Optimization of Cash Flow

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Abstract— This project addresses the optimization of cash flow redistribution among Coppel retail stores in Guadalajara, Mexico. Due to high volumes of cash transactions and varied demand across branches, there is an imbalance in cash availability: some stores accumulate surplus cash while others operate under their reorder point (ROP), risking their ability to function. To address this, we developed two linear programming models. The first model minimizes transportation costs by reallocating cash from donor stores (above optimal levels) to recipient stores (below ROP), considering distance and insurance costs. The second model activates when internal transfers are insufficient, allowing transfers from non-Coppel stores to Coppel branches through electronic channels and direct shipments. The models integrate operational constraints such as vehicle capacity, minimum cash reserves, mandatory electronic deposits, and cost parameters (e.g., $25/km, 0.5% operational fees, 0.1% transfer fees). The proposed solution achieves significant cost savings (total weekly cost: $249,019.10), reduces security risks, and ensures liquidity balance. Finally, we present recommendations for future implementations based on data quality, operational realism, and network simulation.

Keywords—Model, Reorder Point, Coppel, Cash, Transportation, Optimization

I. INTRODUCTION

Grupo Coppel is one of the most important companies in the Mexican retail sector, with a wide network of branches throughout the country and a prominent presence in the financial sector through Bancoppel. In particular, in the city of Guadalajara, 33 stores operate, offering a wide variety of products and services, from clothing, furniture, and mobile top-ups to personal loans and banking services.

Coppel's operating model involves intensive management of cash flows, because many transactions are carried out in cash, both in sales and in the collection of repayments. However, this dynamic generates considerable disparity in the distribution of liquidity among branches. Some stores accumulate excess cash, which increases security risks and financial inefficiency; while others face deficits that affect their ability to grant credit, make sales, or even have sufficient change for day-to-day operations.

Faced with this problem, this project aims to design and propose an optimization model for cash redistribution among branches, minimizing the costs associated with transfers and ensuring that each store has the financial resources necessary to operate efficiently. In particular, the goal is to implement a minimum-cost flow network model that determines the best way to move resources among stores, considering factors such as distance, logistics costs, and maximum limits per transfer.

This effort not only has the potential to reduce operating costs and security risks, but also to improve the allocation of liquidity, strengthen the company's responsiveness to changes in demand, and increase customer satisfaction by ensuring the constant availability of cash and credit.

II. METHODOLOGY

For the development of the project, Coppel provided multiple files with the necessary information. Among these were:

1. **tiendasGDL:** In this file we were provided the store code, store name, and store type (which was fundamental for the development of the second model).

2. **ventas:** In this file we were provided the sales made, including store number, day of the week, type of purchase, portfolio to which it belongs, and the average sale.

3. **abonos:** As its name indicates, in this file we find the repayments made, including day of the week, portfolio, and the average repayment.

a. EDA

Prior to designing and implementing the optimization models, we performed an exhaustive exploratory data analysis in order to understand the dynamics of financial flows in Coppel stores. This process was essential to define realistic assumptions, identify patterns in the data, and establish operational parameters such as the reorder point (ROP), daily demand, and minimum cash limits.

Various relevant variables were explored, including daily sales by portfolio type, recorded repayments, the weekly be-

havior of stores, and the levels of loans granted. However, two visualizations proved particularly revealing for the model's setup.

The first graph compares daily loans with their weekly average (see Figure 1). Through this representation, strong variability among days of the week was evident, with marked peaks on Wednesdays and Saturdays. Nevertheless, the behavior was sufficiently stable to justify a mean approximation: a constant daily demand per store was considered, calculated from the weekly average.
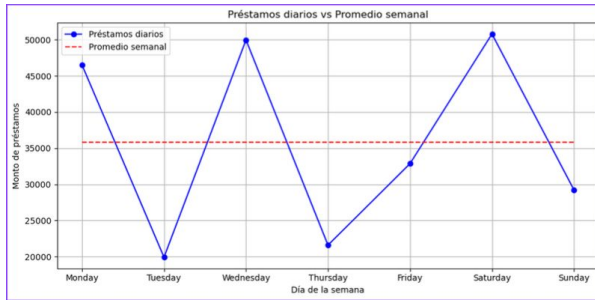

Fig. 1: Comparison between daily loan amounts and the weekly average. The red dashed line represents the weekly average.

