



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

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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.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
date	product	price	costs	unit margin (p-c)	time	flour	yeast	quantity produced	demand	real profit	daily real profit	max profit	daily max profit	real used time(h)	total real used time(h)
lunedì 1 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	610	608	1.276,80 €	1.314,30 €	1.281,00 €	1.468,50 €	48,80	54,80
lunedì 1 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	15	3	37,50 €		187,50 €		6,00	
martedì 2 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	638	1.339,80 €	1.377,30 €	1.365,00 €	1.490,00 €	52,00	56,00
martedì 2 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	10	3	37,50 €		125,00 €		4,00	
mercoledì 3 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	640	640	1.344,00 €	1.494,00 €	1.344,00 €	2.219,00 €	51,20	79,20
mercoledì 3 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	70	12	150,00 €		875,00 €		28,00	
giovedì 4 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	645	1.354,50 €	2.042,00 €	1.365,00 €	1.827,50 €	52,00	66,80
giovedì 4 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	37	55	687,50 €		462,50 €		14,80	
venerdì 5 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	650	651,00 €	1.026,00 €	1.365,00 €	1.552,50 €	52,00	58,00
venerdì 5 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	15	30	375,00 €		187,50 €		6,00	
sabato 6 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	800	780	1.638,00 €	2.138,00 €	1.680,00 €	1.680,00 €	64,00	64,00
sabato 6 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	0	40	500,00 €		0,00 €		0,00	
domenica 7 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	310	310	651,00 €	676,00 €	651,00 €	651,00 €	24,80	24,80
domenica 7 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	0	2	25,00 €		0,00 €		0,00	
lunedì 8 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	600	580	1.218,00 €	1.230,50 €	1.260,00 €	1.472,50 €	48,00	54,80
lunedì 8 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	17	1	12,50 €		212,50 €		6,80	
martedì 9 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	650	1.365,00 €	1.427,50 €	1.365,00 €	1.490,00 €	52,00	56,00
martedì 9 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	10	5	62,50 €		125,00 €		4,00	
mercoledì 10 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	625	1.312,50 €	1.362,50 €	1.365,00 €	2.240,00 €	52,00	80,00
mercoledì 10 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	70	4	50,00 €		875,00 €		28,00	
giovedì 11 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	630	630	1.323,00 €	1.998,00 €	1.323,00 €	1.823,00 €	50,40	66,40
giovedì 11 dicembre 2025	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	40	54	675,00 €		500,00 €		16,00	
sabato 12 dicembre 2026	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	650	650	1.365,00 €	1.677,50 €	1.365,00 €	1.515,00 €	52,00	56,80
sabato 12 dicembre 2026	sweets	22,00 €	9,50 €	12,50 €	0,4	0,6	0,003	12	25	312,50 €		150,00 €		4,80	
sabato 13 dicembre 2025	bread	3,20 €	1,10 €	2,10 €	0,08	0,75	0,01	800	760	1.596,00 €	2.071,00 €	1.680,00 €	1.680,00 €	64,00	64,00

