Optimization of Daily Production in a Sardinian Bakery: A Linear Programming Approach

Quantitative Methods for Management

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Business Case

Family-owned bakery in Sardinia, producing two different type of products

- **Standard Bread:** Stable demand, lower margins.
- **Traditional Sweets:** Highly profitable, resource-intensive (time & materials)

"What is the optimal daily production mix to maximize profit while respecting physical and market constraints?”

Dataset

- **Features:** Unit costs, selling prices, raw material (flour/yeast) consumption, and labor time.
- Data Cleaning (R):
  - Handled missing values and date conversions.
  - **Seasonality:** Split dataset into Normal vs. Festive (Christmas) periods to capture shifts in demand and capacity.

Constraints

We used realistic limits from the data:

- **Flour and yeast constraints (f, l)** are set at the **75th percentile** of observed daily usage;
- **Working time constraints (w)** are computed as the average available working hours, excluding non-working days.

$$Max\ Z = \pi_1 x_1 + \pi_2 x_2$$

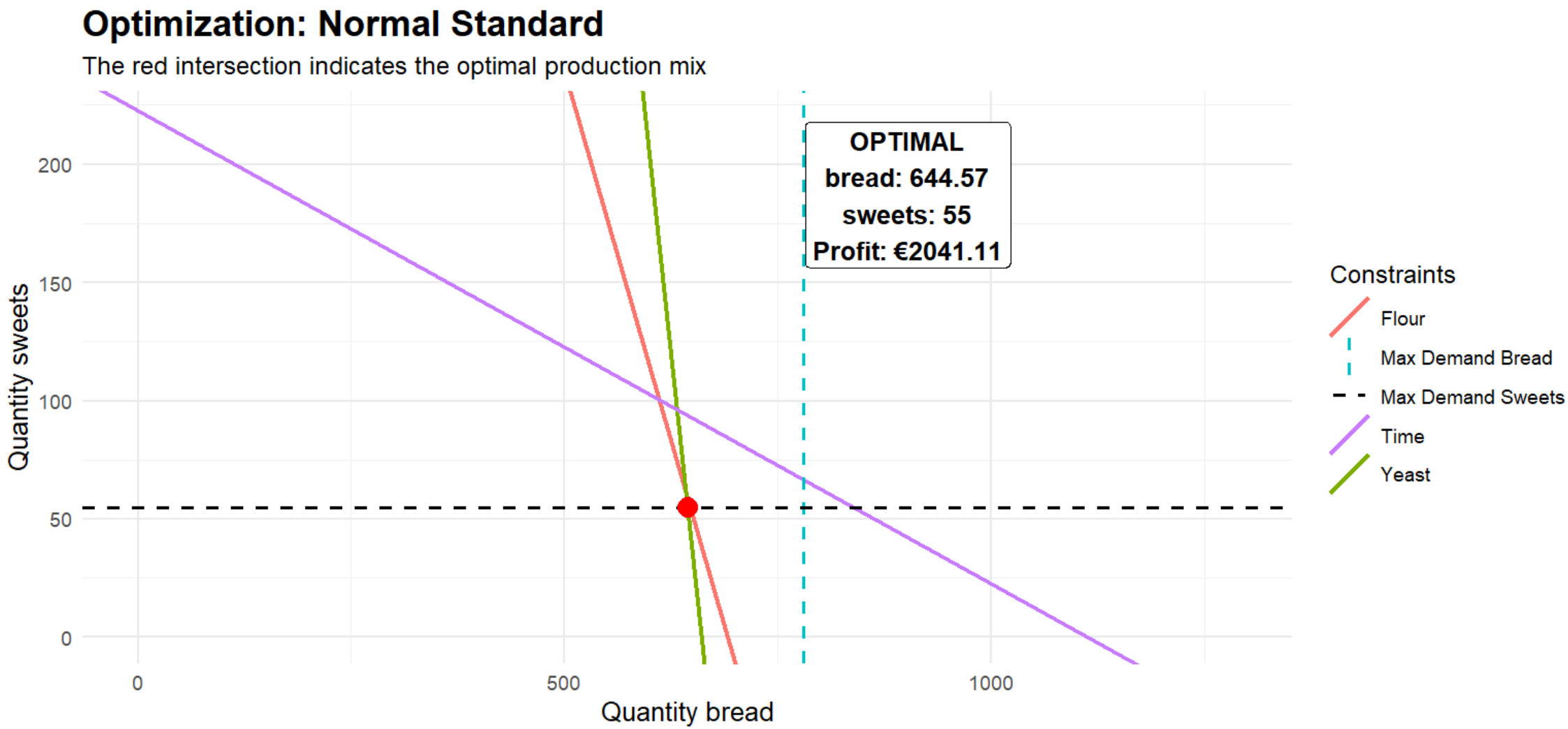
Decision Variables:

- x_1 : bread quantity
- x_2 : sweets quantity

Constraints:

