Application of Design Thinking (Double Diamond Framework) and Optimization Methods for Optimizing the Supply Chain of Multinational Cigarette Companies Using Value Stream Mapping Tools

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Received: 2025-05-16 Received in revised from 2025-09-14 Accepted: 2025-09-30

Abstract

This research examines the supply chain optimization strategy of a UK-based multinational cigarette company with manufacturing plants in Indonesia, with a primary focus on improving operational efficiency and sustainability through the application of a Design Thinking approach using the Double Diamond framework, optimization methods, and Value Stream Mapping (VSM) tools. The project is aimed at addressing a number of complex challenges in the supply chain, including high material costs, manufacturing inefficiencies, SKU complexity, and distribution and logistics inefficiencies. With the selection of a strategic end-country market that contributes more than 25% of the company's total volume (worth GBP 5 million in working capital), a thorough mapping of the current process and waste identification was carried out using a lean approach. The Discover and Define stages were used to explore the root causes through fishbone analysis and VSM, while the Develop stage designed solutions based on optimization methods such as Greedy Algorithm for material procurement, Simulated Annealing for production scheduling, and Mixed Integer Linear Programming (MILP) for logistics and transportation. The implementation of the Deliver phase solution resulted in production cost savings of more than GBP 2 million, cash flow release of GBP 15 million, improved customer service, and carbon emission reduction of up to 10%. The study confirms that the integration of Design Thinking approach, optimization methods, and Lean-Circular principles can improve operational efficiency and meet sustainability targets in a measurable and applicable manner.

Keywords: *Design Thinking (Double Diamond Framework) and Optimization Methods; Multinational Cigarette Companies; Supply Chain; Value Stream Mapping*

1. Introduction

In the face of global competition and sustainability demands, multinational companies in the manufacturing sector, including the tobacco industry, are required to continuously innovate in managing their supply chains efficiently and adaptively. Supply chain effectiveness becomes a key element that not only impacts the company's cost structure but also its capacity to meet market demand in a timely and consistent manner. This study focuses on a multinational tobacco company with a production network in Indonesia that serves the global market with a highly diverse product portfolio. The main challenges faced include demand fluctuations, SKU management complexity, dependence on imported raw materials, and sustainability targets related to emission reduction and energy efficiency.

To address these challenges, a Design Thinking approach using the Double Diamond framework is applied to promote innovative and structured thinking through four main phases: Discover, Define, Develop, and Deliver [1]. Value Stream Mapping [2] is used as the primary tool to map current processes, identify waste, and design a leaner and more responsive future state. Further optimization strategies are supported by algorithmic methods such as the Greedy Algorithm for local vendor selection [3], Simulated Annealing for production scheduling [4], and Mixed Integer Linear Programming for logistics planning [5]. The analysis focuses on key SKUs classified into base and agile categories based on demand patterns[6], and evaluates their contribution to working capital and operational efficiency.

The implementation of these solutions not only results in significant financial impact but also supports the achievement of ESG targets, including carbon emission reduction, reuse of C48 packaging, and the reduction of single-use materials in packaging. This study contributes to the development of an integrative approach to supply chain optimization, combining design thinking, quantitative methods, and sustainability values into one practical and measurable operational innovation framework.

The multinational tobacco company, headquartered in the United Kingdom and operating a manufacturing facility in Indonesia, runs on a multi-category scale. This facility not only produces for the local market but also serves as a global export hub. As an internationally operating company, efficiency and sustainability are top priorities to remain competitive in this highly dynamic industry.

In response to the major challenges mentioned above, this research adopts a Design Thinking approach using the Double Diamond Framework combined with optimization methods. In practice, the Value Stream Mapping (VSM) tool is used to map value flows across the company's business processes. The stages of the Double Diamond Framework—Discover, Define, Develop, and Deliver—are followed. In the Develop stage, the research elaborates on how optimization methods play a role in identifying effective solutions and how those solutions can be optimized to achieve better outcomes.

