

A Study on the Application of Operations Research in the Apparel Industry

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ABSTRACT

This paper on application of Operations Research in Apparel Industry discusses some of the well-known problems and their respective solution approaches, review current research in the field and highlight emerging areas of future importance. The paper applies concepts of Operations Research inclusive of Transportation Method on some of the companies.

INTRODUCTION

The global apparel market grew from \$551.36 billion in 2021 to \$606.19 billion in 2022 at a compound annual growth rate (CAGR) of 9.9%. Subsector Group Industry Garment Manufacturing Establishments with two different manufacturing processes:

- (1) Cutting and Sewing (i.e. purchasing fabric and cutting and sewing to make garments), and
- (2) First Making knitwear, then cutting and sewing the fabric.

The Apparel Manufacturing subsector includes various facilities that produce a complete line of ready-to-wear and be spoke apparel.

Job seekers are performing entrepreneurial functions in apparel manufacturing. Tailoring, the creation of custom garments for individual customers is one of them. When done on its own, knitting falls under the subsector of textile mills, but when knitting is combined with the manufacture of complete garments, the Activities are categorized under Garment Manufacturing.

OR TECHNIQUES USED:

Program Evaluation and Review Mode (PERT)) Identifies each task associated with the project, the time required to complete each task, and the dependencies between tasks.

Critical Path Analysis, also known as "Critical Path Planning", is a project management system that evaluates the duration of various tasks and determines the shortest route to complete the job.

The transportation problem is a special kind of linear programming problem that computes the cost of transporting a particular commodity from a set of sources or origins (factories, manufacturing facilities, etc.) to a set of destinations (ware houses, etc.). Goal, business) to a minimum. Each source has a finite supply (that is, the maximum number of products that can be shipped from it), but each destination has a demand that must be met (that is, the minimum number of products that must be shipped). Shipping costs from origin to destination are directly proportional to the number of units shipped. The transport problem is a special kind of linear programming problem used for optimal resource allocation. This is a very useful tool for cost optimization managers and supply chain engineers.

IMPORTANCE:

OR helps one plan the factory's MPS. This minimizes costs when production orders are completed before or after the customer's desired delivery date, and also minimizes the time to complete pre-sewing work in the cutting department in between. The sewing department can meet several production volumes specified by the cutting department.

The main advantages are:

- Defects and Waste–Defects and unnecessary physical waste, including over use of raw materials, avoidable defects, costs associated with remanufacturing defective products, and unnecessary product features that customers do not require. Reduced
- Cycle Time–Reduce Manufacturing Leads Save time and production cycle time by reducing waiting times between processing stages, reducing process lead times and product/model conversion times.
- Inventory Levels–Minimize inventory levels at all stages of production, especially during
- Ongoing work between production stages.

LITERATURE REVIEW

The Following Literature Reviews Discuss The Application Of Operations Research In The "Manufacturing Apparel Industry."

Pert/Cpm Operational Research Application in the Apparel Industry

Some of the most common problems in garment manufacturing are:

How to estimate the duration of activities, calculate order lead times, and identify zero-tolerance activities that require special attention to avoid delays in final delivery. How to identify and rationalize employee furlough penalties to minimize performance impact or prioritize purchases of items for bottleneck activities.

PERT incorporated uncertainty into task duration estimates by allowing projects to be planned without knowing the exact details and duration of all activities. In contrast, CPM was able to incorporate uncertainty into activity time estimates. They were used as if a single estimate was known or certain.

A PERT diagram shows the events, activities, duration, and dependencies to complete a project. The estimated time it takes to move from one event to another is optimistic (minimum time required to complete an activity) and pessimistic (maximum time needed to perform the same action). It is calculated as the weighted average of the most likely time required to complete the activity 6). Lead time, in contrast, is the amount of time that a preceding event must meet in order to allow sufficient time for the activities that must pass before a particular PERT event completes.

Like any other project management, apparel manufacturing is a network of activities that run sequentially and in parallel. Garment pre-production consists of many activities, but we will consider only a few garment manufacturing activities for simplicity.

(Jana, PERT/CPM Operation Research Application in Apparel Industry, 2011)

The Following Three Methods Are Used To Solve The Problems Of The Fashion Industry:

Simulation methods: where the goal is to develop simulators that provide the decision-maker with the ability to conduct sensitivity studies to search for improvements and test and benchmark the improvement ideas being made. Revenue management entails accurately forecasting the demand and adjusting the price structure over time to allocate fixed capacity more profitably.