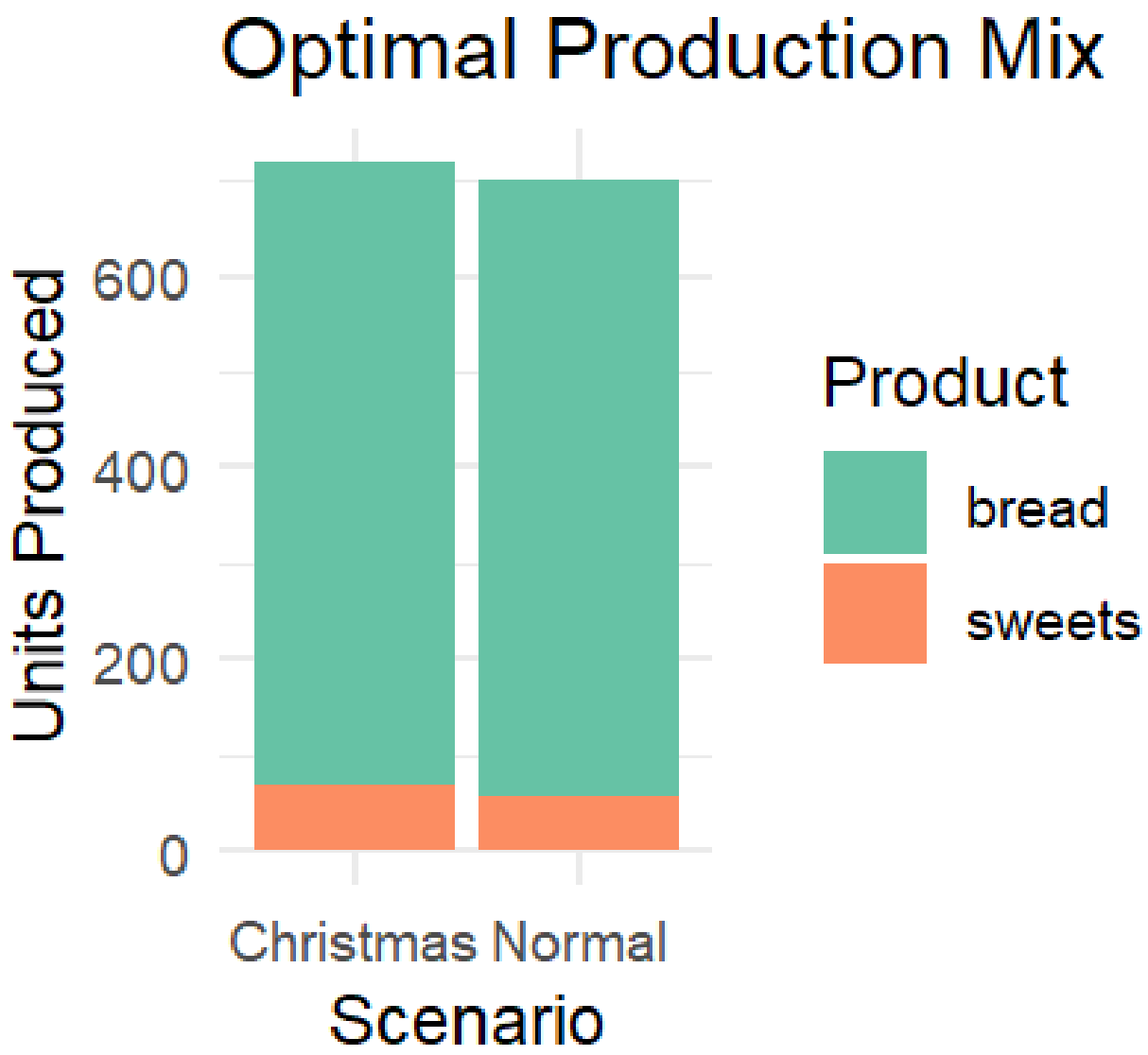
$$\begin{cases} f_1 x_1 + f_2 x_2 \leq F \text{ (flour)} \\ l_1 x_1 + l_2 x_2 \leq L \text{ (yeast)} \\ w_1 x_1 + w_2 x_2 \leq W \text{ (labour)} \\ x_1 \leq D_1, x_2 \leq D_2 \text{ (market demand)} \end{cases}$$

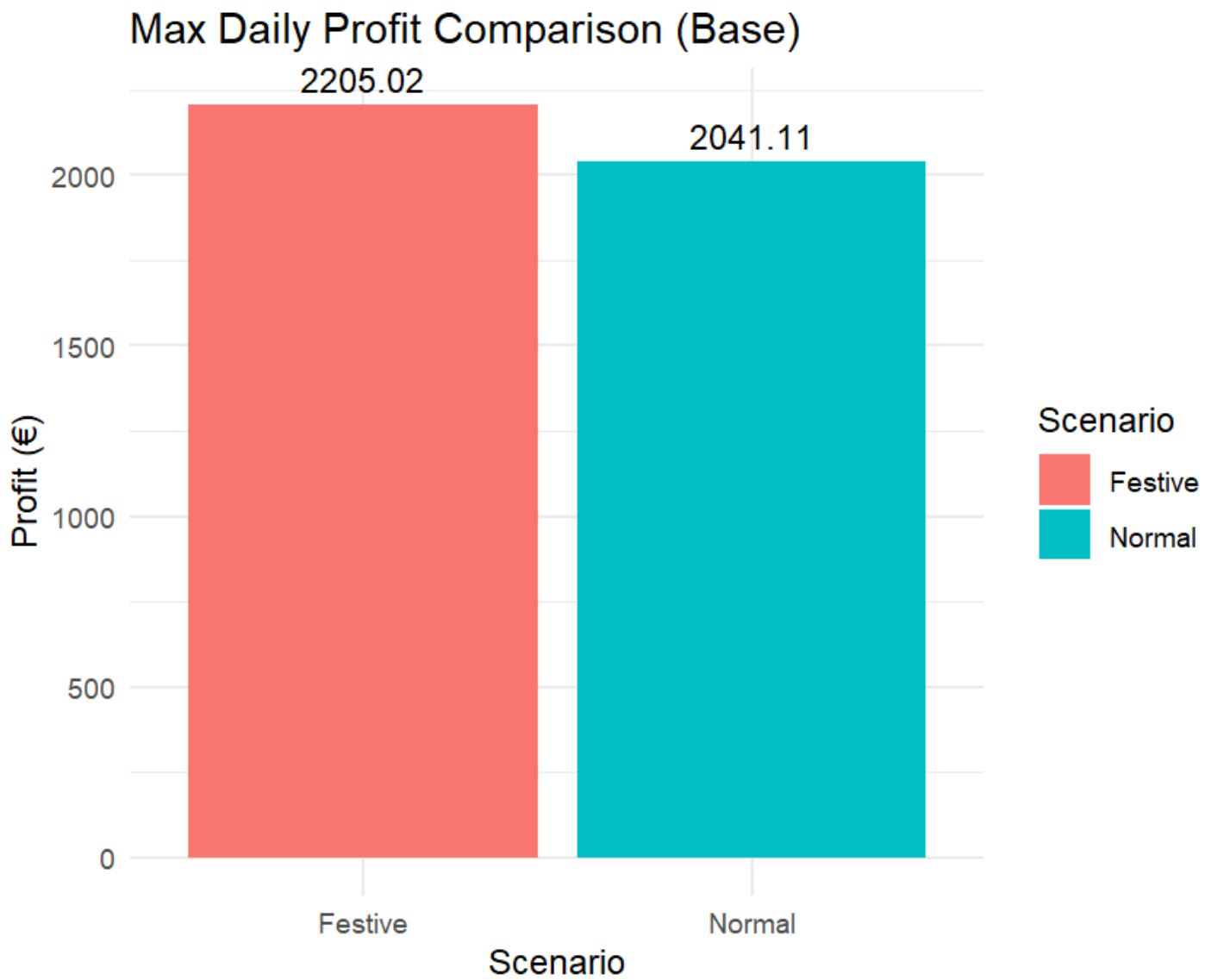
Optimized Production Results			
Period	**Product**	**Quantity**	**Total Profit**
Normal Days	Bread	644.58	
	Sweets	55.00	€ 2,041.11
Festive Days	Bread	651.20	
	Sweets	67.00	€ 2,205.02