The Double Diamond Framework was chosen because, according to the Design Council (The Double Diamond – Design Council), this approach is particularly suitable for solving complex and layered problems, such as those commonly encountered in supply chain improvement efforts. It enables a deeper understanding of the problems in the Discover and Define stages, and fosters the development and implementation of solutions iteratively in the Develop and Deliver stages. Integration with Value Stream Mapping allows the company to identify and eliminate waste, and enhance value flow at each stage of the supply chain, contributing to increased efficiency and sustainability.

2. Method

The methodology in this study is designed to provide measurable and practical solutions to complex problems in the supply chain of a multinational tobacco company. The primary approach used is Design Thinking, structured around the Double Diamond Framework, which consists of four iterative phases: Discover, Define, Develop, and Deliver. This framework was chosen for its ability to accommodate the dynamics and complexity of operational problems and to enable a structured exploration of ideas—from problem identification to solution implementation [1]. To identify and eliminate waste in process flows, Value Stream Mapping (VSM), as introduced by Rother and Shook [2], is applied. VSM is highly effective in detecting non-value-added activities within production and distribution systems.

The process begins with the Discover phase, which involves value chain mapping and data collection from various internal stakeholders, including manufacturing, supply chain, planning, distribution, and local distributors. Country A was selected as the primary focus due to its significant contribution to global volume (over 25%) and high SKU complexity, with more than 100 active product variants. Data were collected through direct observation, internal documentation, and in-depth interviews, using an SKU segmentation approach that categorizes products into two main groups: Base SKUs, with stable demand patterns and high production volumes, and Agile SKUs, which are characterized by high demand fluctuations and require flexibility in production and distribution processes[6].

Once data were collected, an initial analysis was conducted to identify potential waste and its root causes using Fishbone Diagrams and activity classification based on Value-Added Activities (VAA) and Non-Value-Added Activities (NVAA)[7]. The analysis revealed six major types of waste: manufacturing process inefficiencies, SKU complexity, labor inefficiency, demand fluctuations, ESG-related challenges, and cost-saving opportunities (savings contributors).

In the Define phase, a Pareto analysis was conducted to prioritize the issues that contributed most to waste and increased working capital. Four key focus areas were identified: material costs, production waste, SKU complexity, and logistics/supply chain issues. This analysis produced several key baselines: total company working capital amounted to GBP 12.4 million, Processing Lead Time (PLT) was 228 days, and Value Creation Time (VCT) was only 1 day, highlighting a significant inefficiency across the value stream.

In the Develop phase, solutions were developed using algorithmic optimization and mathematical modeling approaches. For material procurement, a Greedy Algorithm was used to minimize purchasing costs from various vendors by considering capacity, unit costs, and delivery distances (Kirkpatrick & Dahlquist, 2010)[3]. This strategy was chosen for its efficiency in solving problems with capacity and time constraints. For production scheduling, the Simulated Annealing (SA) method was applied—an effective metaheuristic algorithm for finding near-optimal solutions in complex and dynamic production environments [4][8]. SA was used to optimize production sequencing, machine selection, and changeover times, while considering SKU specifications, cleaning times, airing, and addback requirements.

To address logistics and delivery planning issues, Mixed Integer Linear Programming (MILP) was applied—widely used for strategic decision-making in multi-variable supply chain systems (Hillier & Lieberman, 2021)[5]. The MILP model in this study was designed to optimize transportation costs, truck capacity utilization, overtime, and stock management. Decision variables included the number of deliveries, overtime hours, inventory levels, and the minimum volume shipped via third-party logistics (3PL).

Finally, sustainability aspects were also addressed within the Develop and Deliver phases. The proposed solutions included carbon emission reduction through optimized shipment capacity, use of environmentally friendly packaging such as C48 box reuse, and more efficient production processes that do not increase waste. This approach aligns with Circular Economy principles and ISO 14001 environmental management standards [12][13]. The sustainability strategy is reinforced by a commitment to the global ESG targets outlined by the United Nations Global Compact [9].

