SOLVING THE TRANSPORTATION PROBLEM USING THE NORTH-WEST CORNER METHOD WITH THE HELP OF SOFTWARE

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Many complex problems of the national economy can be solved by reducing them to a transportation problem. This makes it possible to solve the given problem completely from both a mathematical and an economic point of view, that is, to determine the optimal plan and the resulting efficiency. The transportation problem, in general, is a linear programming problem, and taking into account its specific features, special and convenient methods have been developed for its solution.

The potential method, the differential rent method, the delta method, and others belong to this group. Of course, in all methods, the choice of the initial plan plays an important role, because if it is chosen closer to the optimal plan, fewer subsequent computational steps are required. Therefore, determining the initial plan can also be considered a separate problem. Several methods have been proposed to solve it, including the north-west corner method, the least cost method, the double preference method, and others.

The general formulation of the transportation problem:

$A_1, \ldots, A_i, \ldots, A_m$ there are supply points that trade in the same type of product,

A_i - the quantity of the product at the supply point a_i let these products be equal to one unit each $B_1, \ldots, B_j, \ldots, B_n$ it is required to distribute them to the consumption points. In this B_j - the quantity of the product that needs to be delivered to the consumption point b_j let it be equal to one unit. A_i -the supplier B_j - the cost of delivering one unit of product from the supplier to the consumer, let it be equal to c_{ij} soms. It is required to transport the products from the supply points to the consumers with the minimum cost. To solve the given problem, the quantity of products planned to be transported from supplier x_{ij} to consumer B_j via A_i is determined, and the mathematical model of the problem is formulated, that is:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \to \min \qquad (1)$$

$$\sum_{j=1}^{n} x_{ij} = a_i, \quad i = 1, \ldots, m \qquad (2)$$

$$\sum_{i=1}^{m} x_{ij} = b_j, \quad j = 1, \ldots, n \qquad (3)$$

$$x_{ij} \geq 0, \quad i = 1, \ldots, m, \quad j = 1, \ldots n. \qquad (4)$$

Here, (2) represents the constraint on the quantity of products to be taken from each supplier, (3) represents the constraint on the quantity of products to be delivered to each consumer, and (1) is called the objective function, which determines the total cost of transporting the products. Thus, (1) indicates that this total cost must be minimized.

North-West Corner Method. This method starts by satisfying the demand of consumer B_1 with the available products of supplier A_1. If the demand is fully met (which requires that $a_1 \geq b_1$), then the remaining products of A_1 are used to satisfy the demand of B_2, and so on. If supplier A_1 cannot fully meet the demand of B_1, then the products of supplier A_2 are used to satisfy B_1's demand, either fully or partially.

During this process, the quantities of products planned to be shipped from suppliers to consumers are recorded in the corresponding cells. Since a closed transportation problem is being considered, this process continues until all available products from the suppliers are completely distributed to the consumers. At each step of the process, either the products of the current supplier are fully distributed, or the demand of the current consumer is fully satisfied.

If both situations occur at the same time, that is, all available products of a supplier are fully distributed and the corresponding consumer's demand is fully satisfied, a zero is entered in the appropriate cell to the right or below. Such zeros in some cells are placed to make the initial plan **non-degenerate** (as explained below).

There are software-selling companies $\square_1, \square_2, \square_3, \square_4$ and $\square_5$ with the available quantities of software products as follows: $\square_1 = 100, \square_2 = 250, \square_3 = 150, \square_4 = 110, \square_5 = 70$.

There are seven legal entities $\square_1, \square_2, \square_3, \square_4, \square_5, \square_6$ and $\square_7$ that require this software product, and their respective demands for the product are $\square_1 = 70, \square_2 = 50, \square_3 = 160, \square_4 = 80, \square_5 = 100, \square_6 = 90$ va $\square_7 = 130$ The cost of delivering one unit of the product from each supplier to any legal entity, $\square_{\square\square}$ is given as follows: $\square_{11} = 3, \square_{12} = 2, \square_{13} = 3, \square_{14} = 4, \square_{15} = 5, \square_{16} = 4, \square_{17} = 7, \square_{21} = 1, \square_{22} = 8, \square_{23} = 2, \square_{24} = 10, \square_{25} = 9, \square_{26} = 3, \square_{27} = 2, \square_{31} = 2, \square_{32} = 3, \square_{33} = 4, \square_{34} = 4, \square_{35} = 4, \square_{36} = 2, \square_{37} = 1, \square_{41} = 4, \square_{42} = 3, \square_{43} = 2, \square_{44} = 5, \square_{45} = 8, \square_{46} = 8, \square_{47} = 3, \square_{51} = 4, \square_{52} = 5, \square_{53} = 5, \square_{54} = 6, \square_{55} = 5, \square_{56} = 3, \square_{57} = 8$ This problem can be organized into a table as follows:

Companies	Legal Entities							Available Quantity of Software
	$\square_1$	$\square_2$	$\square_3$	$\square_4$	$\square_5$	$\square_6$	$\square_7$	

$\square_1$	3	2	3	4	5	4	7	100
$\square_2$	1	8	2	10	9	3	2	250
$\square_3$	2	3	4	4	4	2	1	150
$\square_4$	4	3	2	5	8	8	3	110
$\square_5$	4	5	5	6	5	3	8	70
Demand	70	50	160	80	100	90	130	680

We will check whether this problem is **closed or open**:

Suggestions: $100 + 250 + 150 + 110 + 70 = 680$

Requirements: $70 + 50 + 160 + 80 + 100 + 90 + 130 = 680$

Since the total demand equals the total supply, this problem is considered a **closed (balanced) problem**.

***North-West Corner Method*:**

Companies	Legal Entities							Available Quantity of Software
	$\square_1$	$\square_2$	$\square_3$	$\square_4$	$\square_5$	$\square_6$	$\square_7$	
$\square_1$	3 70	2 30	3	4	5	4	7	100
$\square_2$	1	8 20	2 160	10 70	9	3	2	250
$\square_3$	2	3	4	4 10	4 100	2 40	1	150
$\square_4$	4	3	2	5	8	8 50	3 60	110
$\square_5$	4	5	5	6	5	3	8 70	70
Demand	70	50	160	80	100	90	130	680

In company $\mathbf{A_1}$, the available number of software units is 100. We start by satisfying the demand of the legal entity with the smallest demand, $\mathbf{B_1}$: 70 out of 100 units are allocated to $\mathbf{B_1}$, leaving $\mathbf{A_1}$ with 100−70=30 units. The remaining 30 units are given to $\mathbf{B_2}$, leaving $\mathbf{B_2}$ still needing 50−30=20 units, which are supplied by $\mathbf{A_2}$. Next, the remaining 250−20=230 units of

A_2 are sent to **B_3**, satisfying **B_3**'s demand of 160 units. Then, the leftover 230−160=70 units from **A_2** are sent to **B_4**. To meet the remaining demand of **B_4** (80−70=10 units), units from **A_3** are used.

The surplus of **A_3** (150−10=140 units) satisfies the 100-unit demand of **B_5**, leaving 140−100=40 units, which are sent to **B_6**. The remaining demand of **B_6** (90−40=50 units) is fulfilled by **A_4**. After satisfying **B_6**, the remaining 110−50=60 units from **A_4** and the 70 units from **A_5** fully cover the demand of **B_7**.

Based on this algorithm, the initial allocation plan is as follows:

$$\square_{11} = 70, \square_{12} = 30, \square_{13} = \square_{14} = \square_{15} = \square_{16} = \square_{17} = 0, \square_{22} = 20, \square_{23} = 160,$$

$$\square_{24} = 70, \square_{21} = \square_{25} = \square_{26} = \square_{27} = 0, \square_{34} = 10, \square_{34} = 100, \square_{36} = 40,$$

$$\square_{31} = \square_{32} = \square_{33} = \square_{37} = 0, \square_{46} = 50, \square_{47} = 60,$$

$$\square_{41} = \square_{42} = \square_{43} = \square_{44} = \square_{45} = 0, \square_{57} = 70,$$

$$\square_{52} = \square_{52} = \square_{53} = \square_{54} = \square_{55} = \square_{56} = 0$$

To calculate the total cost corresponding to this plan, multiply the values in the respective cells of Table 2 by the corresponding costs and sum the products. For this problem, the total cost for the obtained initial allocation is:

$$70 * 3 + 30 * 2 + 20 * 8 + 160 * 2 + 70 * 10 + 10 * 4 + 100 * 4 + 2 * 40 + 8 * 50 + 60 * 3 + 8 * 70 = 3110$$

Units

A program was created to generate this example, and its results were compared accordingly.