The power of utilizing OR methods allow for comprehensively examining this rather complex and convoluted chain and searching among a vast number of combinations for the resource optimization and allocation strategy that seem most effective and beneficial to the operation. In the pattern department, the problem of pattern planning involves finding a viable pattern with the minimum number of plies. His proposed two-stage planning model solves the hybrid flow shop problem in pre-sewing operations and the master production planning problem in garment manufacturing.

OR helps you plan your factory's MPS. This minimizes costs when production orders are completed before or after the customer's desired delivery date and also minimizes the time to complete pre-sewing work in the cutting department. The sewing department can meet several production volumes specified by the cutting department.

The main benefits are Defects and wastage -Reduce defects and unnecessary physical wastage, including excessive use of raw material, preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers' Cycle Times -Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times Inventory levels -Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. (Prabir Jana, 2011).

Operations Management in Apparel Retailing: Processes, Frameworks, and Optimization:

This article summarizes the many research opportunities in this area. For example, there is plenty of room for further work on analytical models of retail processes. Indeed, changing practices requires integrating new approaches into existing models. For example, how to manage dynamic assortments and product launches, how to manage store space, how to manage seasonal purchases and designs, and more. These problems require complex dynamic optimization techniques.

This model is suitable when the production lead time is very long and when the season starts, it is impossible to increase the production volume to get to the stores by the end of the season. Another simplification is to assume that consumers do not exchange based on what items they have in stock but rather on whether they were in their original selection S (the latter is called an assortment-based exchange), the former corresponds to a). Shortage). base replacement). With this arrangement, finding the best assortment, S can be formulated as the optimization problem-

$$\max (r - c)q_j - C(q_j)$$

(Caro, 2013)

Operations Strategy Processes and Performance: Insights from the Contract Apparel Manufacturing Industry:

This paper examines the importance and dynamics of various operational strategy processes in understanding the relationship between strategy processes, context, and performance. The findings are supported by a statistical analysis of empirical data drawn from the rapidly developing national garment industry. The results are expected to contribute to farm management theory as they provide statistical evidence to support the findings of recent qualitative studies. The results also confirm the existence of operational strategy processes in developing countries that correspond to conceptual understandings developed in the context of developed countries.

(Jagoda, 2014)

Zara Uses Operations Research To Rethink Global Distribution Processes

As far as I know, this piece represents her O.R.'s primary reported application. To fast fashion retail operations acquired by companies such as Zara, H&M and Mango. The forecasting model generates weekly demand forecasts for each product size in each store in the Zara network and is inherently based on a multivariate quality methodology. The intuitive appeal of this interpretation has aided internal communication related to predictive models. However, this final functional form has been determined by extensive empirical testing of many possible predictive equations. From a mathematical point of view, this model analyzes a probabilistic model that considers the sales opportunities for different font sizes as independent Poisson processes.

In conclusion, he concludes that this paper is a successful and practical application of his O.R. Technology in the field of fashion retail that is highly visible to the general public and currently needs to be recognized as a legal application field in this field. Therefore, we hope our work will increase the popularity of O.R. To prolong and improve awareness of its applicability. (Felipe Caro (UCLA Anderson School of Management), Jérémie Gallien (MIT Sloan School of Management), Javier García Torralbo, Jose Manuel Corredoira Corras, Marcos Montes Vazquez (Inditex S.A), José Antonio Ramos Calamonte (Carrefour S.A), Juan Correa (Dell Inc.), 2009, (Zara, 2009)

A Comparative Review of Zero-Waste Fashion Design Thinking and Operational Research On Cutting And Packing Optimization:

This white paper compares the textile industry's cutting and packaging (C&P) research and the Zero Waste Fashion Design (ZWFD) field. Both research areas aim to minimize waste and approach the problem from different perspectives. The C&P study examines mathematical and computational techniques for reducing material waste in marker planning problems. At the same time, ZWFD offers creative cutting-pattern solutions to the same problem. A systematic literature search was performed based on content and literature analysis of 22 articles published in peer-reviewed journals from 2010 to 2021. This paper presents the research directions of both C&P and ZWFD as an opportunity to stimulate further research in the future, turning the fashion design process into a C&P optimization algorithm design process.