Overall, this methodology combines an empathetic and iterative design thinking approach, lean manufacturing analysis, and algorithm- and model-based optimization to produce solutions that are not only operationally efficient but also environmentally and socially responsible.

3. Results and Discussion

3.1. DISCOVER: Problem Identification and Initial Analysis

In the Discover phase, the primary focus is to gain a deep understanding of the problem by collecting information and data from all elements involved in the supply chain. This stage aims to identify key focus areas and potential sources of waste that could impact operational efficiency.

The initial research approach centers on gaining in-depth insights into the supply chain through value mapping and waste identification. Value Stream Mapping (VSM) is employed to uncover non-value-added processes (Rother & Shook, 2003)[2], aligning with the principles of Lean Management, which emphasize the elimination of waste in business processes (Chiarini, 2014)[7].

Country A was selected due to its significant contribution to the company's global working capital. The emphasis on SKU segmentation is based on the importance of understanding demand patterns as a foundation for efficient supply chain planning (Slack, Brandon-Jones, & Johnston, 2020)[6].

1. Scope (End Market Selection)
   Country A was chosen as the focus market due to its contribution of over 25% of the company's total volume, equivalent to GBP 5 million in working capital, and its management of over 100 SKUs, indicating high demand complexity. The SKUs were segmented to distinguish products by their demand behavior and market characteristics:
   - Base SKUs: Products with stable demand and high, consistent production volumes.

- Agile SKUs: Products with fluctuating demand requiring high flexibility in both production and distribution.

2. Data Collection
   Data were collected from multiple sources to support the initial analysis. Based on the selected country, SKUs with significant contributions were identified for each segmentation, and data were gathered from relevant stakeholders:
   - Manufacturing: Information on production capacity, setup time, downtime, and waste, involving departments such as PMD, DIET, C&F, and SMD.
   - Supply Chain: Material management, lead time, and distribution, involving roles such as Scheduler, Warehouse, and Transport.
   - Planner: Alignment of production planning with demand, involving the Supply Network team, including Purchasing Planners and Master Planners.
   - Trade: Market demand trends and product positioning, with a focus on delivery needs to distributors.
   - Distributor: Stock management and distribution challenges, including goods receipt and purchase order processing for delivery to depots or areas within Country A.

3. Preliminary Losses Identification
   At this stage, several types of waste were identified:
   - Manufacturing Waste: Material and time waste within each department of the production process, leading to increased production costs.
   - SKU Complexity: Management difficulties due to high product variation, requiring SKU segmentation strategies for simplification.
   - Manpower Efficiency: Imbalances between machine capacity and human resources, resulting in support needs without increasing headcount.
   - Demand Complexity: Demand fluctuations impacting production and distribution, requiring strategies that support flexibility across departments.
   - ESG Challenges: Sustainability-related issues, including waste reduction, carbon emissions, and other environmental initiatives.
   - Savings Contributors: Identification of productivity initiatives that could contribute to cost-saving opportunities.

4. Initial Analysis and Analytical Tools
   To further investigate the root causes of waste, two main analytical tools were used:
   - Fishbone Diagram (Ishikawa Diagram): Used to identify root causes of losses. This tool was applied within each department to analyze the causes of the preliminary losses.
   - Work Process Improvement (WPI): Involves analyzing Value-Added Activities (VAA) and Non-Value-Added Activities (NVAA) to identify unnecessary tasks and optimize the process:
     - Value-Added Activities: Tasks that directly increase the product's value.
     - Non-Value-Added Activities: Tasks that do not add value, such as inefficient setup times or distribution-related waste.

5. Stakeholders and Project Team
   A small project team was established to support the implementation of analysis and identified solutions:
   - Project Leader: Responsible for the Daily Monitoring System (VSM DMS).
   - Team Members: Representatives from the manufacturing, supply chain, planning, trade, and distributor departments. This team is responsible for implementing the solutions and engaging all stakeholders to ensure optimal outcomes.

3.2. DEFINE: Developing Solutions Based on Problem Identification

In the DEFINE phase, the main focus is to consolidate the information gathered during the DISCOVER phase in order to deepen the understanding of the root causes of the identified problems and formulate effective solutions.