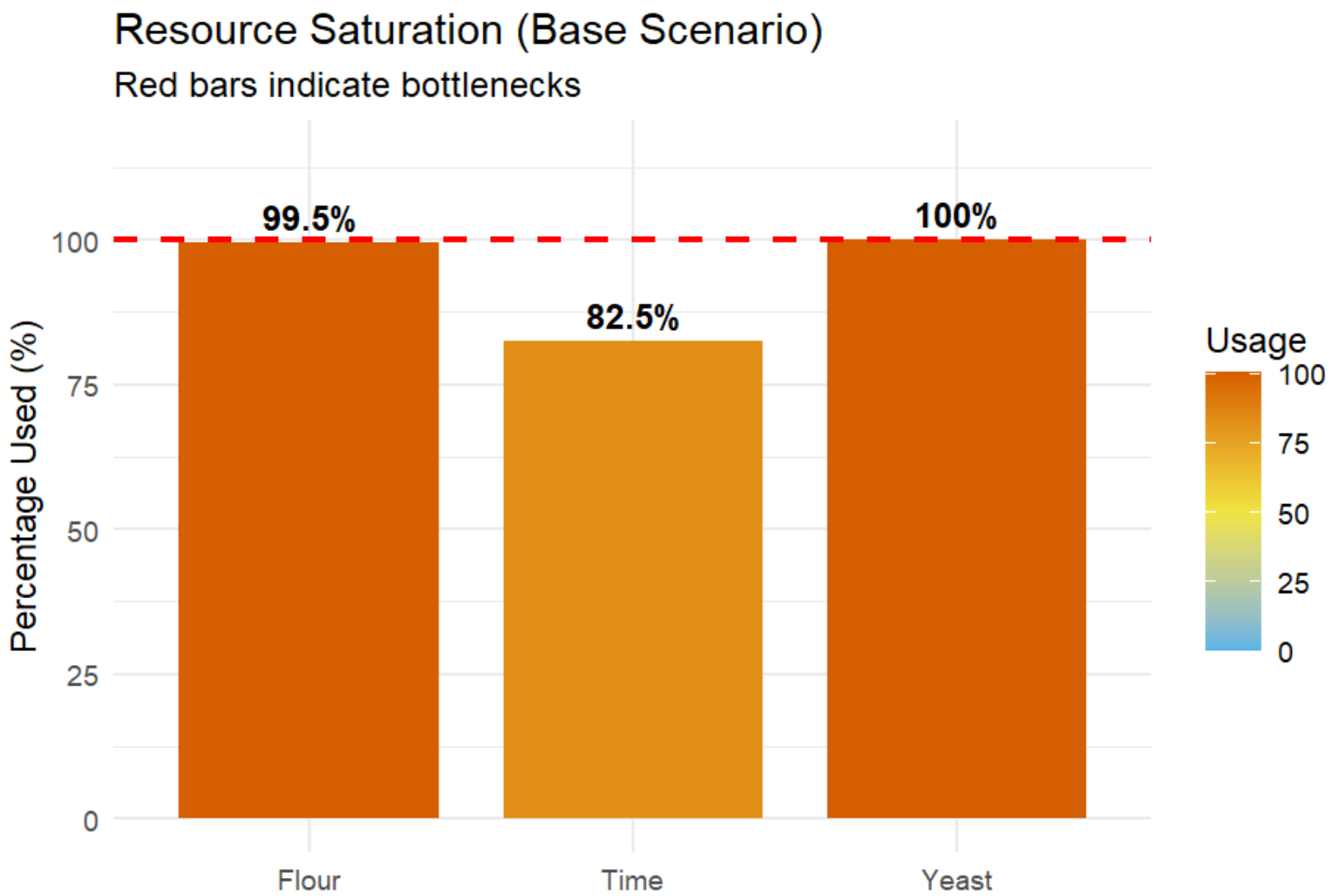

Optimization: Normal Standard
The red intersection indicates the optimal production mix
OPTIMAL
bread: 644.57
sweets: 55
Profit: €2041.11
Quantity sweets
200
150
100
50
0
0
500
1000
Quantity bread
Constraints
Flour
Max Demand Bread
Max Demand Sweets
Time
Yeast

Optimization: Festive Standard

The red intersection indicates the optimal production mix


Optimal Production Mix
Units Produced
600
400
200
0
Christmas
Normal
Scenario
Product
bread
sweets


Max Daily Profit Comparison (Base)
2205.02
2041.11
2000
1500
1000
500
0
Profit (€)
Festive
Normal
Scenario
Scenario
Festive
Normal


Resource Saturation (Base Scenario)
Red bars indicate bottlenecks
Percentage Used (%)
100
75
50
25
0
99.5%
82.5%
100%
Flour
Time
Yeast
Usage
100
75
50
25
0