With the advent of fast fashion and increasing fashion consumption, the business model of the fashion industry has shifted to cost-cutting methods and techniques, ignoring important factors such as the environmental costs of the fashion industry (Niinimäki & Hassi, 2011). . Fashion designers are beginning to question the linearity of their systems, seeking to eliminate waste by eliminating fabric waste during the cutting stage of apparel manufacturing. This paper outlines two of his research paradigms for eradicating fabric waste during the garment-cutting stage. The

first is Operational Research (OR) Cutting and Packing (C&P), which develops computational methods for cutting problems. C&P's research has contributed to the design of automated markers for software providers such as Lectra, using various optimization algorithms and artificial intelligence to minimize fabric waste during the cutting stage. Another research paradigm is Zero Waste Fashion Design (ZWFD). It challenges traditional fashion design principles and reduces fabric waste to 0%. However, most advanced methods achieve minimal rather than zero waste due to various variables influencing the design decision-making process. Automated markers still need to utilize 100% of the fabric and are not designed for zero-waste design practices, making them available to zero-waste designers as part of the design process. Software becomes challenging to use, and speed and efficiency are sacrificed. The industry needs to consolidate. It is estimated that the waste material generated at the fabric-cutting stage accounts for approximately 15% of all materials used in manufacturing. It has been. Despite some waste management efforts.

To our knowledge, the literature must link the C&P and ZWFD research areas aimed at eliminating fabric waste. The relationship between the two regions offers an opportunity to explore how zero-waste fashion design principles can be incorporated into automated markers, with potential for industrial applications. This review aims to synthesize knowledge from zero-waste fashion design and C&P research. This integration will enable future research for his C&P to improve marker automation and provide a flexible system for traditional fashion design and ZWFD thinking.
(ElShishtawy, 2021)

Dye Schedule Optimization: A Case Study in a Textile Industry:

Production management plays a fundamental role in a company's reference in a demanding globalized market. By properly managing the production floor, companies can achieve productivity gains, reduce operating costs, and contribute to the competitiveness of their competitors. When you define your strategic goals in your production system, you need to develop a plan for managing your people and strategy based on your requirements. In this context, planning, production, and management are the best allies of an organization. By properly deploying PPC activities, companies can minimize backlogged production orders, reduce the inventory of raw materials and finished goods, and minimize the idle time of human resources through efficient work distribution. You can save time and reduce production lead time. In this study, we propose to organize and develop a model to predict equipment gains in fabric dyeing processes structured by the traveling salesman problem.

Globalization crosses national borders, and free trade between nations is intensifying. Some sectors of the economy benefited from trade barriers that restricted import and export quotas and felt threatened by foreigners. The threat of new entrants means competing for market share, lower profit margins, and improved performance, quality, cost, productivity, and operational efficiency. These factors are, therefore, essential for companies to be consistently used as the new competitive edge. An organization depends on financial and economic results and coordinated and integrated operational management. Resource management is therefore aimed at reducing costs without compromising customer profits. These resources must be managed efficiently to minimize waste and costs and maximize profits.

In this context, the planning area plays a fundamental role in corporate strategy, coordinating the flow of information to direct the available resources to serve the end customer at the lowest cost. Companies are increasingly using tools to support decision-making to use resources efficiently. The Apparel sector is no exception, suffering from a loss of market share for imported products and low operational efficiency. The planning process is highly complex in this sector due to the extensive product portfolio required to keep up with the dynamics of the fashion market.

(Dye Schedule Optimization: A Case Study in a Textile Industry, 2021)

Role of Om in Fashion Industry

In retail, especially fashion, O.M. involves examining, understanding, and potentially perfecting the process of every part of the chain, from distribution center to store, including transportation and other distribution conditions. Administrative management refers to the management of business practices to achieve the highest possible and most influential position within the association. It is about transforming your property and labor into goods and services as efficiently as possible to maximize your club's profits.

The management of the fashion industry is carried out as follows.

- I. Product design
- II. Quality management
- III. Process and capacity design

- IV. Supply Chain Management
- V. Inventory management
- VI. Planned
- vii Design decision

Operations management helps address issues related to low turnover and turnover, excess inventory, and high manufacturing costs in the fashion industry to improve productivity and competitiveness. Operations management provides supply chain integration, suitable demand forecasting methods, S&OP methods, and strategies to drive lean. It must be taken into account that the clothing sector has seasonal demands that require constant renewal of inventory to meet demand and avoid unsold inventory, which is a massive loss for the business value to the product. Given the circumstances, to regain consumer and retailer confidence, apply operationally and supply management strategies to integrate, optimize and manage the forecasting process from raw material suppliers to end users is essential. (Kiron, 2022)

Problem

How to predict the length of any operation is a current issue in the textile manufacturing industry. How to calculate the lead time for an order; How to spot tasks that bear zero forbearance and redundant care to help holdbacks in final delivery; How to determine and justify hand leave warrants to ensure minimum performance impact, or indeed how to priorities the accession of products for tailback Operations.