The second graph shows the weekly average of loans per store (see Figure 2). This visualization made it possible to detect a large disparity among branches: while some stores recorded average amounts above $180,000 pesos, others remained below $20,000, and at least one store had no loan records at all during the analyzed period. This finding made it clear that it was necessary to establish a minimum operational cash level in order to prevent low-activity stores from being underestimated in the redistribution models.
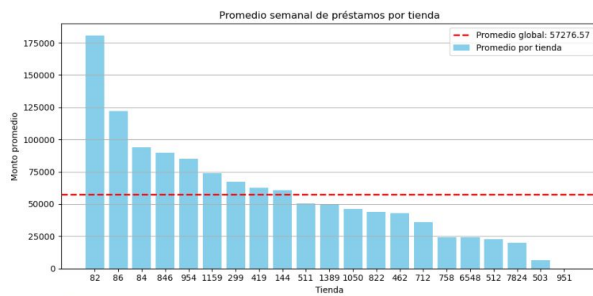

Fig. 2: Weekly average of loans granted per store. The distribution of the average amount in each branch is shown, ordered from highest to lowest. The red dashed line indicates the global average.

Both graphs were fundamental to define key parameters of the model, such as:

1. Average daily demand per store, the basis for calculating the ROP.

2. Minimum operational cash, which ensured minimum liquidity even in stores with low turnover.

This exploratory analysis formed the basis for realistic modeling, adapted to the heterogeneity of the system and the dynamic behavior of the stores.

b. Constraints

For the correct formulation of the cash-flow optimization model among stores, various operational and business constraints were defined that reflect the real conditions imposed by the company:

1. **Cash limit per store:** Each store cannot accumulate more than $250,000 MXN in cash. This cap is essential to reduce security risks and maintain appropriate liquidity levels.

2. **Minimum required change:** To ensure smooth operations and customer service, each store must have at least 100 units of each monetary denomination (bills or coins of 50, 20, 10, 5, 2, and 1 peso). This condition is particularly critical in the clothing department, which presents greater demand for change, followed by footwear and then furniture.

3. **Mandatory electronic deposits:** It is established that at least 30% of the daily sales of each store must be deposited electronically to the central office, which allows maintaining financial traceability and accounting efficiency.

These constraints were integrated into the mathematical model in order to ensure the operational feasibility of the proposed solutions, respecting the physical, logistical, and regulatory capacities of financial operations among branches.

c. Costs

The model considers different cost components associated with the transfer, handling, and processing of cash, as well as electronic operations among stores. These elements are part of the objective function, which seeks to minimize the total expenditure in the company's internal financial system. The main costs involved are described below:

1. **Cash-in-transit cost:** Each kilometer traveled by the transport vans represents an expense of $25 MXN. Additionally, an insurance cost equivalent to $3 MXN for each $1,000 MXN of cash transported is included. Each vehicle has a maximum capacity of $100,000 MXN per trip.

2. **Cash collection cost:** A commission of 0.5% is charged on cash sales collected at each store.

3. **Repayment cost:** Customer repayments imply an administrative cost of 0.5% on their total value.

4. **Electronic transfer fee:** Each electronic transaction incurs a charge of 0.1% of the amount transferred.

5. **Credit sales condition:** In credit sales, an initial cash down payment of 15% of the total is required, which affects the cash flow available in-store and must be considered in balance calculations.

These costs were integrated into the model to accurately reflect the real expenses that the company faces in the daily management of cash and financial operations among branches. Minimizing these costs allows resources to be optimized without compromising operations.

d. Assumptions

Lastly, it was necessary to establish a series of assumptions that delimit the scope of the problem, simplify its resolution, and allow operational conditions to be represented in a structured way. These assumptions are classified into two categories: those defined by Coppel and those assumed by the team to facilitate model implementation.

Assumptions provided by Coppel:

1. **No banking agents or home collection:** The intervention of third parties in cash management is omitted, focusing the analysis exclusively on internal flows among stores.

2. **Store and department keys given by headquarters:** It is assumed that the necessary categorical information (e.g., store or department identifiers) is already defined and available for use.