# 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.

$$\textit{Max } Z = \pi_1 X_1 + \pi_2 X_2$$

**Decision Variables:**

- $x_1$  : bread quantity
- $x_2$  : sweets quantity

**Constraints:**

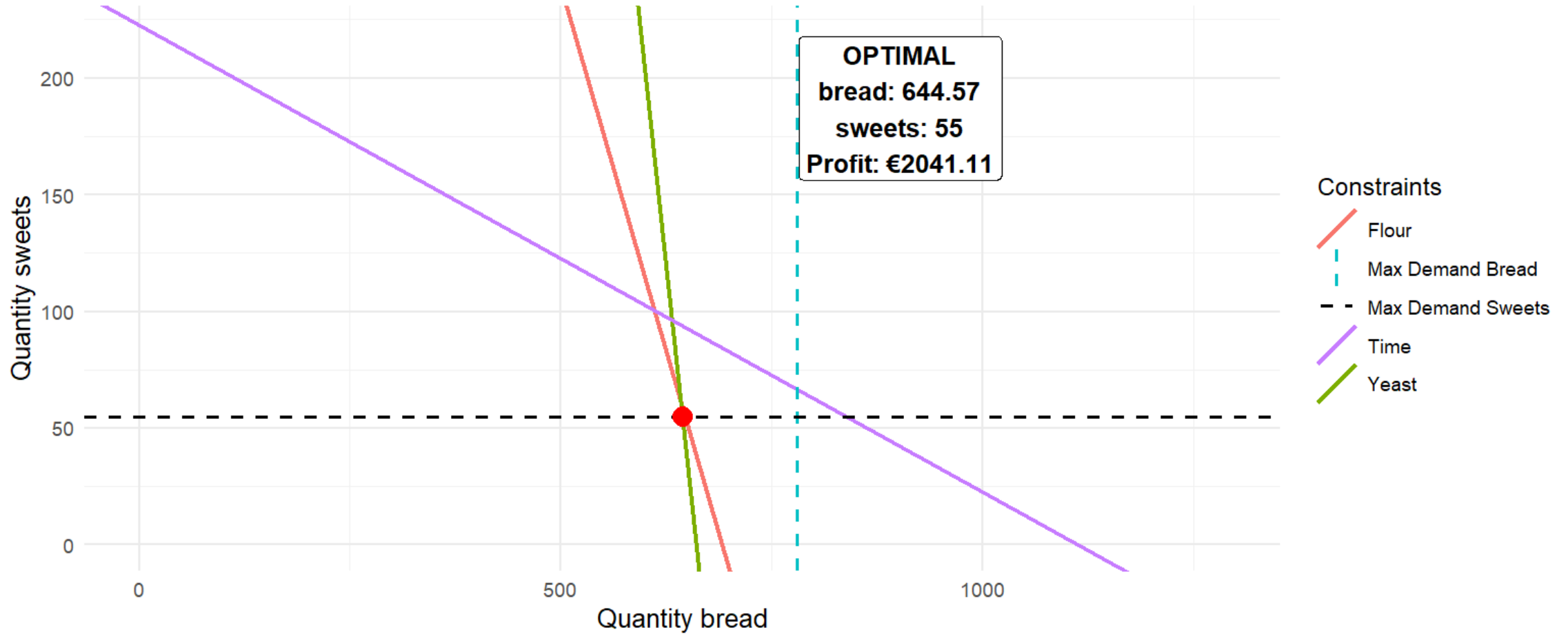
$$\left\{ \begin{array}{l} f_1 x_1 + f_2 x_2 \leq F \text{ (flour)} \\ l_1 x_1 + l_2 x_2 \leq L \text{ (yeast)} \\ w_1 x_1 + w_2 x_2 \leq W \text{ (labour)} \\ x_1 \leq D_1, x_2 \leq D_2 \text{ (market demand)} \end{array} \right.$$