New Market Scenario

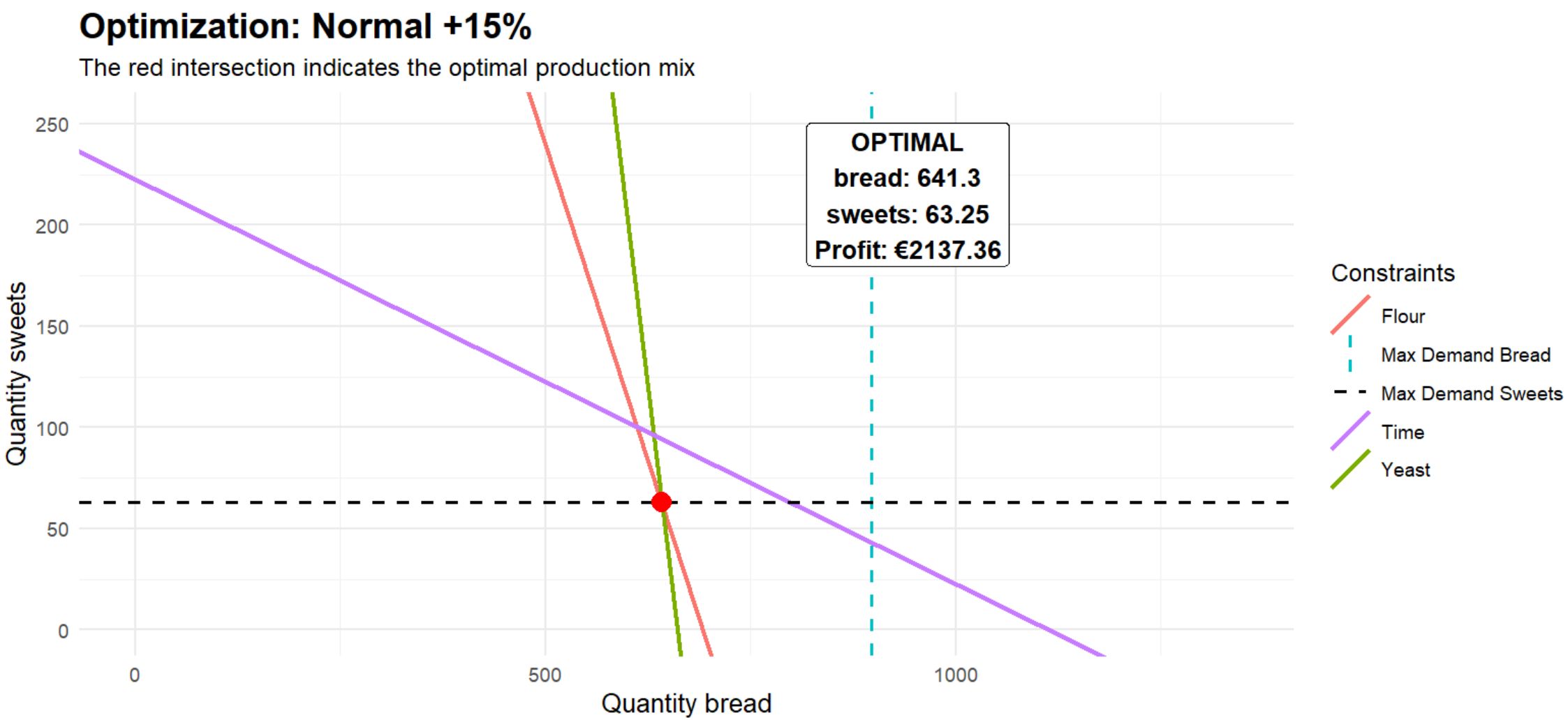
Context: increasing in demand +15%

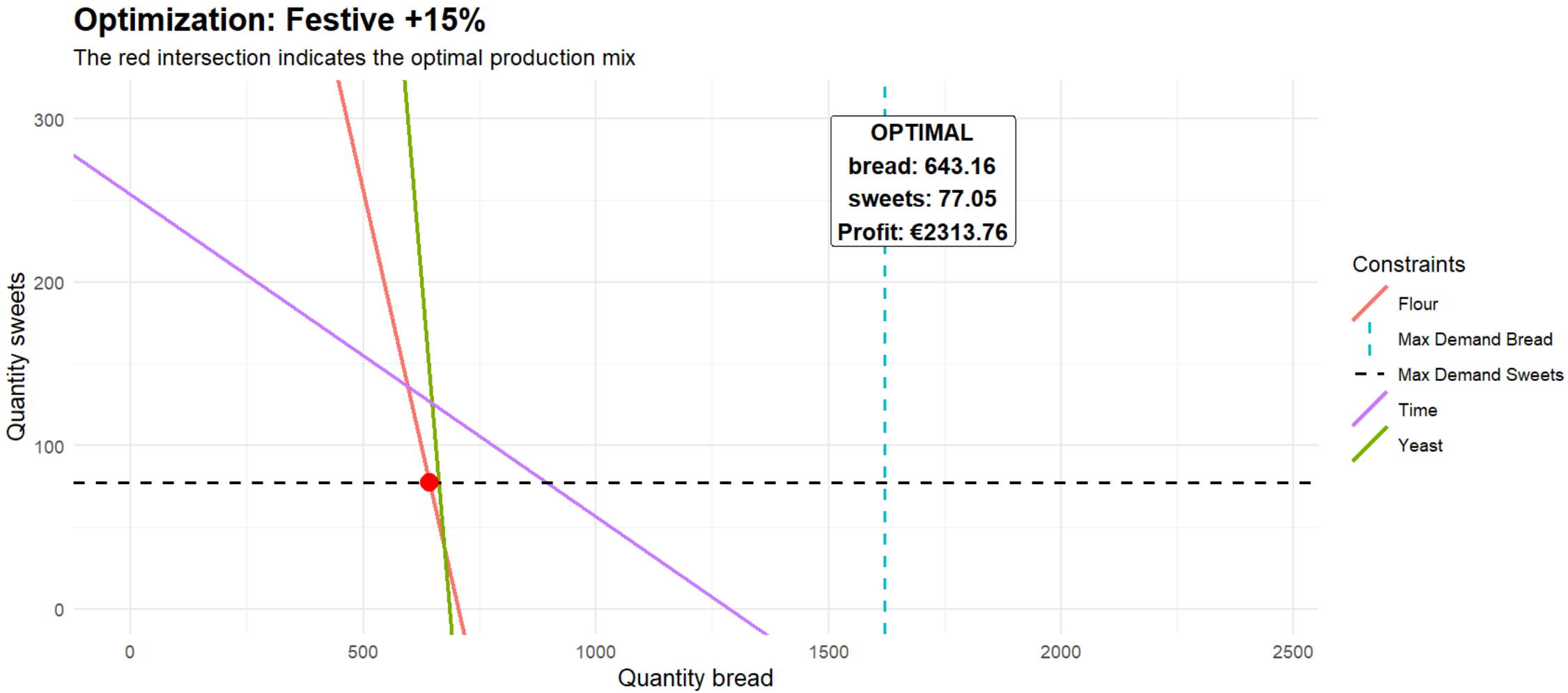
Strategic impact: our model created a new distribution of raw materials, showing the new optimal production