Root causes of inefficiencies were analyzed using fishbone diagrams and value-added activity mapping. Within the Lean approach, such mapping helps differentiate between value-adding and non-value-adding activities [7][2].

Furthermore, Pareto analysis was applied to determine the key problems contributing most significantly to waste. This aligns with classical operations management methods for setting improvement priorities [5].

1. Improvement Objectives
   The primary objective of the DEFINE phase is to reduce production costs and increase process efficiency without compromising product quality. The focus is on optimizing the supply chain by addressing sustainability aspects and reducing waste across all production lines.
2. Key Problems Identified
   Based on the analysis conducted in the DISCOVER phase, four major problems were identified:
   - Material Cost: Extended storage times in warehouses and fluctuating demand contribute to increased material costs. Additionally, dependency on imported materials results in higher spending and excessive stock volumes.
   - Manufacturing Waste: Inefficiencies in the production process—such as long setup times, material wastage, and frequent brand changeovers—increase overall production waste.
   - SKU Complexity: A high number of SKUs leads to demand uncertainty and complicates the allocation of machines and labor, making it difficult to plan efficient production schedules.
   - Supply Chain Issues: Inefficiencies such as delayed deliveries and unplanned overtime contribute to fulfillment inaccuracies and inventory mismanagement.
3. Pareto Diagram Analysis
   A Pareto Diagram was used to further analyze the impact of each issue on overall waste. The analysis revealed that the four main problems significantly contribute to waste and lead to an increase in the company's working capital requirements. Although Environmental, Social, and Governance (ESG) challenges did not appear prominently in the Pareto analysis, they remain a critical component of the company's sustainability strategy.
4. Data and Previous Results
   Using Value Stream Mapping (VSM), the following key figures were identified that represent the current operational conditions:
   - Total Working Capital: GBP 12.4 million
   - Processing Lead Time (PLT): 228 days
   - Value Creation Time (VCT): 1 day

   The current state map highlights several areas where waste and time inefficiencies dominate the supply chain.
5. Stakeholders and Project Team
   The stakeholders involved in this process were previously identified during the DISCOVER phase. The project team responsible for formulating solutions includes representatives from various departments: manufacturing, supply chain, planning, trade, and distribution.
6. Prioritization and Solutions
   Based on the analysis, the priority of the DEFINE phase is to identify and design solutions that reduce waste, optimize resource utilization, and enhance flexibility in production and distribution. To achieve these goals, the focus will be on:
   - Reducing material costs
   - Minimizing manufacturing waste
   - Simplifying SKU complexity
   - Enhancing supply chain efficiency

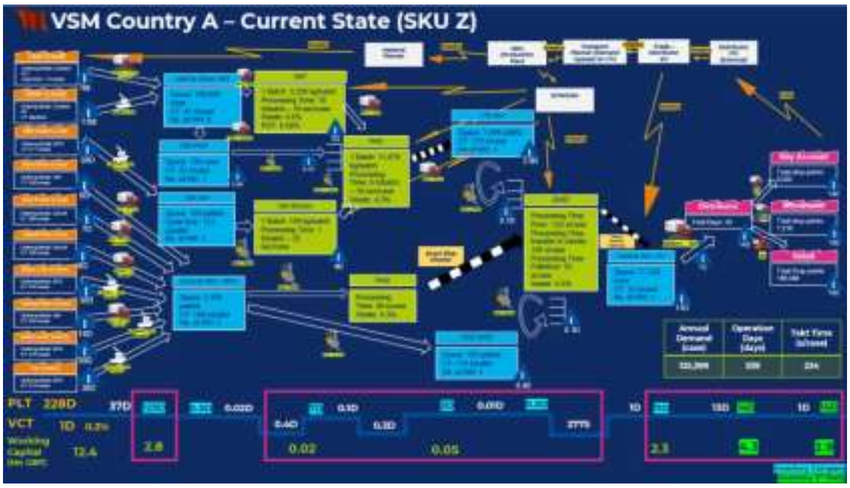

Figure 1. VSM Country A – Current State (SKU Z)

3.3. DEVELOP: Designing and Testing Solutions for Optimal Results

In the DEVELOP phase, the primary focus is on designing solutions that address the previously identified problems and testing these solutions to ensure optimal outcomes. The strategies developed should enhance efficiency, reduce waste, and deliver sustainable results.