## Optimized Production Results

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

## Optimization: Normal Standard

The red intersection indicates the optimal production mix

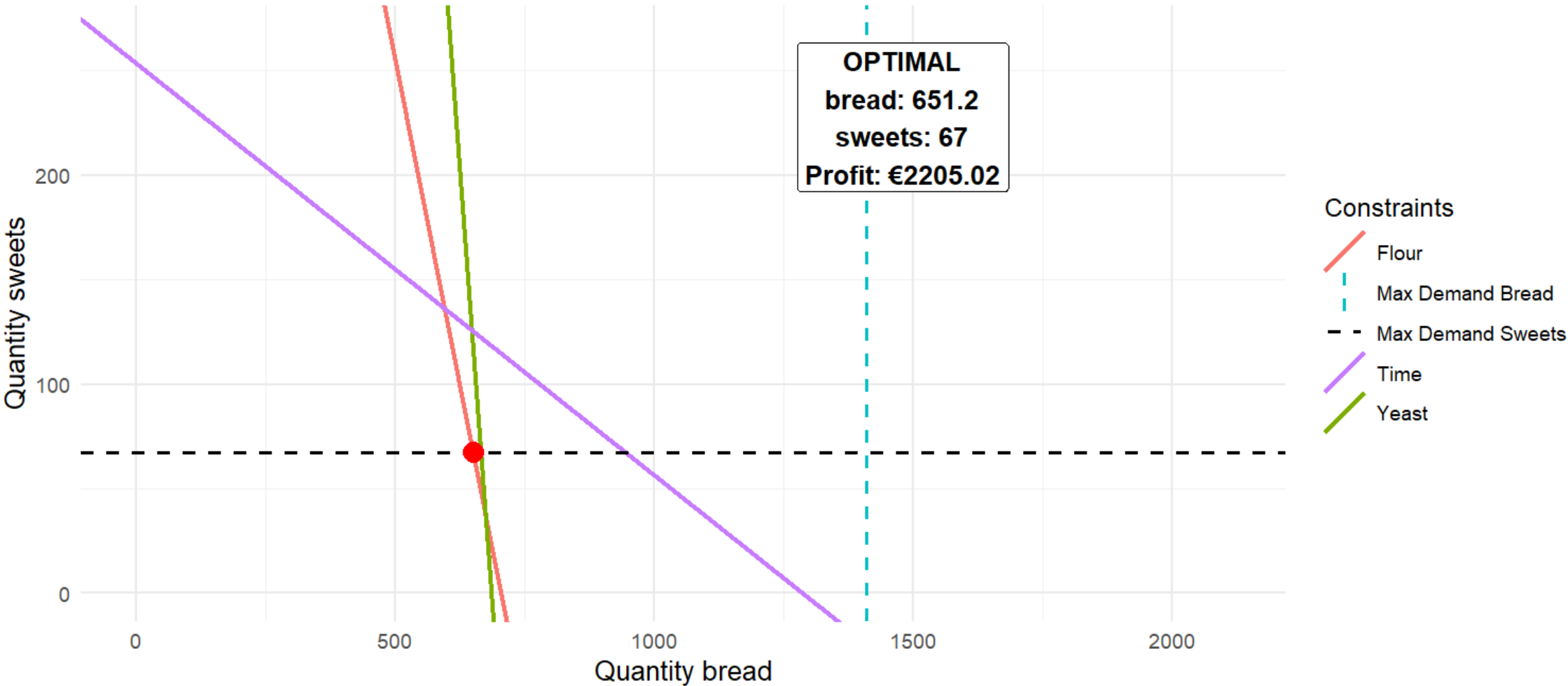




