Case Assignment 4

BAN 630 – Optimization for Analytics

Group 3

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Shawls or Stoles

Create an optimal production plan for LL. Assume spinning, plying, and dyeing are already complete.

The model optimizes profit maximization while considering raw material, labor, and demand constraints for seven woven and knitted products. It determines the optimal production mix, ensuring minimum production requirements, raw material limits (15kg woven, 23kg knit), and labor capacities (5 weavers, 13 knitters) are met.

Key Insights:

Optimal Total Profit: ₹65,689.16
Higher-margin products like shawls, sweaters, and scarves are prioritized.
Dyed production is capped at 60%, affecting allocation.

```
Optimal Total Profit = 65689.16 INR

Shawl    => Dyed=   6.00, Natural=   4.00
         Per-unit cost(dyed)= 8638.10, sell=10797.62, profit= 2159.53
         Per-unit cost(nat )= 7808.10, sell= 9760.12, profit= 1952.03
------------------------------------------------
Stole    => Dyed=   3.00, Natural=   2.00
         Per-unit cost(dyed)= 6734.60, sell= 8418.25, profit= 1683.65
         Per-unit cost(nat )= 6099.60, sell= 7624.50, profit= 1524.90
------------------------------------------------
Scarf    => Dyed=  15.00, Natural=  10.00
         Per-unit cost(dyed)= 3880.50, sell= 4850.62, profit=  970.12
         Per-unit cost(nat )= 3538.50, sell= 4423.12, profit=  884.62
------------------------------------------------
Sweater  => Dyed=   3.00, Natural=   2.00
         Per-unit cost(dyed)= 5880.00, sell= 7350.00, profit= 1470.00
         Per-unit cost(nat )= 5392.00, sell= 6740.00, profit= 1348.00
------------------------------------------------
Muffler  => Dyed=   3.00, Natural=   2.00
         Per-unit cost(dyed)= 3233.75, sell= 4042.19, profit=  808.44
         Per-unit cost(nat )= 2948.75, sell= 3685.94, profit=  737.19
------------------------------------------------
Cap      => Dyed=   3.00, Natural=   2.00
         Per-unit cost(dyed)= 1217.25, sell= 1460.70, profit=  243.45
         Per-unit cost(nat )= 1095.25, sell= 1314.30, profit=  219.05
------------------------------------------------
Gloves   => Dyed=   3.00, Natural=   2.00
         Per-unit cost(dyed)= 1298.50, sell= 1558.20, profit=  259.70
         Per-unit cost(nat )= 1179.50, sell= 1415.40, profit=  235.90
------------------------------------------------
```

Meeting Okhai's demand alone leaves raw materials underutilized, presenting an opportunity for further production. So, we analyzed that in in the following section:

Extended Production Analysis:

A key aspect of this analysis was determining the optimal production period to meet demand while maximizing profit. Initially, we identified that a minimum of 5 days was required to fulfill Okhai's order requirements. However, upon extending production beyond this threshold, we observed that profit continued to increase. This indicated that raw materials were still available, allowing for additional production. Rather than limiting manufacturing to only meet Okhai's demand, we explored utilizing the remaining resources to produce more units that could be sold through the Leh store, thereby optimizing raw material usage and increasing profitability.

The trend showed that profit kept rising until 36 days, after which it standardizes, signaling exhaustion of all available raw materials. This suggests that continuing production up to 36 days allows Looms of Ladakh to fully leverage its raw material and labor capacity while preventing waste. Beyond this point, any further production is infeasible as materials are depleted.