1. Material Cost

   Extended storage periods in warehouses, demand fluctuations, and dependency on imported materials have significantly increased material costs and tied up higher working capital at the factory level.

   To address the high material costs caused by import dependency, an algorithmic approach is adopted using the Greedy Algorithm for vendor selection. This strategy is widely used in logistics decision optimization due to its efficiency and ease of implementation under capacity constraints [3].

   Proposed Solutions:

   - Supplier Localization: Reducing dependency on imports by localizing certain material suppliers—especially for packaging—can lower procurement costs and shorten delivery times.
   - Procurement Model Enhancement: Transitioning from fixed procurement contracts (contract POs) to a more flexible call-off system enables factories to order materials based on actual demand, thereby reducing unused inventory and storage costs.
   - Just-in-Time (JIT): Implementing JIT for selected materials ensures timely delivery, minimizes excess stock, and reduces waste.

   The optimization method using the Greedy Algorithm aims to minimize the total material procurement cost by comparing local and foreign vendors without compromising material quality.

   Problem Definition:

   - Minimize material costs by selecting vendors to meet material demand.
   - Each vendor *i* has a unit cost *ci*, capacity *Ki*, and distance *di*.
   - Total material demand is *D* units.

   Step 1: Sort Vendors

   Sort vendors by unit cost *ci* (ascending), and by distance *di* (ascending) in the case of ties.

   Step 2: Greedy Vendor Selection

   Select vendor *i* with the lowest cost to fulfill the material demand *D*.

   Objective Function:

$$\text{Total Biaya} = \sum_{i=1}^{n} (x_i \cdot c_i)$$

   Minimize total material procurement cost:

   where *xi* is the quantity ordered from vendor *i*, and *ci* is the unit cost.

   Constraints:

$$\sum_{i=1}^{n} x_i = D$$

- Demand Fulfillment: The total material ordered must meet the request D:
- Vendor Capacity: The amount of material ordered from each vendor must not exceed their capacity:

$$0 \leq x_i \leq K_i$$

Greedy Process:
- Sort vendors based on cost and proximity.
- Order material from the vendor with the lowest cost (up to demand or capacity limits).

Conclusion:
The Greedy Algorithm selects vendors in order of increasing cost and capacity to satisfy the total material demand *D*, ensuring efficient procurement with minimal cost.

2. Manufacturing Waste & SKU Complexity
   Inefficiencies in production, such as long setup times, material waste, and high SKU variation, exacerbate production waste and hinder efficient production planning.
   Efficient production scheduling is essential to reducing waste. Therefore, Simulated Annealing is employed—an effective method for approximating optimal solutions to complex scheduling problems, particularly in manufacturing environments with multiple SKUs and machines (Wang & Wang, 2021)[4].
   This approach aligns with Pinedo's [8] assertion that metaheuristic algorithms are highly beneficial when scheduling complexity increases due to product variation and resource constraints.
   Proposed Solutions:
   - SKU Segmentation: Segment SKUs based on product type and demand profile:
     - Base SKUs: These have stable and predictable production volumes. Production is locked into fixed daily volumes and schedules. Lower-skilled manpower is sufficient, and brand changeovers are minimized due to predictable processes.
     - Agile SKUs: These experience fluctuating demand. They require more flexible labor and machines capable of rapid changeovers to avoid time waste.
   - Optimization of Production Scheduling using Simulated Annealing (SA)
     The Simulated Annealing (SA) optimization technique is applied to design a more efficient production schedule, aiming to reduce waste and optimize processing time.
     1) Objective
        Reduce waste-related costs and optimize production time by considering:
        - SKU Specifications: Filter type, cigarette type, menthol type, outer level type.
        - Machines: Three machines with varying technologies.
        - Changeover Time: Transition time between brands.
        - Additional Time: Cleaning, airing, and addback durations.
     2) Objective Function
        Minimize total cost:
        $Z = \text{Total Waste Cost} + \text{Total Production Time Cost}$
        - Waste Cost: Material and time waste due to frequent changeovers.
        - Production Time Cost: Total production time, including cleaning, airing, and addback.
     3) Implementation Steps
        1. Initial Solution:
           Start with a randomly generated production schedule including SKU order, machine assignment, and production start time.
        2. Move Operation:
           Apply small modifications such as swapping SKU order, assigning a different machine to a SKU, or adjusting start times.
        3. Solution Evaluation:
           Calculate the total cost of the new solution based on the objective function.