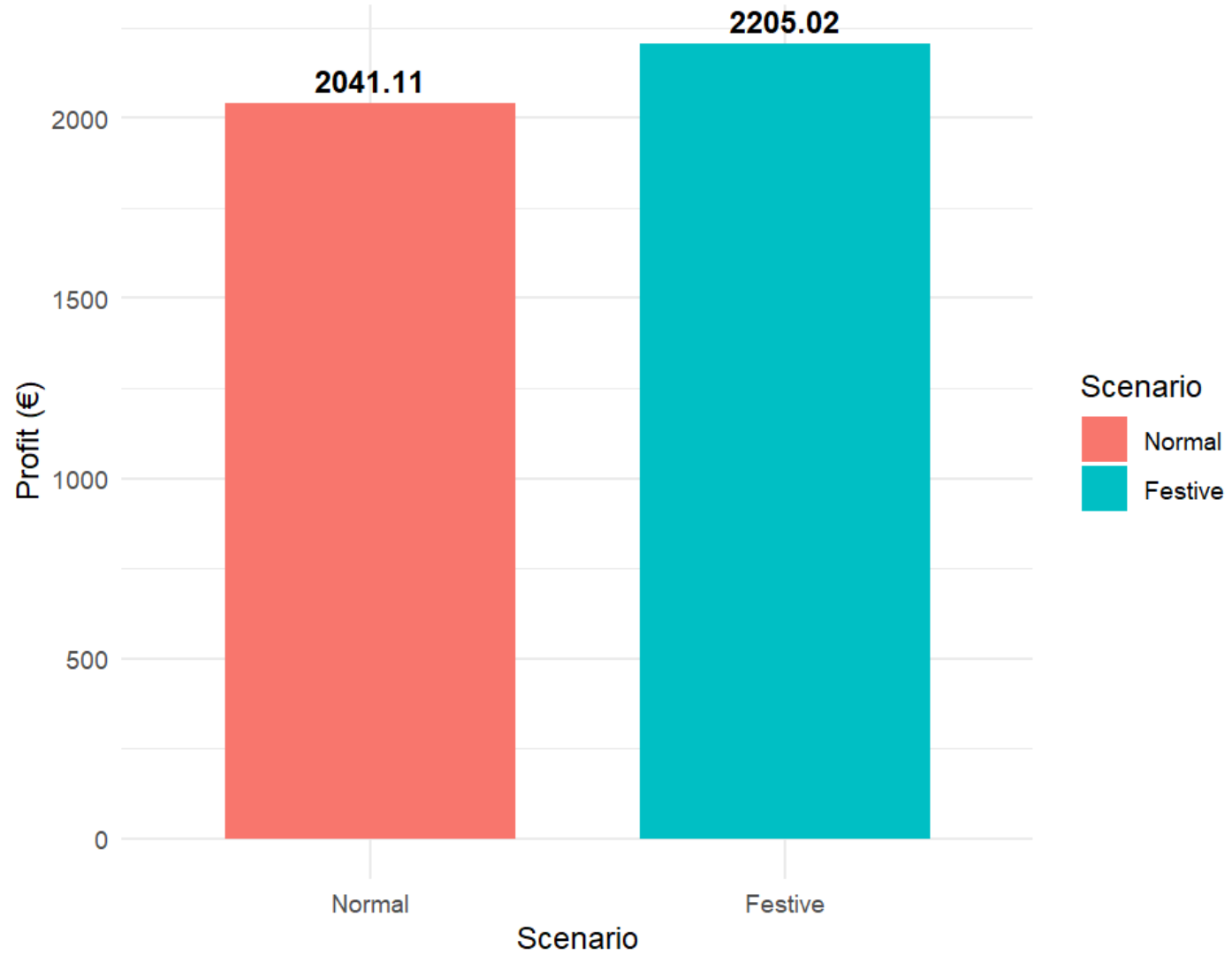
# Optimization: Festive Standard

The red intersection indicates the optimal production mix

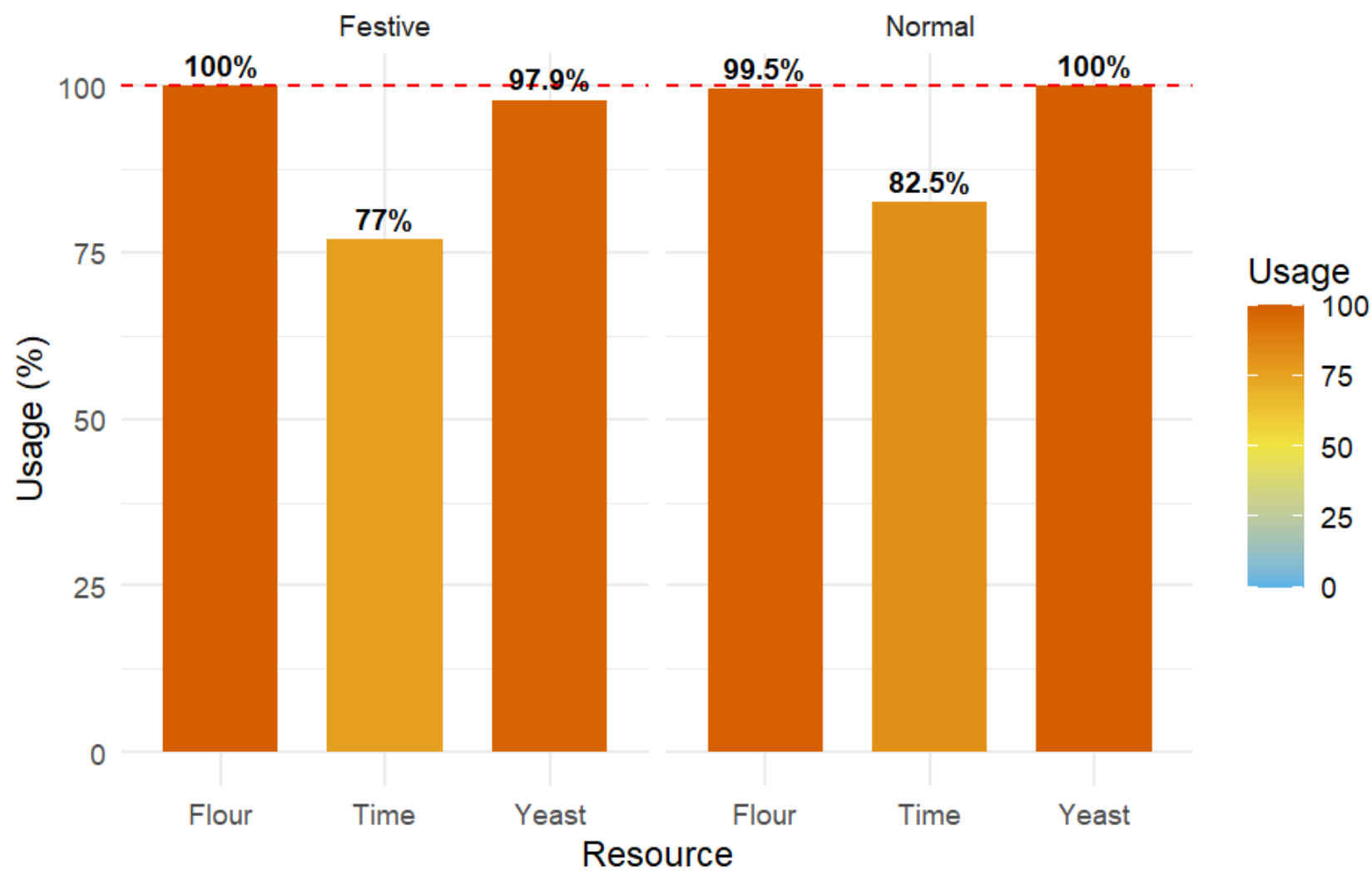
**OPTIMAL**  
bread: 651.2  
sweets: 67  
Profit: €2205.02