3. **Focus on internal financial flow:** The problem is restricted to modeling the circulation of cash and electronic transactions among stores, without considering external aspects such as suppliers, banks, or end customers.

The following additional assumptions were proposed by the team to complement the information provided by the company and allow better implementation of the mathematical model:

1. Cash inflows are the sum of cash sales and repayments.

2. Outflows are equivalent to loans and, at the same time, equivalent to demand.

3. Demand behaved similarly across days of the week; therefore, a daily demand (weekly average) was assumed.

4. Demand varies considerably among stores; therefore, each store has a different demand.

In addition to these assumptions determined by our team, we performed calculations for each store that would help later in the development of the problem:

1. **Reorder point (ROP)** = Average demand multiplied by replenishment time (1 day)

2. **Optimal point (PO)** = ROP multiplied by 1.3 (30% higher than the ROP)

3. **Minimum cash** = 8,800

e. Model 1: Optimization of the cash transportation cost

The first model developed aims to minimize the total cost associated with transporting cash among stores, in order to replenish those that are below their reorder point (ROP). To this end, stores are classified into two groups. The group of donor stores are those that have a cash surplus. The group of recipient stores are those that have a cash level below their ROP and require replenishment.

The objective function considers two main components: the cost proportional to the amount transferred (commissions and insurance) and the cost proportional to the distance traveled by transport units. The function is expressed as:

$$\text{Min } Z = \sum_i \sum_j X_{ij}(0.003) + D_{ij}(25)$$

where:

X_{ij} = Amount of money transferred from store i to store j

D_{ij} = Distance in KM between store i and store j

In addition, it is considered that each store cannot exceed the following operational limit:

Cash limit per store: $250,000

The constraints that define the feasibility of the model are the following:

$$\sum_j X_{ij} \leq PO_j - \text{current cash}_i$$

$$\sum_j X_{ij} \leq \text{current cash}_i - \text{cash limit}$$

$$0 \leq X_{ij} \leq \text{Maximum per trip}$$

$$\text{MaxTrip} = 100,000$$

$$i \neq j$$

These constraints ensure that cash is only transferred from stores with surplus to stores with real need, respecting the defined operational limits.

f. Model 2: Optimization of the cash transportation cost from Coppel stores to non-Coppel stores

The second model was developed due to the need to reformulate the solution. This model follows Model 1. At the moment when Model 1 becomes unsatisfactory because the cash flow in the network exceeds what the constraints allow, Model 2 comes into operation.

Model 2 is a transportation model that seeks to minimize the cost of redistributing the cash surplus from non-Coppel stores to Coppel stores. For this, the key variables are the surplus of the stores, the type of store, and the maximum amount of money per trip. The two stages of the solution are:

1. **Direct transfer:** When there is a surplus in a Coppel store. It makes an electronic transfer (paying its respective commission) to the Bancoppel inside the same branch. This generates transfer cost but not a travel cost.

2. **Minimize redirection of surplus to Coppel stores:** When there is a surplus in non-Coppel stores, this surplus is transported to Coppel stores. Once in the Coppel store, an electronic transfer (paying its respective commission) is made to Bancoppel within the same branch. In this stage, the objective is to minimize the transport cost of the cash flow.

The objective function is expressed as:

$$\text{Min } Z = \left(\sum_{ij}(0.003)X_{ij} + 25D_{ij} \right) + \sum_k (0.001)X_k$$

where the decision variables are:

$$X_{ij} = \text{Amount transferred from donor } i \text{ to recipient } j$$

$$D_{ij} = \text{Distance in KM from donor } i \text{ to recipient } j$$

$$X_k = \text{Amount transferred electronically}$$

with the following constraints:

$$\sum_{ij} X_{ij} = \text{surplus}_i$$

$$0 \leq X_{ij} \leq \text{Maximum per trip}$$

$$\text{MaxTrip} = 100,000$$

$$i \neq j$$

g. Model Implementation

To solve the problem of cash redistribution in the network of Coppel stores, two optimization models were implemented and programmed in Python, which made it possible to pose and solve linear programming problems efficiently. The operational logic of both models was organized around the classification of stores as donors (with cash surplus relative to their optimal point) and recipients (below their reorder point).