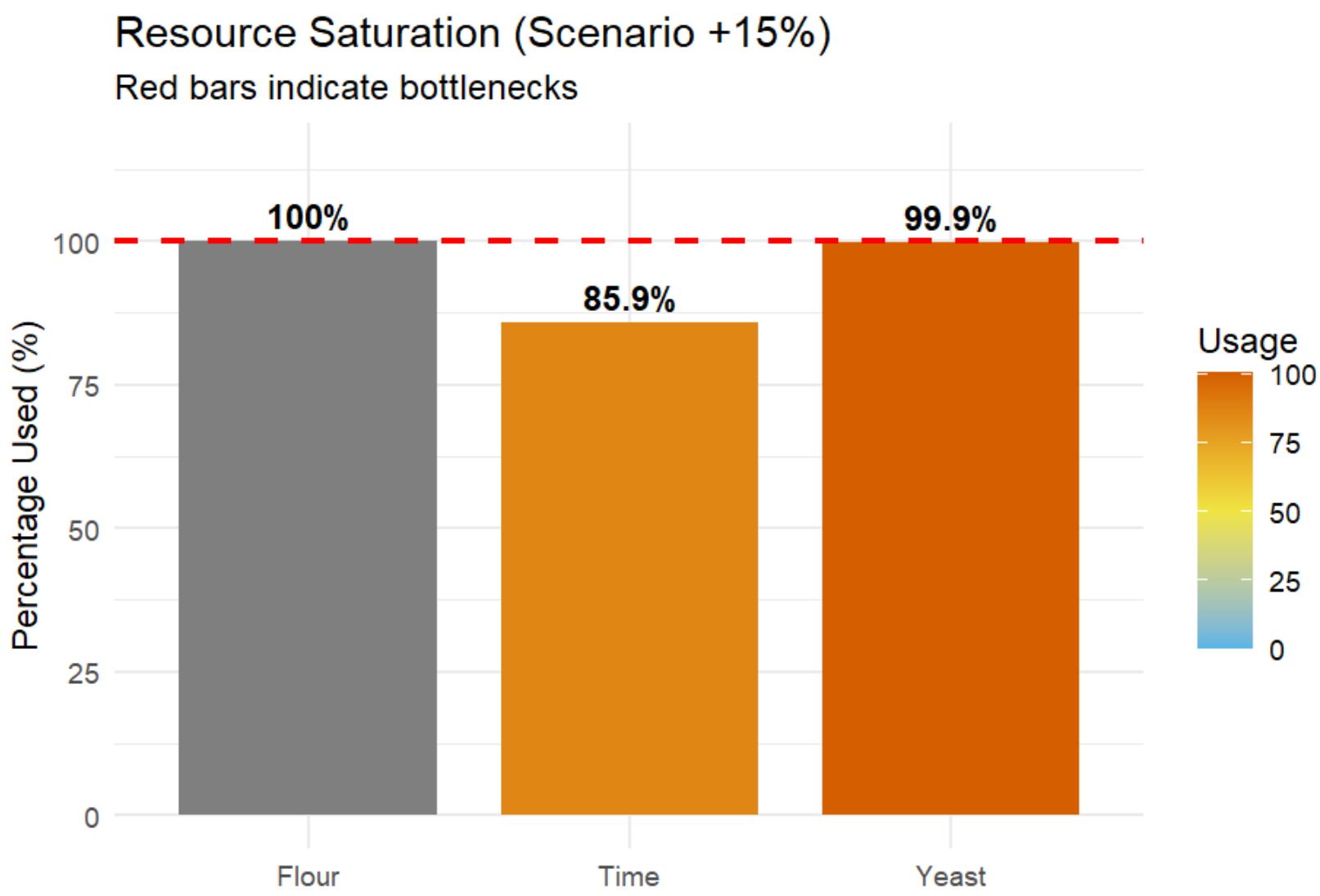
$$D_{1,2} = +15\% \text{ (market demand)}$$