4. SA Iteration:
   Acceptance Criteria:
   - If the new solution reduces cost (ΔZ < 0), accept it.
   - If the cost increases (ΔZ > 0), accept it with a probability:
   - P=e−ΔZ/TP = e^{-\Delta Z/T}P=e−ΔZ/T
   - where *T* is the temperature, which gradually decreases.
5. Cooling Schedule:
   The algorithm begins at a high temperature and gradually cools, allowing broader exploration initially and focusing more narrowly as convergence nears.
6. Search Loop:
   Repeat steps 2 to 5 for a set number of iterations or until a minimum temperature is reached.
7. Final Outcome:
   Upon completion, the best solution found is adopted as the optimal production schedule, minimizing waste and production time.

4) SA Application in Production Scheduling
   - Input Variables: SKU list, machine capabilities, brand changeover times, production times per SKU per machine, and additional times (cleaning, airing, addback).
   - Objective: Optimize SKU production sequence and assign the most suitable machine to each SKU to minimize time and material waste while maximizing production efficiency.

5) Advantages of SA Implementation
   - Enables more flexible scheduling by incorporating multiple production constraints and variables.
   - Provides near-optimal solutions even in large and complex search spaces involving diverse machines and SKUs.

3. Supply Chain Issues
   Inefficiencies in the supply chain—such as delivery delays and unplanned overtime—result in inaccurate demand fulfillment and poor inventory management.
   These supply and logistics issues are addressed using Mixed Integer Linear Programming (MILP), which integrates variables including capacity, demand, inventory levels, and overtime. MILP is widely used in supply chain decision-making as it can handle multiple constraints and scenarios within realistic time frames [5].
   Proposed Solutions:
   - Shipment Schedule Segmentation: By improving SKU segmentation, delivery schedules become more predictable, optimizing truck utilization and reducing shipping costs.
   - Overtime Reduction: Coordinated planning between production and delivery schedules helps minimize unplanned overtime for both employees and distributors.
   - Out-of-Stock (OOS) Risk Mitigation: Better delivery schedule management helps reduce supplier-side stock shortages, improving customer satisfaction and lowering shortage-related costs.
   - 3PL Cost Negotiation: Accurate early forecasting of shipping volumes enhances the ability to negotiate better shipping rates with third-party logistics providers, reducing unexpected costs.

Mixed Integer Linear Programming (MILP) dengan formulasi berikut:

1. Objective Function:
   Minimize total costs:
   $$Z = C_{\text{transport}} + C_{\text{overtime}} + C_{\text{inventory}} + C_{\text{shortage}} + C_{\text{3PL}}$$
   Information:

- $C_{\text{transport}} = \sum c_{ij} x_{ij}$: Biaya pengiriman.
- $C_{\text{overtime}} = \sum o_t \cdot h_t$: Biaya overtime.
- $C_{\text{inventory}} = \sum h_k \cdot I_k$: Biaya penyimpanan stok.
- $C_{\text{shortage}} = \sum p_k \cdot S_k$: Biaya kekurangan stok.
- $C_{\text{3PL}} = \sum f_v \cdot T_v$: Biaya 3PL.