For each day of the week, a transportation matrix was built, which represents the possible combinations of cash shipments among stores, as well as the costs associated with each route. Below is a schematic example of this matrix:

TABLE 1: COST MATRIX AMONG STORES WITH SURPLUSES AND DEFICITS

	Store 1 (60)	**Store 2** (50)
Store 3 (110)	Shipment 3→1: x	Shipment 3→2: y
Store 4 (50)	Shipment 4→1: w	Shipment 4→2: x

The logic behind the model consists of determining the optimal assignment of amounts to transfer between each donor–recipient store pair, minimizing the total operating cost, which includes both distance-based costs and the associated insurance. The model also evaluates the feasibility of solutions in accordance with operational constraints.

If Model 1 could not satisfy all demand, Model 2 was activated. Both models were executed iteratively for each day of the week, with dynamic data input (sales, repayments, outflows) and daily updating of store balances. The results obtained were stored in tables and visualized through maps with Leaflet and optimized routes with OSRM.

III. RESULTS

Below are the results obtained from the implementation of the two optimization models developed for the management and redistribution of cash flow in Coppel stores. The results include both the analysis of costs derived from cash transportation and the efficiency in resource allocation between stores with deficit and surplus cash.

a. Operational and logistics costs per day

The behavior of logistics and operational costs was evaluated over a full week. Table 2 breaks down daily costs:

TABLE 2: DAILY COSTS FOR TRANSPORTATION AND OPERATIONS

Day	Travel Costs ($)	Operational Costs ($)	Total Cost ($)
Monday	869.10	26,956.60	27,825.70
Tuesday	6,122.00	25,590.30	31,712.30
Wednesday	10,605.50	25,916.50	36,522.10
Thursday	10,993.00	24,274.40	35,267.50
Friday	11,500.50	24,231.00	35,731.60
Saturday	15,003.50	31,801.30	46,804.80
Sunday	12,128.80	23,026.10	35,154.90
Totals	**67,222.70**	**181,796.40**	**249,019.10**

The total accumulated cost at the end of the week was $249,019.10, of which $67,222.70 correspond to transportation costs and $181,796.40 to operational costs. It is observed that Saturday concentrates the largest share of the total cost, which could be related to higher cash demand in stores over the weekend.

b. Visualization of optimized routes

With the support of tools such as *OSRM* and *Leaflet*, geospatial visualizations were generated to represent the optimal routes for transporting cash among stores. These routes consider both the minimum distances and the operational limits per trip. The attached images show how routes were assigned between stores with deficit and those with surplus cash.

Fig. 3: Visualization of the optimal routes generated by the model for Tuesday. Yellow markers represent Coppel stores, while blue markers correspond to non-Coppel stores. The color of each route indicates the number of trips made between points.

c. General analysis

The models developed enabled a significant reduction in costs through more efficient management of cash flow. In addition, it was observed that proper redistribution can prevent the need for costly external replenishments, optimizing both logistics and financial resources. The system proved reproducible and scalable, subject to improvements in data accuracy and greater operational control over pickup and delivery points.

IV. CONCLUSIONS

This work made it possible to address, in a structured and efficient way, the problem related to the management and redistribution of cash flow in Coppel stores. Based on the available data and certain operational assumptions, two opti-

mization models were developed that responded to specific needs within the store network:

- **Model 1** made it possible to identify stores with cash deficits and assign them resources from stores with surpluses, optimizing transport routes and minimizing logistics costs. This directly contributed to better planning of cash replenishment at the operational level.

- **Model 2** broadened the perspective by incorporating non-Coppel stores as potential sources of cash. Thanks to its two-stage implementation (direct transfers and redirection), it was possible to efficiently integrate external resources into the main network, reducing costs and increasing system flexibility.

Both models proved to be functional, scalable, and reproducible, meeting the constraints imposed by the problem conditions. The results show that the correct application of linear programming tools can have a significant impact on logistics decision-making, especially in contexts where cash handling is costly and operational.

However, the development of the model also revealed certain limitations, mainly related to the availability and specificity of the data. For future implementations, it is recommended to:

- Expand the historical data of sales and operations per store.

- Clearly differentiate between cash and digital transactions.

- Include more realistic simulations of network behavior, considering variables such as security, transport availability, and external conditions.

In summary, the model developed not only minimized costs but also generated a solid foundation for designing more robust and adaptable cash management systems.