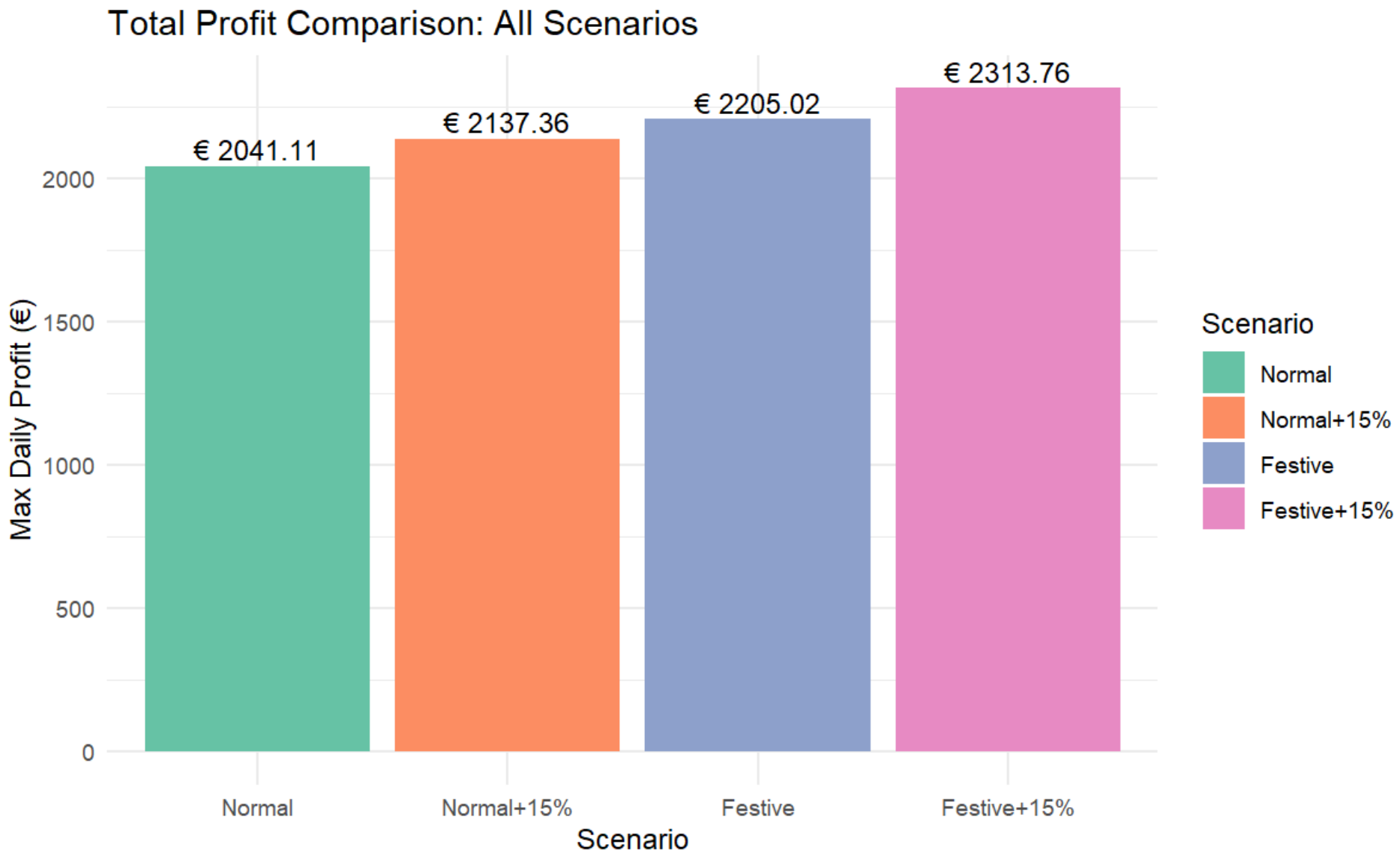
Results with Demand Increment (+15%)

Period	Product	Quantity	Total Profit
Normal Days	Bread	641.30	€ 2,137.36
	Sweets	63.25	
Festive Days	Bread	643.16	€ 2,313.76
	Sweets	77.05	


Optimization: Normal +15%
The red intersection indicates the optimal production mix
OPTIMAL
bread: 641.3
sweets: 63.25
Profit: €2137.36
Quantity sweets
250
200
150
100
50
0
0
500
1000
Quantity bread
Constraints
Flour
Max Demand Bread
Max Demand Sweets
Time
Yeast


Optimization: Festive +15%
The red intersection indicates the optimal production mix
OPTIMAL
bread: 643.16
sweets: 77.05
Profit: €2313.76
Quantity sweets
Quantity bread
0
100
200
300
0
500
1000
1500
2000
2500
Constraints
Flour
Max Demand Bread
Max Demand Sweets
Time
Yeast


Resource Saturation (Scenario +15%)
Red bars indicate bottlenecks
Percentage Used (%)
100
75
50
25
0
100%
85.9%
99.9%
Flour
Time
Yeast
Usage
100
75
50
25
0


Total Profit Comparison: All Scenarios
€ 2041.11
€ 2137.36
€ 2205.02
€ 2313.76
2000
1500
1000
500
0
Max Daily Profit (€)
Normal
Normal+15%
Festive
Festive+15%
Scenario
Scenario
Normal
Normal+15%
Festive
Festive+15%

Let's compare the results

With an increase in demand pf 15% on normal days the profit will increase by **4.7%** and on holidays by **4.9%**

Period	Variable	Base scenario	New scenario	difference
Normal days	Bread	644,58	641.30	**-3.28**
	Sweets	55	63.25	**+8.25**
	Profit	2041,11	2,137.36	**+96.25**
Festive days	Bread	651,20	643.16	**-8.04**
	Sweets	67,00	77.05	**+10.05**
	Profit	2205,02	2,313.76	**+108.74**

Let's compare the results

When the market demands more product (+15%), the bakery does not simply increase its entire production.

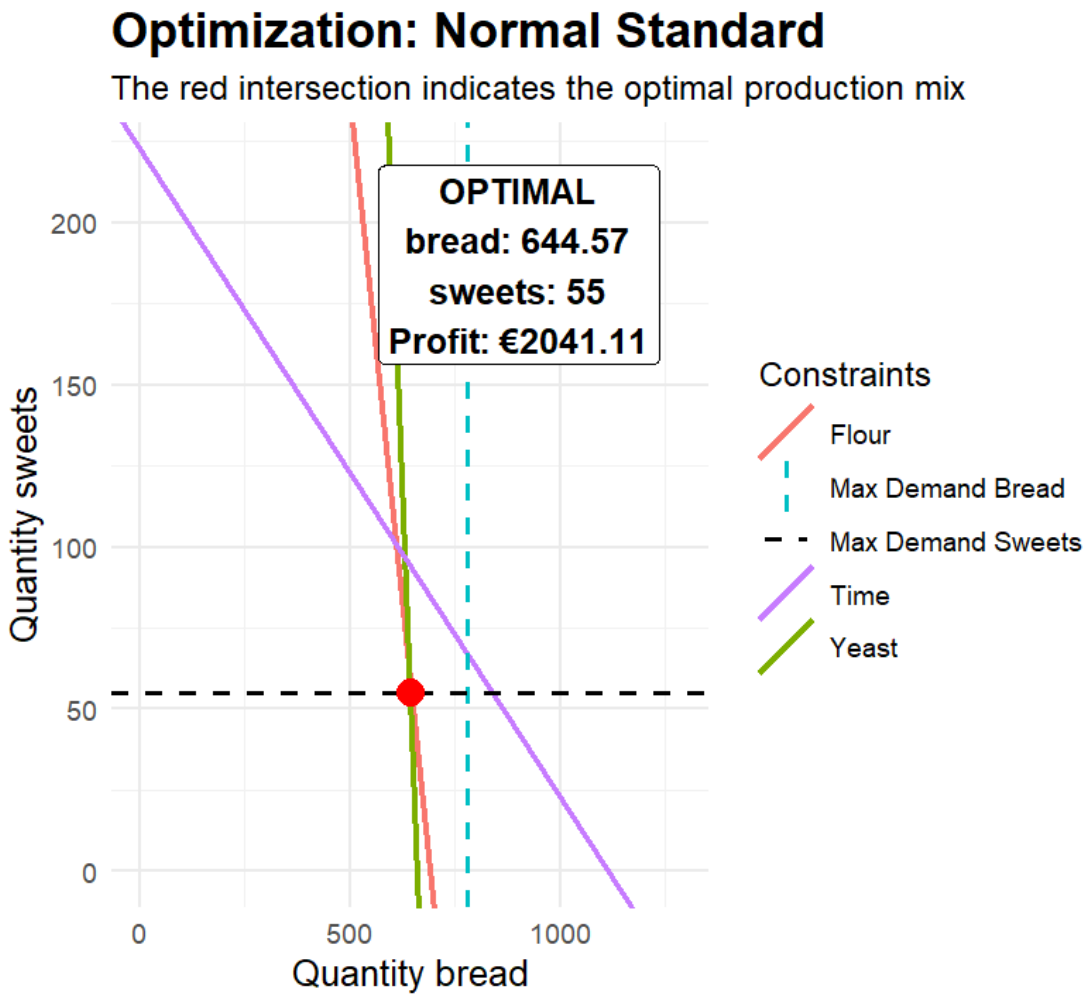
Makes a strategic choice:

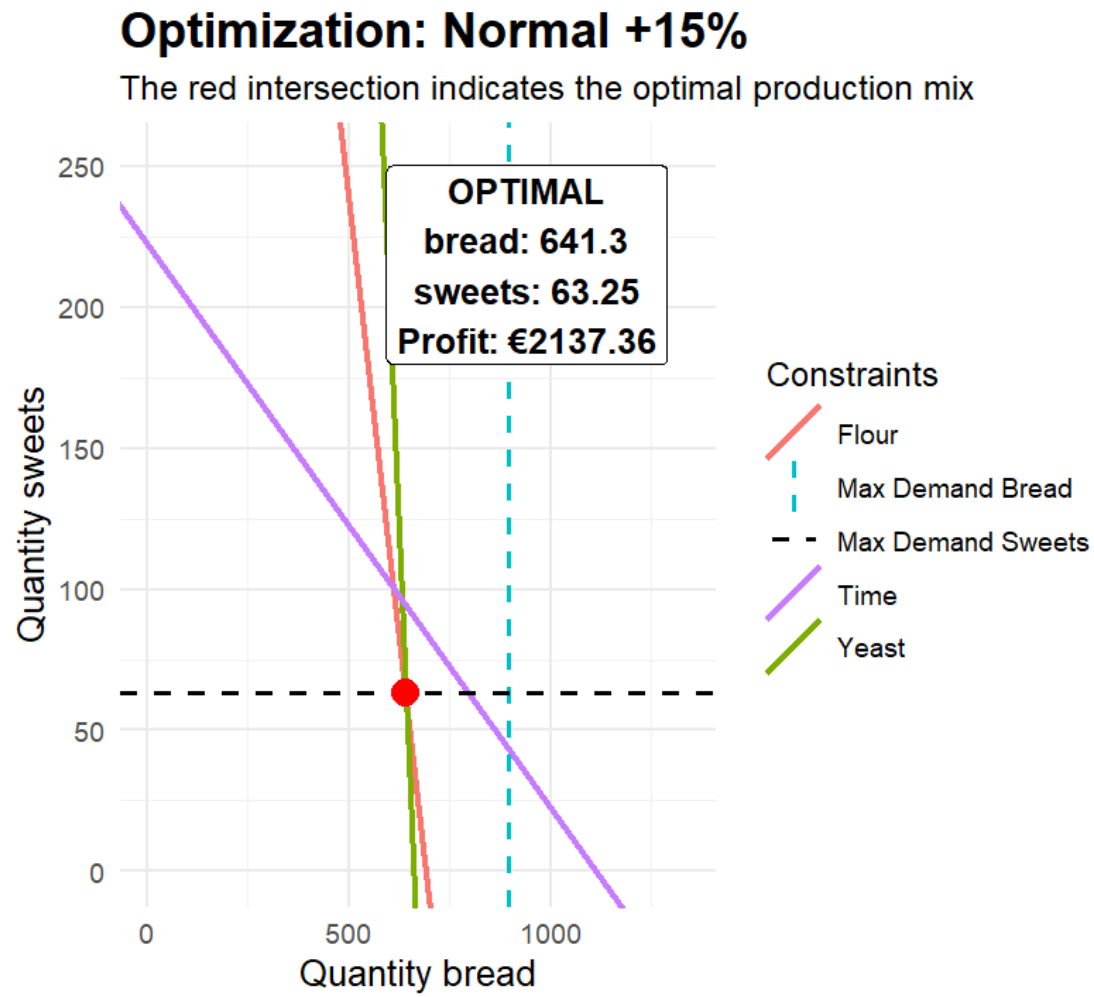
- slightly reduces bread
- increases sweets, because sweets generate more profit per unit of resource (time/flour/yeast).