2. Constraints:
   1. Transportation Capacity:

$$\sum x_{ij} \leq \text{Cap}_i, \forall i$$

   2. Demand Balance:

$$\sum x_{ij} \geq D_j, \forall j$$

   3. Produksi dan Lembur:

$$P_t + h_t \leq \text{MaxProd}_t, \forall t$$

   4. Supplies:

$$I_{t+1} = I_t + P_t - D_t - S_t, \forall t$$

   5. Minimum Volume 3PL:

$$T_v \geq \text{MinVol}_v, \forall v$$

3. Decision Variables:
   - x_{ij}: Quantity of goods shipped.
   - P_t: Regular production volume.
   - h_t: Overtime hours.
   - I_t: Inventory level.
   - S_t: Stockout (shortage) quantity.
   - T_v: 3PL (Third-Party Logistics) shipment volume.

4. Sustainability
   The implementation of environmentally friendly strategies is also a critical component of the solution, particularly regarding truck usage and packaging materials.
   As part of its sustainability initiative, the company integrates Circular Economy principles, such as recycling C48 packaging and reducing carbon emissions through transport efficiency (Geissdoerfer et al., 2017).
   This approach aligns with global efforts toward environmentally and socially responsible supply chain governance [9].
   Proposed Solutions:
   - Truck Utilization Optimization for Carbon Reduction:
     By optimizing truck utilization, the company can reduce the number of trips required, thereby minimizing transportation-related carbon emissions.
   - Eco-Friendly Packaging:
     The use of sustainable packaging materials—such as reducing single-use plastics—helps minimize waste and environmental impact. For example, using reusable C48 boxes can significantly reduce packaging waste.
   - Production Efficiency:

Optimizing production processes to minimize waste, including the use of eco-friendly packaging materials without generating additional waste, supports sustainability goals without compromising productivity.

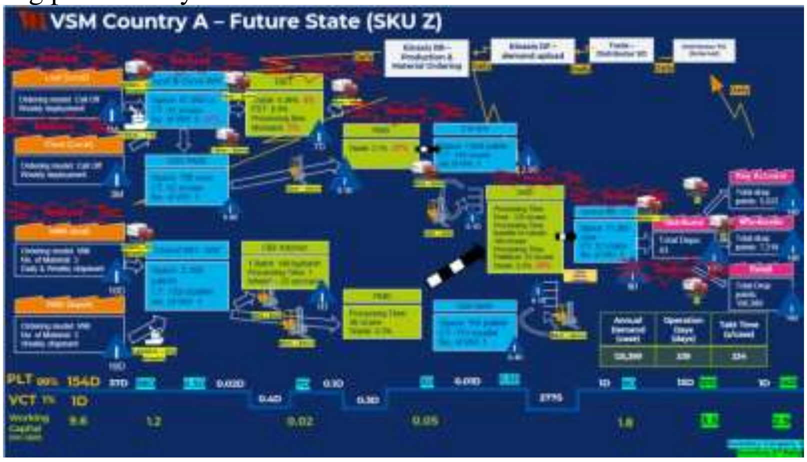

Figure 2. VSM Country A – Future State (SKU Z)

3.4. DELIVER: Implementation and Performance Measurement

The DELIVER phase focuses on implementing solutions and measuring outcomes to ensure the achievement of defined objectives. Implementation efforts are concentrated on cost reduction and cash flow improvement. Strategies such as the call-off system and SKU segmentation support flexibility and efficiency, aligning with the core principles of Design Thinking, which emphasize user needs in an adaptive and innovative context[10].

