that hiring and properly training employees were crucial factors in guaranteeing a company's productive capacity. In addition, the correct allocation of labour, taking into account employees' individual skills and aptitudes, was also fundamental to guaranteeing efficient production. The research also demonstrated some limitations and suggestions for future research. One of the limitations identified was the lack of historical data on the company's sales demand in order to be able to carry out a more in-depth analysis of demand behaviour during periods of market seasonality that directly influence sales demand, which made it difficult to carry out a more assertive analysis. It is therefore suggested that further research be carried out based on more comprehensive and historical data.

**Figure 1**

*Graph 1 - Demand for hours needed and available per month*

4.2 Case Study: Increasing Production Capacity

The aim of this section is to present the research experience, based on the methodology applied. It demonstrates the methodology for analysing and applying actions to meet sales demand by increasing production.

4.2.1 Analysing the current situation

In November 2022, we began analysing the assembly process in order to identify losses and opportunities for improvement with the aim of meeting the increase in demand, so the
team was challenged to implement an efficiency project. We analysed the BOX 10 speaker assembly line - the model implemented in 2022.

4.2.2 Current process flow

The assembly strategy adopted at first followed the same line as previous models, divided into preparation and assembly cells, as well as functional and visual tests. To better understand the stages of each process, we used the process flow methodology, which illustrates these work stages in a simple and sequential way. Figures 2, 3 and 4 show the initial process flowchart for the new model.

Figure 2

*Process flow stages Joinery and Cell 5*
Analysis of sales demand and production capacity to determine the need for direct labour

Figure 3
Process Flow Cell 4

Assembly of wooden box, Power PCBA and back cover

Figure 4
Process Flow Final Assembly Line

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4.2.3 Analysing production line balancing

We used the chrono-analysis methodology to support the capacity studies, feeding the Production Line Balancing matrix with the times collected (Figure 5). Harman da Amazônia works considering the capacity rate of its processes not as 100% capacity, but as 85% efficiency, because it works with a 15% downtime margin, we can verify a target of 25 pieces per hour with 34 operators, working at an efficiency of 73.15%.

Figure 5
*Graph 2 - Production line balancing matrix Box 10*

Using the GEMBA methodology on the production line, after carrying out capacity analyses, it was identified that:

- Although the line was running without any major interventions, an excess of movement between processes was observed, operators travelling long distances;
- Many units awaiting production, in a waiting state;
- Intervals of time in which the assembly and packaging stations on the line stopped because they were waiting for parts;
- Excess materials in the process;
- Idle operators;
- Daily target not reached.
4.2.4 Analysing the route and walkthrough of the process

To be sure of the location of the problem, the following analysis methodologies were used: Spaghetti Diagram (Figures 6, 7 and 8), Chronoanalysis and monitoring of daily targets. Using the diagram we were able to map the entire process. Using the GEMBA methodology on the production line, after carrying out capacity analyses, it was identified that:

- Although the line was running without any major interventions, an excess of movement between processes was observed, operators travelling long distances;
- Many units awaiting production, in a waiting state;
- Intervals of time in which the assembly and packaging stations on the line stopped because they were waiting for parts;
- Excess materials in the process;
- Idle operators;
- Daily target not reached. By collecting the times of all the operations in the process, we were able to identify the bottlenecks and the stations that were overcapacity - making it possible to see how busy the line was in general. By evaluating the spaghetti diagrams, we were able to identify points for improvement in terms of handling. In the Chronoanalysis, it was enough to look at the "Line balancing matrices" for the line to see that the process is less efficient than the company defines as ideal.

Figure 6

*Spaghetti Diagram Cell 4 and Final Assembly Line 4*
4.3 Targets Set to Meet Sales Demand

The target of 85% efficiency for all processes at the Manaus plant was set in the procedure, and as the line in question was below this standard, all efforts were concentrated on achieving the target. These practices are being adopted for new models. The targets set (Figure 9) in this project were:

- Increase efficiency from 73.15% to at least 85%;
- Reduce handling waste by 50%;
- Achieve planned quantity.
4.4 Actions Defined to Increase Production Volume

4.4.1 Relayout of production lines

In the relayout that was carried out on Final Line 4 (Figure 10) and Preparation Cell 5 (Figure 11), the entire line structure was modified, workstations were brought closer together, allowing One Piece Flow to be carried out and other waste was eliminated, such as:

- Overfeeding of materials:
- Overprocessing:
- Counter-flow of the process:
- Waiting time.
A significant change was the incorporation of Preparation Cell 4 into Final Line 4. Before the relayout on Final Line 4 it was possible to see the presence of unused spaces, but after the chronoanalysis study and the new balancing it was possible to integrate Preparation Cell 4 into Final Line 4.

4.4.2 Change in line structure

Preparation Cell 5 had several types of waste: overproduction, excess raw material, process counterflow and material transport by the operator.

4.4.3 Rebalancing the production lines

After all the layout changes had been implemented, we carried out the process of balancing the workstations, defining and adjusting the activities. We started the new process to validate the training and explain the changes to the operators. Everyone underwent a period of training and development. After all the activities, a new chrono-analysis was carried out (Figure 12).
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4.5 Results Achieved

With the modifications implemented on the line and in the production cell, we achieved a huge improvement in the process flow by reducing handling and working with the "one piece flow" (Figures 13 and 14).

Figure 12

*Graph 4 - New Line Balancing*

![Graph 4 - New Line Balancing](image-url)

Figure 13

*Process Flow Steps Carpentry and Preparation Cell 5*

![Process Flow Steps Carpentry and Preparation Cell 5](image-url)
The turnover stipulated by the corporation was reached in 2022. We can see that in 2023 we have already reached more than 50% of the planned amount.

The targets set at the start of the project were 100 per cent achieved:
- The target of increasing line efficiency by 14% (rate 26p/h with 27 people) was achieved 100%. After implementation, we had a reduction of 07 DLs on the Box 10 production line.
- The goal of reducing handling by 50% was realised. We now have a process with reduced handling in which operators no longer have to move from their station to transfer parts or feed other processes.

**Figure 14**
*Graph 5 - Comparison of operational capacity targets*

Conclusions

Sales demand and production capacity are essential elements to consider when analysing an organisation's need for direct labour. This master's thesis sought to explore the interdependence between these factors in order to help companies make strategic decisions related to human resource management.

A key factor in analysing sales demand and production capacity is efficiency. Productive efficiency refers to the optimal use of available resources to maximise production. An efficient company is able to produce more with fewer resources, which results in greater
profitability. An analysis of sales demand and production capacity must take into account the organisation's efficiency levels, identifying possible bottlenecks and opportunities for improvement.

Direct labour plays a critical role in a company's productive capacity. It refers to the employees directly involved in producing goods or providing services. Determining the need for direct labour must take into account factors such as the production time for each task, the number of employees required at each stage of the process and the availability of the human resources involved. An accurate estimate of the need for direct labour allows the company to adjust its workforce according to demand, avoiding problems such as idleness or work overload.

In conclusion, analysing sales demand and production capacity is an essential practice for determining an organisation's need for direct labour. The ability to estimate and plan for future demand, while ensuring efficient and effective production capacity, is vital for business success. By considering these factors and operational efficiency, companies can make informed and strategic decisions to achieve excellence in human resource management and, consequently, achieve better production and sales results. Thus, the analysis of demand, capacity, efficiency, direct labour and production are crucial aspects for developing efficient human resources management and improving organisational results as demonstrated in detail in the case study.

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