This analysis highlights an efficient inventory management strategy—instead of limiting production to Okhai's order, Looms of Ladakh can continue manufacturing as long as resources permit and there is market demand. By producing surplus for the Leh store, they maximize revenue without additional resource investment. The key takeaway is that strategic production planning not only ensures order fulfillment but also enhances overall profitability through optimal resource allocation.

```
=== D=5 days ===
Optimal Profit = 65689.16
  Shawl   : Dyed=  6.00, Nat=  4.00
     costDye=8638.10, profitDye=2159.53, sellDye=10797.62
     costNat=7808.10, profitNat=1952.03, sellNat=9760.12
  Stole   : Dyed=  3.00, Nat=  2.00
     costDye=6734.60, profitDye=1683.65, sellDye=8418.25
     costNat=6099.60, profitNat=1524.90, sellNat=7624.50
  Scarf   : Dyed= 15.00, Nat= 10.00
     costDye=3880.50, profitDye= 970.12, sellDye=4850.62
     costNat=3538.50, profitNat= 884.62, sellNat=4423.12
  Sweater : Dyed=  3.00, Nat=  2.00
     costDye=5880.00, profitDye=1470.00, sellDye=7350.00
     costNat=5392.00, profitNat=1348.00, sellNat=6740.00
  Muffler : Dyed=  3.00, Nat=  2.00
     costDye=3233.75, profitDye= 808.44, sellDye=4042.19
     costNat=2948.75, profitNat= 737.19, sellNat=3685.94
  Cap     : Dyed=  3.00, Nat=  2.00
     costDye=1217.25, profitDye= 243.45, sellDye=1460.70
     costNat=1095.25, profitNat= 219.05, sellNat=1314.30
  Gloves  : Dyed=  3.00, Nat=  2.00
     costDye=1298.50, profitDye= 259.70, sellDye=1558.20
     costNat=1179.50, profitNat= 235.90, sellNat=1415.40
-----------------------------------------------
```

```
=== D=36 days ===
Optimal Profit = 167010.73
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```
=== D=38 days ===
Optimal Profit = 167010.73
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```
=== D=49 days ===
Optimal Profit = 167010.73
```

Focusing more on Scarf and Muffler:

The product mix which generates maximum profit at 167010.73 INR at 36 days suggest producing more scarf and muffler as it's the optimum usage of available resources (raw material and labor)

```
=== SCENARIO: Margin+0%_Days=36 ===
  Optimal Total Profit = 167010.73
  Shawl   : Dyed=  3.00, Nat=  2.00, costDye=8638.10, profitDye=2159.53, costNat=7808.10, profitNat=1952.
03
  Stole   : Dyed=  3.00, Nat=  2.00, costDye=6734.60, profitDye=1683.65, costNat=6099.60, profitNat=1524.
90
  Scarf   : Dyed= 30.00, Nat= 20.00, costDye=3880.50, profitDye= 970.12, costNat=3538.50, profitNat= 884.
62
  Sweater : Dyed=  9.00, Nat=  6.00, costDye=5880.00, profitDye=1470.00, costNat=5392.00, profitNat=1348.
00
  Muffler : Dyed= 60.00, Nat= 40.00, costDye=3233.75, profitDye= 808.44, costNat=2948.75, profitNat= 737.
19
  Cap     : Dyed=  3.00, Nat=  2.00, costDye=1217.25, profitDye= 243.45, costNat=1095.25, profitNat= 219.
05
  Gloves  : Dyed=  3.00, Nat=  2.00, costDye=1298.50, profitDye= 259.70, costNat=1179.50, profitNat= 235.
90
```

b. Sensitivity Analysis:

Profit Margins:

Varying the profit margins was a crucial aspect of our sensitivity analysis. The case study highlights that a 100-gram wool scarf is priced at approximately INR 10,000 in the market. However, in our optimal solution, a 500-gram shawl is being sold for INR 10,797.62— significantly lower than its potential market value, which, based on this pricing, could be assumed to be at least INR 30,000. This substantial gap suggests that increasing our profit margins is a logical and necessary step.

When operating in a B2B model, much of the profit typically gets absorbed by retailers. By increasing our margins and shifting focus toward B2C sales through the Leh store, Looms of Ladakh could directly capture a larger share of the value, maximizing returns. Furthermore, as the case study notes, villagers are also shareholders in the company, meaning higher margins would directly benefit the community.