So the result is:

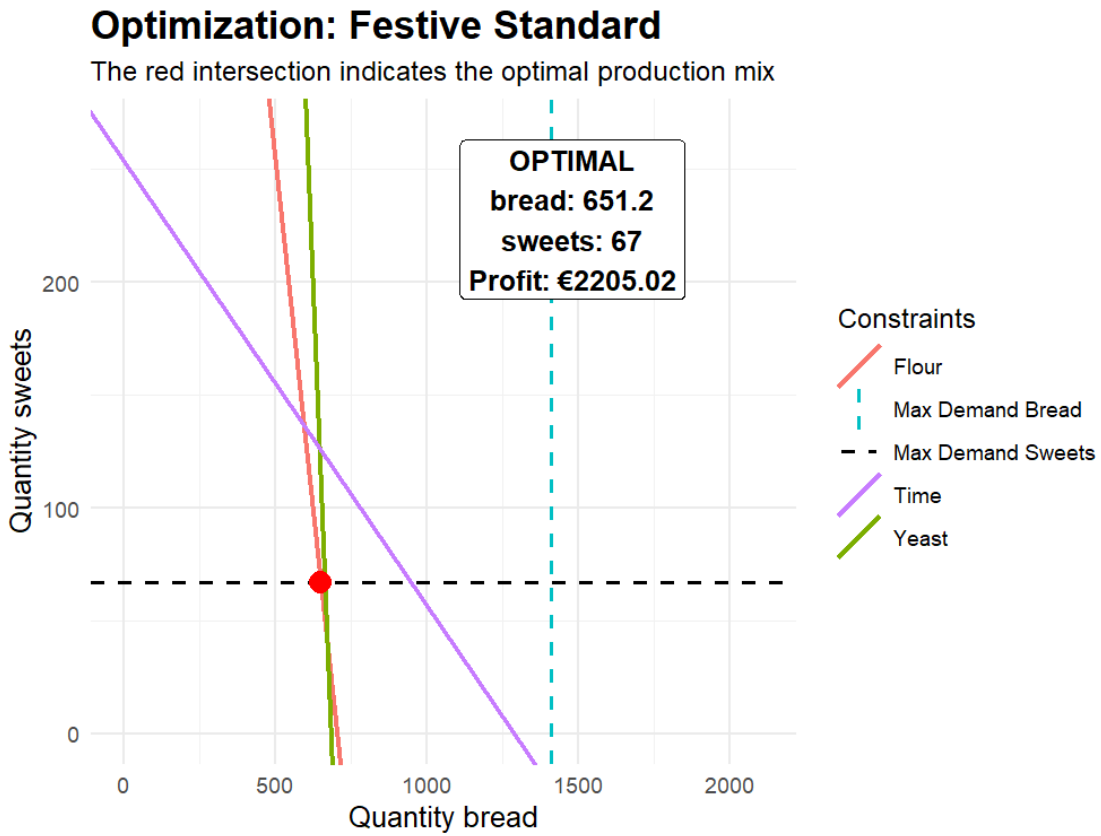
- bread remains a basic product
- the growth must be absorbed above all by increasing the sweets

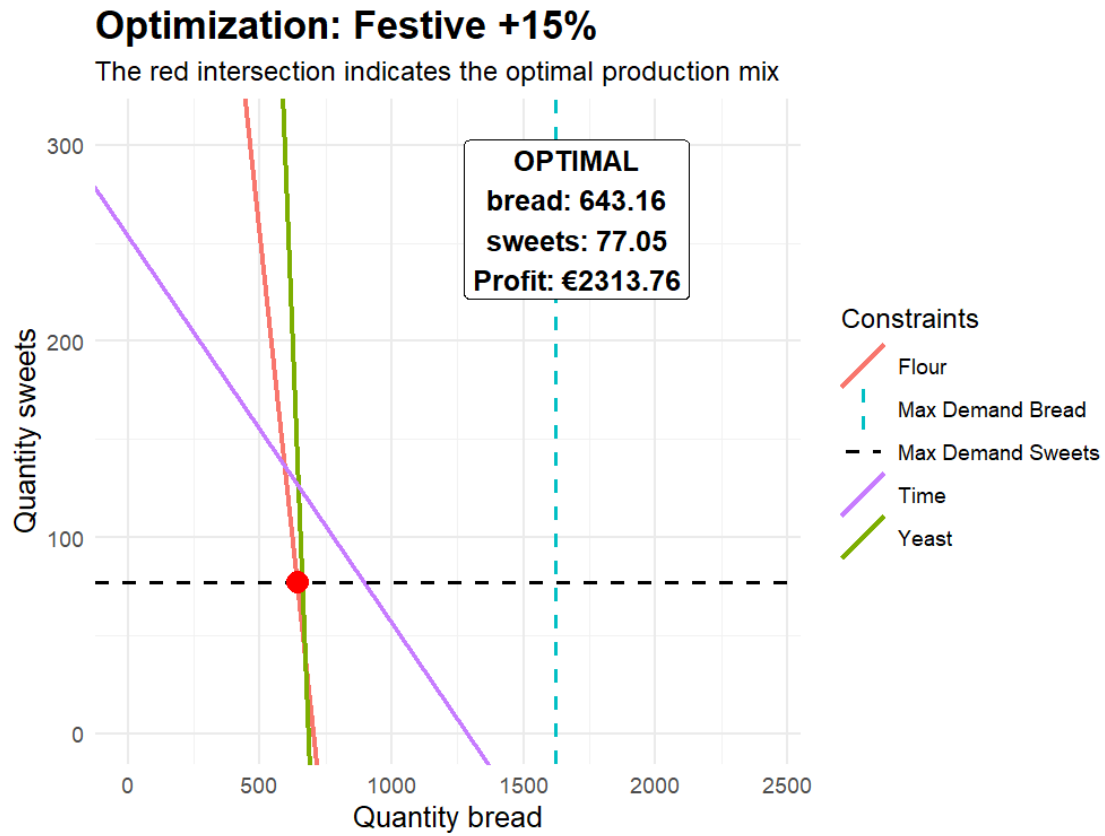
Comparison: Normal vs Normal +15%





Comparison: Festive vs Festive +15%





Practical advice for the baker:

TIP 1: If demand increases, don't increase everything.

The optimal strategy is: maintain stable bread and increase sweets. Because bread is a necessary product as a presence on the market, but it is not the one that maximizes profit.

TIP 2: the problem (bottleneck) is production capacity (time, flour, yeast)

If the bread decreases and sweets increase, it means that the bakery is working close to the limit of the constraints (working hours, flour, yeast).

The bakery does not have the resources necessary to increase all production, it must only increase the product that increases profit.

TIP 3: On holidays it is even more convenient to focus on sweets.

The increase in sweets on public holidays is greater (+10.05 versus +8.25 on normal days).

During the Christmas period, the production of sweets must be greatly increased and the production of bread must be reduced to a sustainable minimum.