Solution

Operation research tools like the Program Evaluation and Review fashion (PERT) and Critical Path system (CPM) are made to offer rational answers to the questions raised above. Cut corridor force is the first operation and is recorded as nil for initiating sewing operations. Once the table is finished, a PERT map can be created to show how several stitching conditioning begin coincidently and ultimately meet on assembly. Critical route aids in estimating the quantum of time a garment will actually take to complete. Because every nanosecond that any crucial path action is delayed will affect in a corresponding detention in the affair of the garment, the sewing processes are crucial and cannot afford any detainments. During a change in style, operations that are on the critical route should be loaded with cut corridor in the order of precedence. Accessories for operations on the critical path should be provided first. To help any implicit holdbacks, accessories for operations on the critical path should be supplied first.

Following steps to apply PERT:

- Divide the design into lower conditioning
- Sequence and identify dependences between conditioning
- Estimate a timescale for each exertion
- Draw a PERT map and indicate critical path
- Slack time computation

HYPOTHETICAL EXAMPLE

A cotton manufacturer must supply different types of cotton to 3 other clothing manufacturers. He needs to do this by minimizing the cost of supply. In this table cost of collection for three different types of cotton is given and Total Supply and Demand. We need to find the minimum price of supply for the same.

	3 Different manufacturer			
Type Of Cotton	Pearl	Red Chill	K&A	TOTAL SUPPLY
Raw Denim	300	400	350	2000
Sateen	250	200	300	1500
Velvet	350	250	300	2500
TOTAL Demand	2000	2000	2000	6000

DEMAND AND SUPPLY ARE IN TONNES

SOLUTION (Question was Solved Using Slover in MS Excel)

3 Different manufacturer				
Type Of Cotton	Pearl	Red Chill	K&A	TOTAL SUPPLY
Raw Denim	300	400	350	2000
Sateen	250	200	300	1500
Velvet	350	250	300	2500
TOTAL Demand	2000	2000	2000	6000
DEMAND AND SUPPLY ARE IN TONNES				

3 Different manufacturer					
Type Of Cotton	Pearl	Red Chill	K&A	FACTORY SUPPLY	TOTAL SUPPLY
Raw Denim	2000	0	0	2000	2000
Sateen	0	1500	0	1500	1500
Velvet	0	500	2000	2500	2500
MANUFACTURER DEMAND	2000	2000	2000		
TOTAL Demand	2000	2000	2000		
TOTAL TRANSPORTATION COST	16,25,000				

Minimum Cost To Supply Three Different Types Of Cotton To Three Different Manufacturer Is Rs. 16,25,000.

LIMITATION

Operations Research (OR) is very expensive. This is because operations research uses mathematical models to make decisions and tackle various problems. Individuals or organizations must create numerous models to address new issues. All of this drives prices up.

Dependence on the computer: The OR method looks for the best answer considering all variables.

Modern society has many facets, and quantifying them and relating them requires many computations that only computers can handle. This capability demoralizes small businesses requiring the most critical operations research approach.

Time investment: Finding the ideal surgical solution and using it in a particular area takes a lot of time. Therefore, a temporary solution to a problem may be preferable to a bug-free solution.

Impractical: Operations research professionals create highly complex models to solve problems. These simulations may not be accurate. These models may work under assumptions that are not applicable in practice. As such, these models may not apply to real-world scenarios.

Complexity: The OR concept is very complex. Carrying out judgments resulting from such a complicated process, taking into account all the nuances of human relationships and behavior is a complex and delicate task. When there are many problems to solve, it is difficult to account for all the fundamental elements of a mathematical problem, and it is difficult to formulate solutions.

Unquantifiable Factors: The OR method only provides a solution if all problem components can be measured.

RECOMMENDATION

While PERT was able to incorporate uncertainty in estimating task duration by making it possible to schedule a project while not knowing precisely the details and durations of all the activities, in CPM a single estimate for activity time was used as if they were known or certain. While PERT is intended for very large-scale, one-time, complex, non-routine projects with probabilistic time estimates, CPM is suitable for optimizing project lead time

for regular repetitive projects with deterministic (certain) time estimates. However, over the time PERT and CPM have been merged into a single technique conventionally referred to as PERT/CPM.

CONCLUSION

The transportation problem is a special type of linear programming problem where the objective is to minimize the cost of distributing a product from a number of sources or origins to a number of destinations. To provide increased overtaking opportunities along the route to address safety and reliability issues. To accommodate increased demand through improved transport infrastructure for all modes.

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