To analyze this, we varied the profit margins from 5% to 20% in increments of 5% and observed the impact on total profitability. In the base model, the total profit stood at INR 167010.73 after 36days of production (using weaving and knitting workforce), with a per-unit profit of INR 2,159.53 for shawls. As we increased the profit margins and reached 36 days of production where profitability stabilized. we observed unit profits of INR 2,342.43 at 5%, INR 2,732.84 at 10%, INR 3,123.24 at 15%, and INR 3,513.65 at 20%. Correspondingly, total profits were INR 200,533.84 at 5%, INR 234,056.95 at 10%, INR 267,580.06 at 15%, and INR 301,103.17 at 20%.

This analysis strongly supports the recommendation that Looms of Ladakh should increase its profit margins, particularly in B2B sales, while simultaneously emphasizing direct-to-consumer (B2C) sales through the Leh store. This strategy not only ensures higher profitability but also aligns with the company's mission of empowering local artisans and shareholders.

Sensitivity Analysis 2: Scenario Where there is a rise in demand for natural (non-Dyed) Products in market

```
=== D=5 days ===
Optimal Profit = 65689.16
  Shawl   : Dyed=  6.00, Nat=  4.00
     costDye=8638.10, profitDye=2159.53, sellDye=10797.62
     costNat=7808.10, profitNat=1952.03, sellNat=9760.12
  Stole   : Dyed=  3.00, Nat=  2.00
     costDye=6734.60, profitDye=1683.65, sellDye=8418.25
     costNat=6099.60, profitNat=1524.90, sellNat=7624.50
  Scarf   : Dyed= 15.00, Nat= 10.00
     costDye=3880.50, profitDye= 970.12, sellDye=4850.62
     costNat=3538.50, profitNat= 884.62, sellNat=4423.12
  Sweater : Dyed=  3.00, Nat=  2.00
     costDye=5880.00, profitDye=1470.00, sellDye=7350.00
     costNat=5392.00, profitNat=1348.00, sellNat=6740.00
  Muffler : Dyed=  3.00, Nat=  2.00
     costDye=3233.75, profitDye= 808.44, sellDye=4042.19
     costNat=2948.75, profitNat= 737.19, sellNat=3685.94

  Cap     : Dyed=  3.00, Nat=  2.00
     costDye=1217.25, profitDye= 243.45, sellDye=1460.70
     costNat=1095.25, profitNat= 219.05, sellNat=1314.30
  Gloves  : Dyed=  3.00, Nat=  2.00
     costDye=1298.50, profitDye= 259.70, sellDye=1558.20
     costNat=1179.50, profitNat= 235.90, sellNat=1415.40
-------------------------------------------------

=== D=36 days ===
Optimal Profit = 167010.73
  Shawl   : Dyed=  3.00, Nat=  2.00
     costDye=8638.10, profitDye=2159.53, sellDye=10797.62
     costNat=7808.10, profitNat=1952.03, sellNat=9760.12
  Stole   : Dyed=  3.00, Nat=  2.00
     costDye=6734.60, profitDye=1683.65, sellDye=8418.25
     costNat=6099.60, profitNat=1524.90, sellNat=7624.50
  Scarf   : Dyed= 30.00, Nat= 20.00
     costDye=3880.50, profitDye= 970.12, sellDye=4850.62
     costNat=3538.50, profitNat= 884.62, sellNat=4423.12
  Sweater : Dyed=  9.00, Nat=  6.00
     costDye=5880.00, profitDye=1470.00, sellDye=7350.00
     costNat=5392.00, profitNat=1348.00, sellNat=6740.00
  Muffler : Dyed= 60.00, Nat= 40.00
     costDye=3233.75, profitDye= 808.44, sellDye=4042.19
     costNat=2948.75, profitNat= 737.19, sellNat=3685.94
  Cap     : Dyed=  3.00, Nat=  2.00
```

```
costNat=2948.75, profitNat= 737.19, sellNat=3685.94
   Cap      : Dyed=  3.00, Nat=  2.00
      costDye=1217.25, profitDye= 243.45, sellDye=1460.70
      costNat=1095.25, profitNat= 219.05, sellNat=1314.30
   Gloves   : Dyed=  3.00, Nat=  2.00
      costDye=1298.50, profitDye= 259.70, sellDye=1558.20
      costNat=1179.50, profitNat= 235.90, sellNat=1415.40
```

```
=== SCENARIO: Margin+0%_Days=5 ===
  Optimal Total Profit = 66960.23
  Shawl   : Dyed=  1.00, Nat=  1.00, costDye=8638.10, profitDye=2159.53, costNat=7808.10, profitNat=1952.03
  Stole   : Dyed=  5.00, Nat=  5.00, costDye=6734.60, profitDye=1683.65, costNat=6099.60, profitNat=1524.90
  Scarf   : Dyed= 18.00, Nat= 18.00, costDye=3880.50, profitDye= 970.12, costNat=3538.50, profitNat= 884.62
  Sweater : Dyed=  1.00, Nat=  1.00, costDye=5880.00, profitDye=1470.00, costNat=5392.00, profitNat=1348.00
  Muffler : Dyed=  5.00, Nat=  5.00, costDye=3233.75, profitDye= 808.44, costNat=2948.75, profitNat= 737.19
  Cap     : Dyed=  3.00, Nat=  3.00, costDye=1217.25, profitDye= 243.45, costNat=1095.25, profitNat= 219.05
  Gloves  : Dyed=  3.00, Nat=  3.00, costDye=1298.50, profitDye= 259.70, costNat=1179.50, profitNat= 235.90
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```