Max Daily Profit Comparison



## Resource Saturation: Standard Scenarios



# 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	

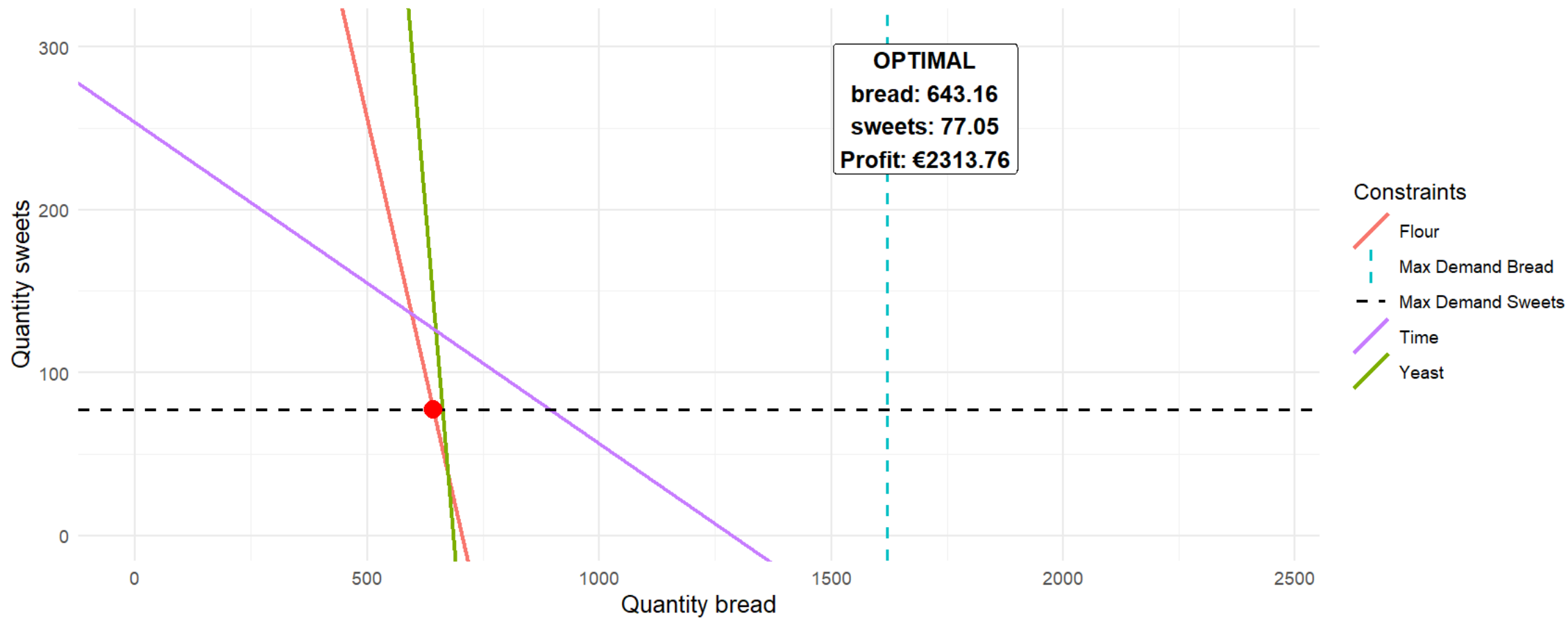
## Optimization: Normal +15%

The red intersection indicates the optimal production mix

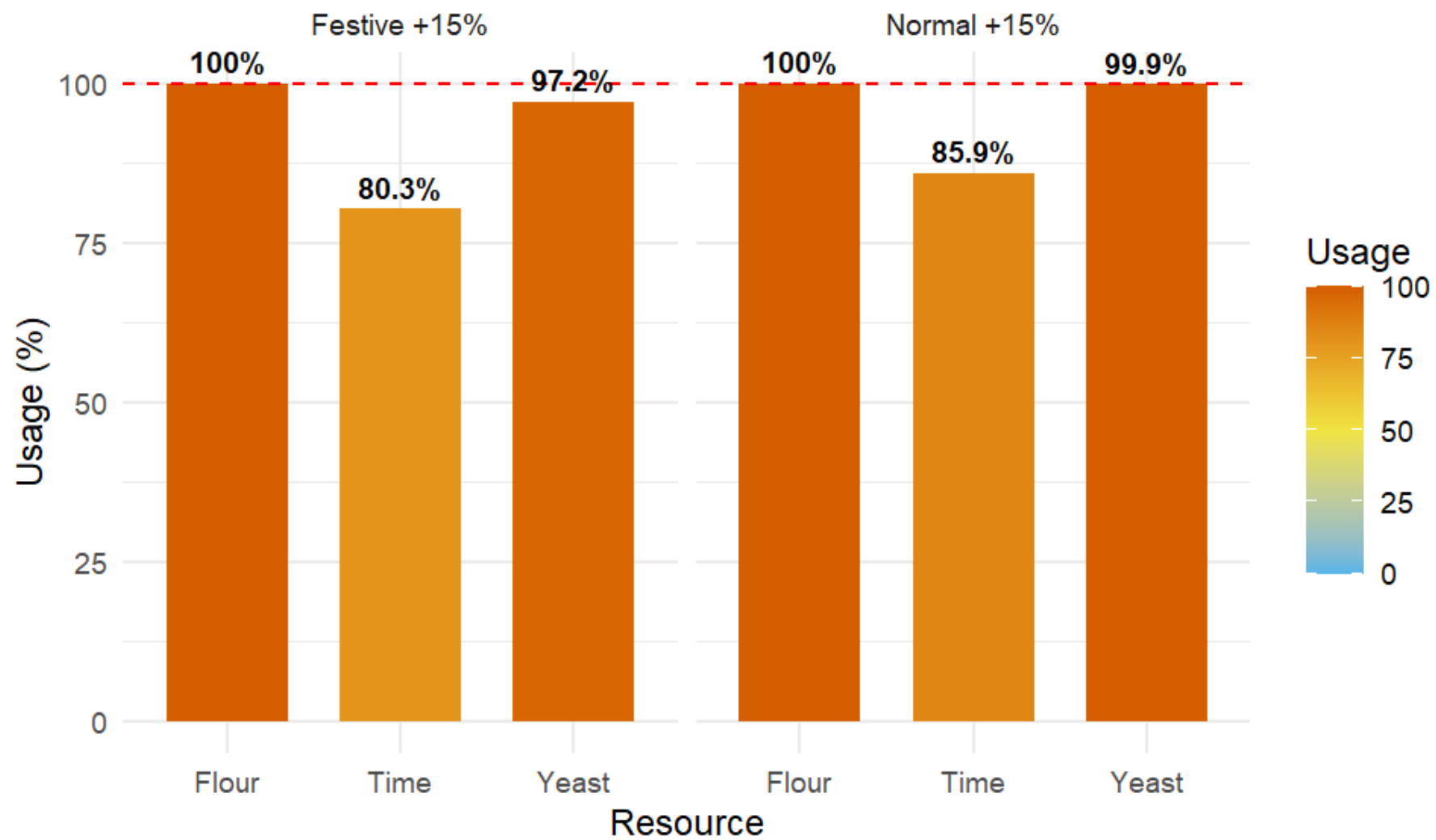


## Optimization: Festive +15%

The red intersection indicates the optimal production mix

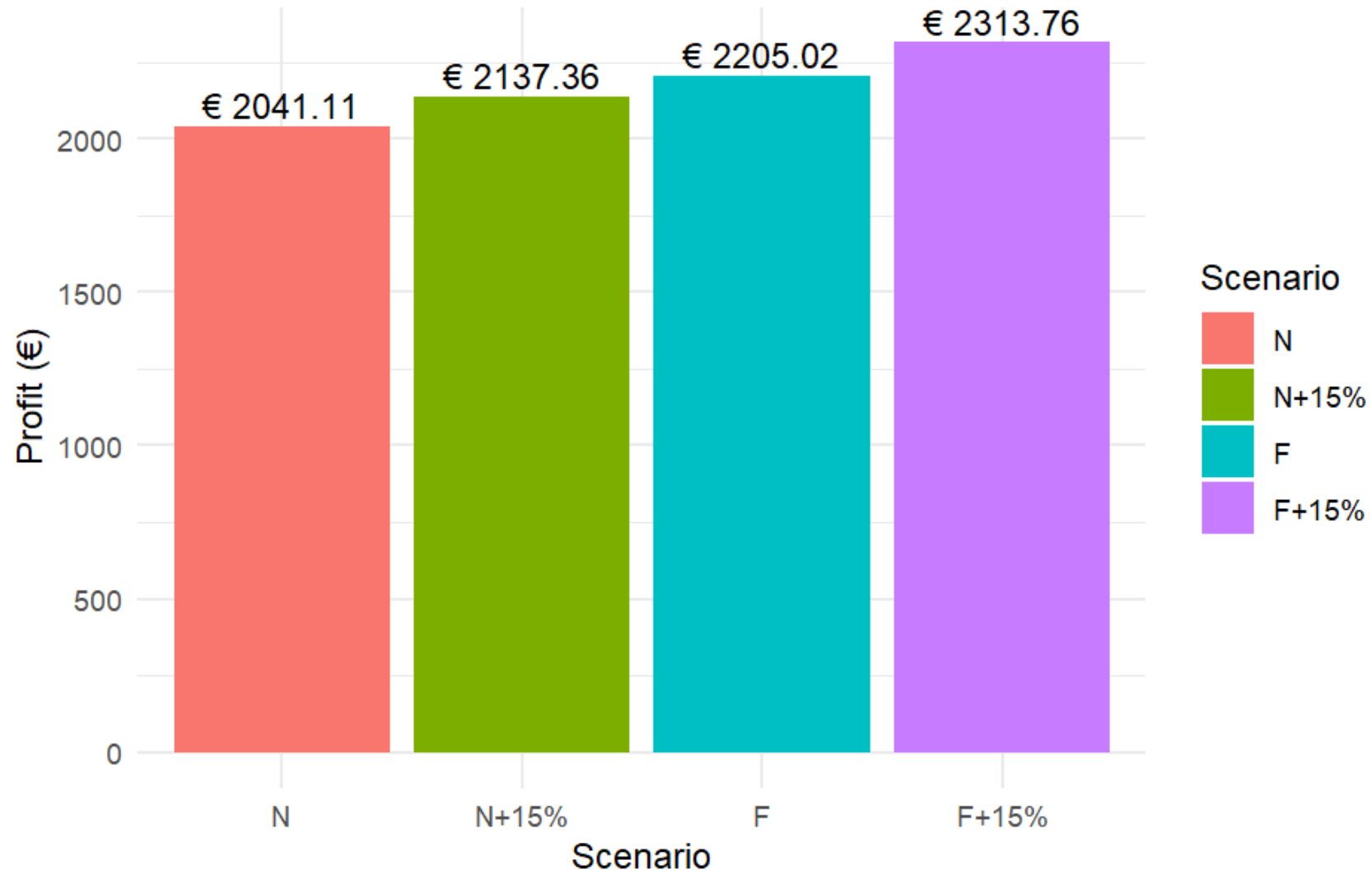


## Resource Saturation: Scenarios +15% Demand





## Max Profit Comparison: All Scenarios



## Let's compare the results

With an increase in demand of 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	<b>-3.28</b>
	Sweets	55	63.25	<b>+8.25</b>
	<b>Profit</b>	2041,11	2,137.36	<b>+96.25</b>
Festive days	Bread	651,20	643.16	<b>-8.04</b>
	Sweets	67,00	77.05	<b>+10.05</b>
	<b>Profit</b>	2205,02	2,313.76	<b>+108.74</b>