By integrating iterative approaches as advocated by the Design Council [1], the company ensures that implemented solutions remain responsive to fluctuating demand and operational challenges. The following outlines the key initiatives for each target area:

1. Cash: >£15 Million Cash Release
   Objective: Enhance cash flow by optimizing the supply chain and production processes to reduce unnecessary material storage.
   Implementation Steps:
   - Call-Off System: Utilize a call-off procurement model for raw materials, ensuring purchases are made only when needed to reduce storage costs.
   - SKU Segmentation and Waste Reduction: Manage SKUs more efficiently to minimize waste and excess inventory.
2. Cost: >£2 Million Productivity Savings
   Objective: Achieve more than £2 million in savings through increased operational efficiency and waste reduction.
   Implementation Steps:
   - Material Productivity: Improve material efficiency without compromising product quality.
   - Production Scheduling Optimization: Reduce cycle time and downtime through changeover analysis and proactive machine maintenance.
   - Material Localization: Shorten lead times and lower transportation costs by sourcing materials locally.
3. Service: Segmentation, Speed to Market, and 100% Fulfillment
   Objective: Improve customer service by implementing SKU segmentation, accelerating delivery times, and achieving 100% demand fulfillment.
   Implementation Steps:
   - Segmentation and Speed to Market: Categorize SKUs into base (stable demand) and agile (volatile demand) segments to respond with flexibility and speed.

- Delivery and Warehouse Optimization: Improve delivery management based on demand segmentation.
- Monitoring and Feedback: Implement daily monitoring systems to ensure on-time and demand-driven deliveries.

4. ESG: C48 Recycling and Up to 10% Carbon Emission Reduction
   Objective: Meet ESG targets by lowering carbon emissions and improving logistics efficiency.
   Implementation Steps:
   - Truck and Container Optimization: Maximize vehicle capacity utilization to reduce the carbon footprint of transportation.
   - Eco-Friendly Pallets and Plastics: Transition to recyclable materials, such as wooden pallets, to reduce plastic waste.
   - C48 Recycling Program: Implement a recycling initiative for C48 boxes to reduce material waste.
5. Monitoring and Continuous Improvement
   Objective: Ensure the implemented solutions remain effective and deliver the intended results.
   Implementation Steps:
   - KPI Tracking: Use Key Performance Indicators to measure cost savings, delivery efficiency, and ESG compliance.
   - Continuous Improvement Loop: Apply Kaizen principles to continuously improve processes and performance outcomes.

4. Conclussion

1. Structured Problem Identification:
   - The Design Thinking approach successfully identified core supply chain issues, particularly in material costs, production waste, SKU complexity, and logistics inefficiencies in Country A.
   - The use of Value Stream Mapping (VSM), Fishbone Diagram, and activity classification (Value-Added Activity [VAA] and Non-Value-Added Activity [NVAA]) proved effective in mapping areas of waste and non-value-added processes.
2. SKU Segmentation and Focus:
   - Segmenting SKUs into Base and Agile categories enabled the company to develop more adaptive and efficient production and distribution strategies in response to demand fluctuations.
3. Material Cost Optimization:
   - The material sourcing strategy was optimized using a Greedy Algorithm, yielding an effective vendor selection process based on cost and capacity, thereby reducing import dependency and lowering working capital requirements.
4. Production Efficiency:
   - The complexity of the production process caused by SKU variation was addressed through Simulated Annealing, which optimized production scheduling. This approach reduced both time and material waste and enhanced the utilization of machines and labor.
5. Supply Chain Optimization:
   - Distribution issues and delivery delays were resolved through the application of Mixed Integer Linear Programming (MILP), which accounted for capacity, inventory, demand, and overtime, resulting in improved delivery efficiency and inventory management.
6. Significant Financial Impact:
   - The implementation of the proposed solutions resulted in:
     - Over £15 million in cash release,
     - More than £2 million in operational cost savings,
     - An increase in the fulfillment rate to 100%.
7. Support for Sustainability (ESG):
   - Environmental initiatives such as reusable packaging (C48 boxes), truck utilization optimization, and carbon emission reductions of up to 10% strongly supported the company's sustainability goals.

8. Flexible and Replicable Model:
   - This approach demonstrated the effectiveness of data-driven optimization methods in complex operational decision-making.
   - The strategies employed are adaptive and replicable in other countries or regions facing similar supply chain challenges.
9. Enhanced Organizational Capability:
   - Cross-functional involvement (manufacturing, supply chain, planning, trade, distribution) fostered strong collaboration and embedded a culture of continuous improvement through KPI monitoring and Kaizen implementation.

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