```
=== SCENARIO: Margin+0%_Days=36 ===
  Optimal Total Profit = 165369.60
  Shawl   : Dyed=  1.00, Nat=  1.00, costDye=8638.10, profitDye=2159.53, costNat=7808.10, profitNat=1952.03
  Stole   : Dyed=  5.00, Nat=  5.00, costDye=6734.60, profitDye=1683.65, costNat=6099.60, profitNat=1524.90
  Scarf   : Dyed= 24.00, Nat= 24.00, costDye=3880.50, profitDye= 970.12, costNat=3538.50, profitNat= 884.62
  Sweater : Dyed=  4.00, Nat=  4.00, costDye=5880.00, profitDye=1470.00, costNat=5392.00, profitNat=1348.00
  Muffler : Dyed= 56.00, Nat= 56.00, costDye=3233.75, profitDye= 808.44, costNat=2948.75, profitNat= 737.19
  Cap     : Dyed=  3.00, Nat=  3.00, costDye=1217.25, profitDye= 243.45, costNat=1095.25, profitNat= 219.05
  Gloves  : Dyed=  3.00, Nat=  3.00, costDye=1298.50, profitDye= 259.70, costNat=1179.50, profitNat= 235.90
  -----------------------------------------------
```

Due to rising demand for natural products in market. The production of dyed products is being dropped by 10%. Changing the threshold limit for dyed products from 60 to 50 changes the product combination. As the profit margins are being applied on the total cost any rise in input cost and value addition rise the total cost of production. Thud when profit margin being applied on increased cost gives higher profit but also higher selling price. Thus changes the profit on day 36 (60% dyed and 40% natural) the total number of shawls produced is 10 whereas on day 36 (50% dyes and 50% natural) the total number of shawls produced is 2 . which reflects the change in product mix. The profit dropped from INR 167010.73 to INR 165369.60 as we reduced the dyed products.

The minimum products constrain are being met at day 4 when the dyed products natural products units share is 50 % each. Meeting the base demand a Day earlier.

C. Summarize your analysis in the form of key recommendations to LL.

- The market price of a pashmina shawl varies from 30000INR to 500000 INR. Giving us the room for increasing the profit margin. Thus a 20% increase in profit margin is viable and increases the total profit nearly two-fold.
- Profit sharing based model with the employees of looms of Ladakh gives a sense of ownership and empowers women. This emphasis on the dual objective of the Laktsal Project.

result, most youngsters from Changpa families preferred to move to the lowlands of Leh and Ladakh and work as laborers, rather than suffer from market uncertainties and low incomes. The Laktsal project had dual objectives: helping local women earn livelihood by adding value to locally available fiber and creating products that could be directly sold in the market, as well as preserving the traditional lifestyles of Changpa families (Exhibit 1 describes the inception of this idea in a Facebook post in 2013).

- Effective marketing and usage of government resources like Tribal Co-operative Marketing Federation of India (TRIFED) (Most employees of Looms of Ladakh belong to changpa tribe) which has a dedicated platform for tribal artisan products and MOU signed with popular ecommerce platforms like Amazon will help marketing the pashmina shawl worldwide hence establishing a stead demand for product in the market. With Geographical Indication (GI) tag being recognized in 2008 is another addition to the uniqueness and craftmanship.
- As Per our analysis reducing the dying cost (which is around 10% of total cost) by 10% which result to 1% total change in production cost wont increase the profit significantly . Trying to Build inhouse workforce for dying will benefit Looms of Ladakh and a emphasis on their dual objective.

result, most youngsters from Changpa families preferred to move to the lowlands of Leh and Ladakh and work as laborers, rather than suffer from market uncertainties and low incomes. The Laktsal project had dual objectives: helping local women earn livelihood by adding value to locally available fiber and creating products that could be directly sold in the market, as well as preserving the traditional lifestyles of Changpa families (Exhibit 1 describes the inception of this idea in a Facebook post in 2013).

- Increasing the total workforce by using the skill development schemes like National Handloom Development Programme (NHDP) a flagship skill development program will enable meeting the increasing product demand and creating greater impact in lives of villages of Ladakh.
- Producing more of scarf and muffler as they need moderate raw materials to produce yet yields higher profits.

Extensive Analysis:
Without Assumption that spinning, plying, and dyeing are already complete

Number of workers and days, to compute total capacity
spinner_count = 8 (assumption)
plyer_count = 8 (assumption)
weaver_count = 5
knitter_count = 13
D = 49 # days
Base model Result:

```
Optimal solution found (tolerance 1.00e-04)
Best objective 4.126766250000e+04, best bound 4.126766250000e+04, gap 0.0000%
Optimal total profit = 41267.66 INR
Shawl: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=8638.10, CostNat=7808.10
Stole: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=6734.60, CostNat=6099.60
Scarf: Dyed=   6.00, Nat=   4.00, Total=  10.00 | CostDye=3880.50, CostNat=3538.50
Sweater: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=5880.00, CostNat=5392.00
Muffler: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=3233.75, CostNat=2948.75
Cap: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=1217.25, CostNat=1095.25
Gloves: Dyed=   3.00, Nat=   2.00, Total=   5.00 | CostDye=1298.50, CostNat=1179.50
```

It takes 49 days to meet the basic demand requirements by Looms of Ladakh.

Sensitivity:
Without Assumption that spinning, plying, and dyeing are already complete
days_list = [10, 15, 20, 25, 30,40,50,60]

# spinner_count & plyer_count in [14..20]
sp_ply_range = range(14, 21)

# Dye cost changes: [-10%, -5%, 0%, +5%, +10%, +15%]
dye_factors = [-0.10, -0.05, 0.0, 0.05, 0.10, 0.15]

It takes a minimum of 20 days with 20 spinners, 14 plyers, 5 weavers and 13 knitters to reach the base product requirement demand of each product.

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-------------------------------------------------
[D=20, spinner=20, plyer=14, dyeCostChange=0%] --> Profit=42436.11
    Shawl    Dyed= 3.00, Natural= 2.00, Profit=10382.62
    Stole    Dyed= 3.00, Natural= 2.00, Profit= 8100.75
    Scarf    Dyed= 6.00, Natural= 4.00, Profit= 9359.25
    Sweater  Dyed= 3.00, Natural= 2.00, Profit= 7106.00
    Muffler  Dyed= 3.00, Natural= 2.00, Profit= 3899.69
    Cap      Dyed= 6.00, Natural= 4.00, Profit= 2336.90
    Gloves   Dyed= 3.00, Natural= 2.00, Profit= 1250.90
```

References:

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https://trifed.tribal.gov.in/retail-marketing/sale-of-tribal-products