Program code for solving a closed problem:

```
import numpy as np

def northwest_corner(supply, demand):
    m, n = len(supply), len(demand)
    supply_left = supply.copy()
    demand_left = demand.copy()
    alloc = np.zeros((m, n), dtype=int)
    i = 0
    j = 0

    while i < m and j < n:
        q = min(supply_left[i], demand_left[j])
        alloc[i, j] = q

        supply_left[i] -= q
        demand_left[j] -= q

        if supply_left[i] == 0 and i < m - 1:
            i += 1
        elif demand_left[j] == 0 and j < n - 1:
            j += 1
        else:
            if supply_left[i] == 0:
                i += 1
            else:
                j += 1

    return alloc

def total_cost(allocation, costs):
    return np.sum(allocation * costs)
```

```
print("=== North-West Corner Method ===")

supply = list(map(int, input("Enter the supplies sequentially (for example: 100 250
150):").split()))

demand = list(map(int, input("Enter the demands sequentially (for example: 80 120 150):
").split()))

# Check balance
if sum(supply) != sum(demand):
    print("Error! The total of demands and supplies must be equal..")
    exit()

m = len(supply)
n = len(demand)

print(f" Enter the unit cost matrix ({m}x{n}) values.:")

costs = []
for i in range(m):
    row = list(map(int, input(f"{i+1}-qator: ").split()))
    if len(row) != n:
        print("Error! The number of elements in the row must be equal to the number of
demands..")
        exit()
    costs.append(row)

costs = np.array(costs)
supply = np.array(supply)
demand = np.array(demand)

allocation = northwest_corner(supply, demand)
cost = total_cost(allocation, costs)
```

```
print("\n=== RESULT ===")
print("Allocation:")
print(allocation)

print("\nTotal cost:", cost)
```

The program result for the above example is:

```
=== Shimoliy-g'arb burchak usuli  ===
Takliflarni ketma-ket kiriting (masalan: 100 250 150): 100 250 150 110 70
Talablarni ketma-ket kiriting (masalan: 80 120 150): 70 50 160 80 100 90 130
Birlik xarajat matritsasi (5x7) qiymatlarini kiriting:
1-qator: 3 2 3 4 5 4 7
2-qator: 1 8 2 10 9 3 2
3-qator: 2 3 4 4 4 2 1
4-qator: 4 3 2 5 8 8 3
5-qator: 4 5 5 6 5 3 8

=== NATIJA ===
Taqsimot (Allocation):
[[ 70  30   0   0   0   0   0]
 [  0  20 160  70   0   0   0]
 [  0   0   0  10 100  40   0]
 [  0   0   0   0   0  50  60]
 [  0   0   0   0   0   0  70]]

Umumiy xarajat: 3110

=== Code Execution Successful ===
```

Conclusion

In this study, an algorithmic approach was applied to construct an initial allocation plan by systematically balancing supply surpluses and demand deficits across multiple sources and destinations. The step-by-step redistribution of excess units ensured that all demands were fully satisfied while efficiently utilizing available supplies. By sequentially assigning surplus resources to unmet demands, the proposed procedure avoided infeasibility and guaranteed a complete and consistent allocation.

The resulting initial allocation plan served as a feasible starting solution for the transportation problem. The total transportation cost associated with this plan was calculated by aggregating the products of allocated units and their corresponding unit costs. This cost evaluation provided a quantitative measure of the effectiveness of the generated allocation and enabled further comparison with optimized solutions.

To validate the correctness and reliability of the proposed algorithm, a computer program was developed to automatically generate the allocation plan. The computational results obtained from the program were compared with the analytical calculations, and full consistency between the two was observed. This confirms not only the accuracy of the algorithm but also its suitability for implementation in automated decision-support systems.

Overall, the findings demonstrate that the proposed approach is efficient, logically consistent, and practical for solving transportation-type optimization problems. Moreover, the algorithm can be effectively integrated into software tools for large-scale applications, where manual computation becomes infeasible, thereby enhancing computational efficiency and supporting informed decision-making in resource allocation tasks.

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