## 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).

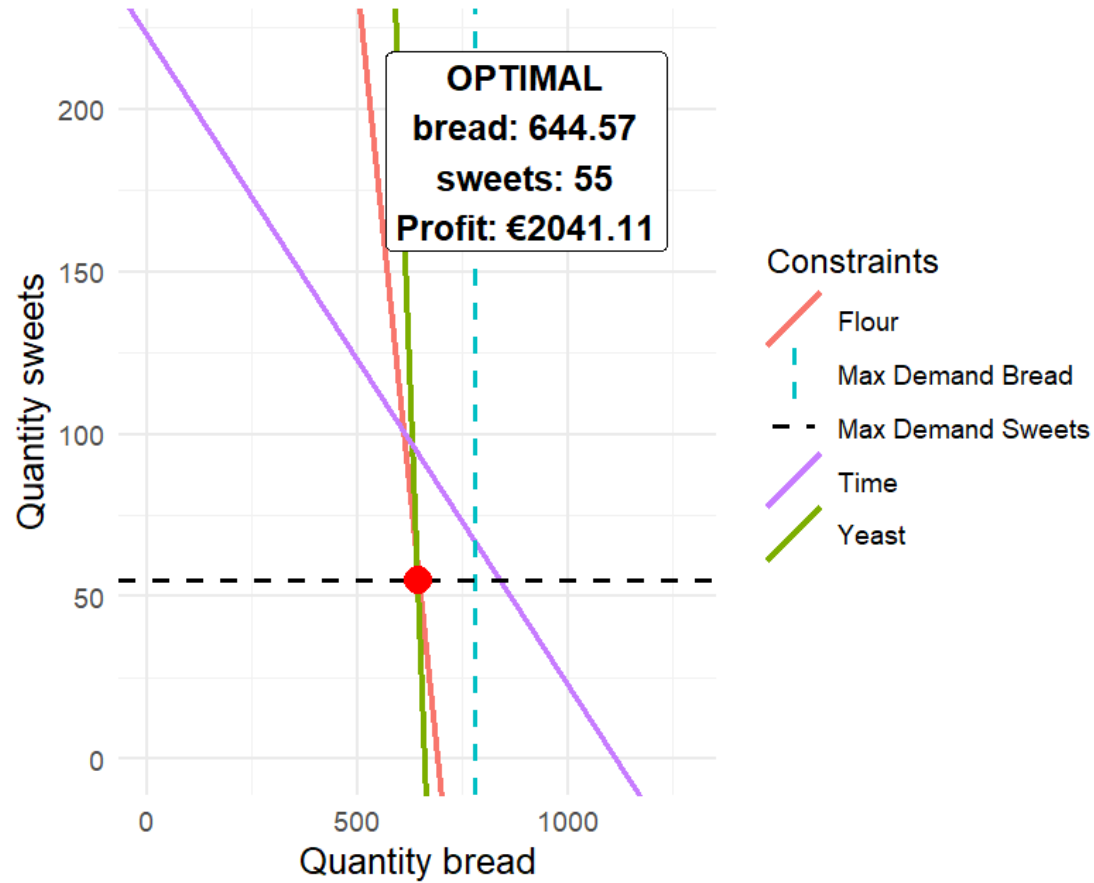
So the result is:

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

Comparison: Normal vs Normal +15%

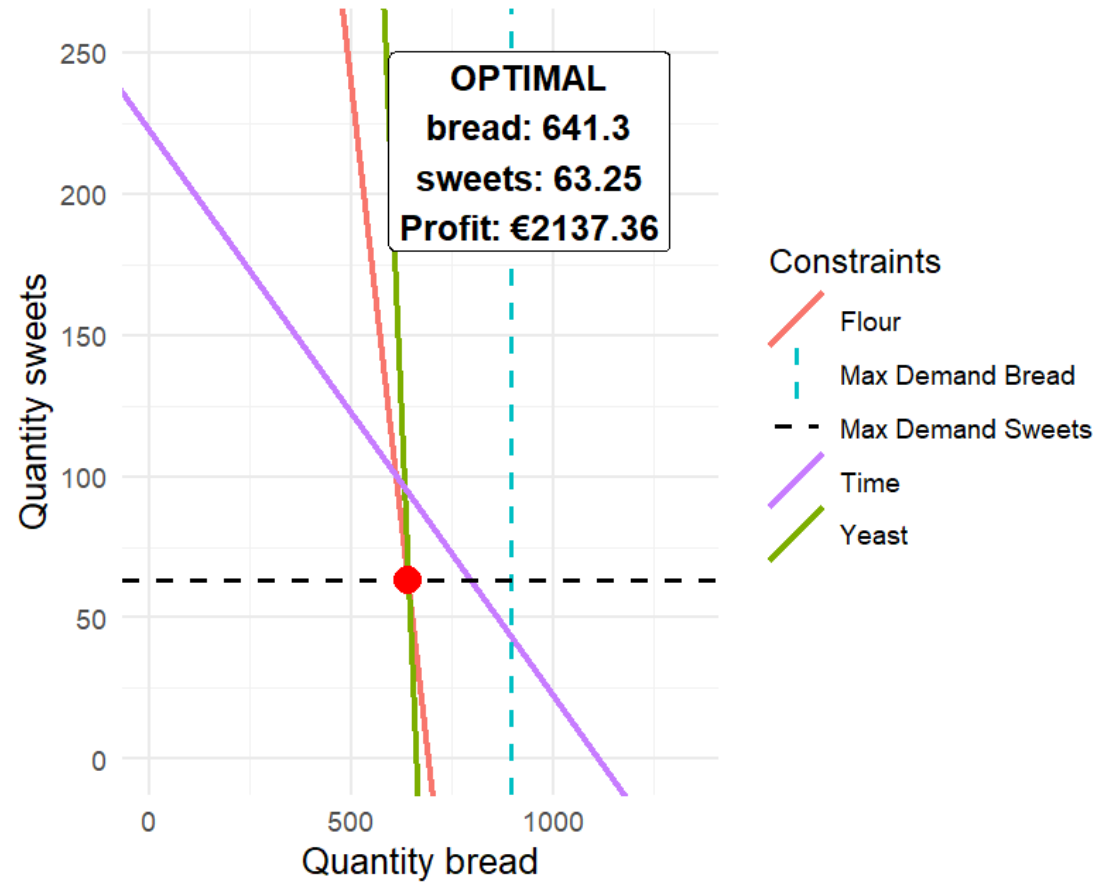
### Optimization: Normal Standard

The red intersection indicates the optimal production mix

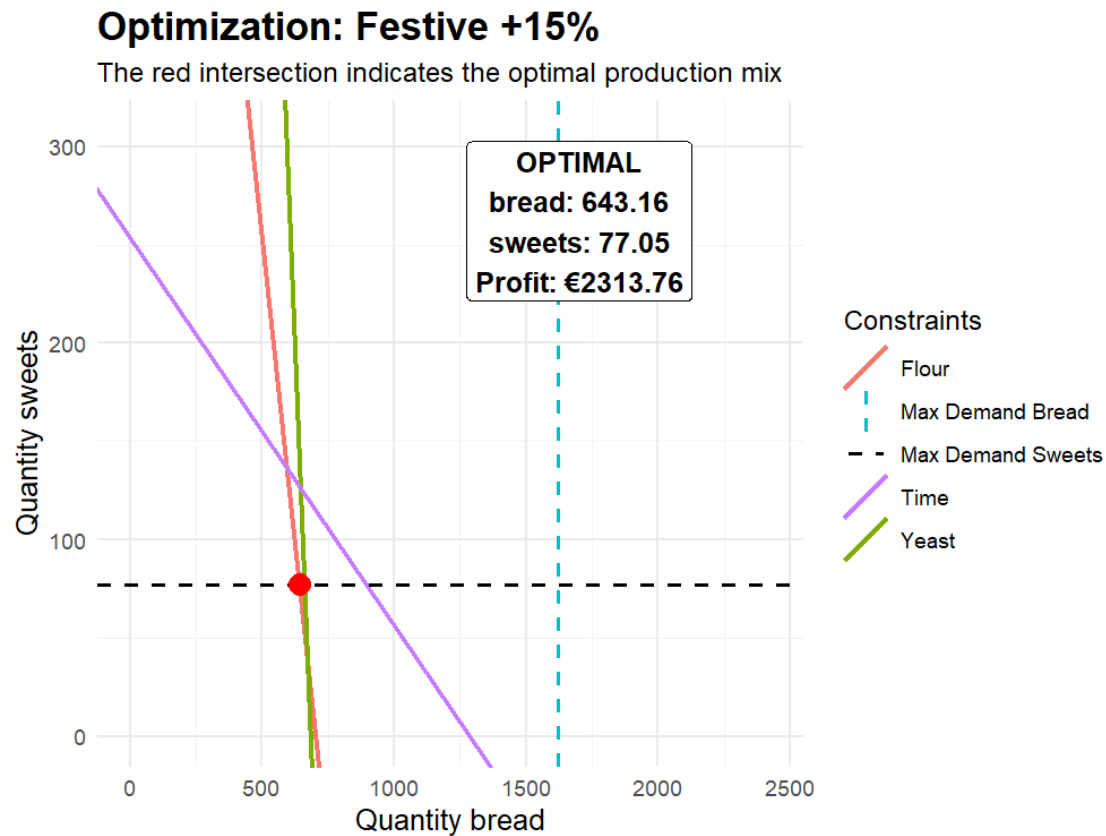
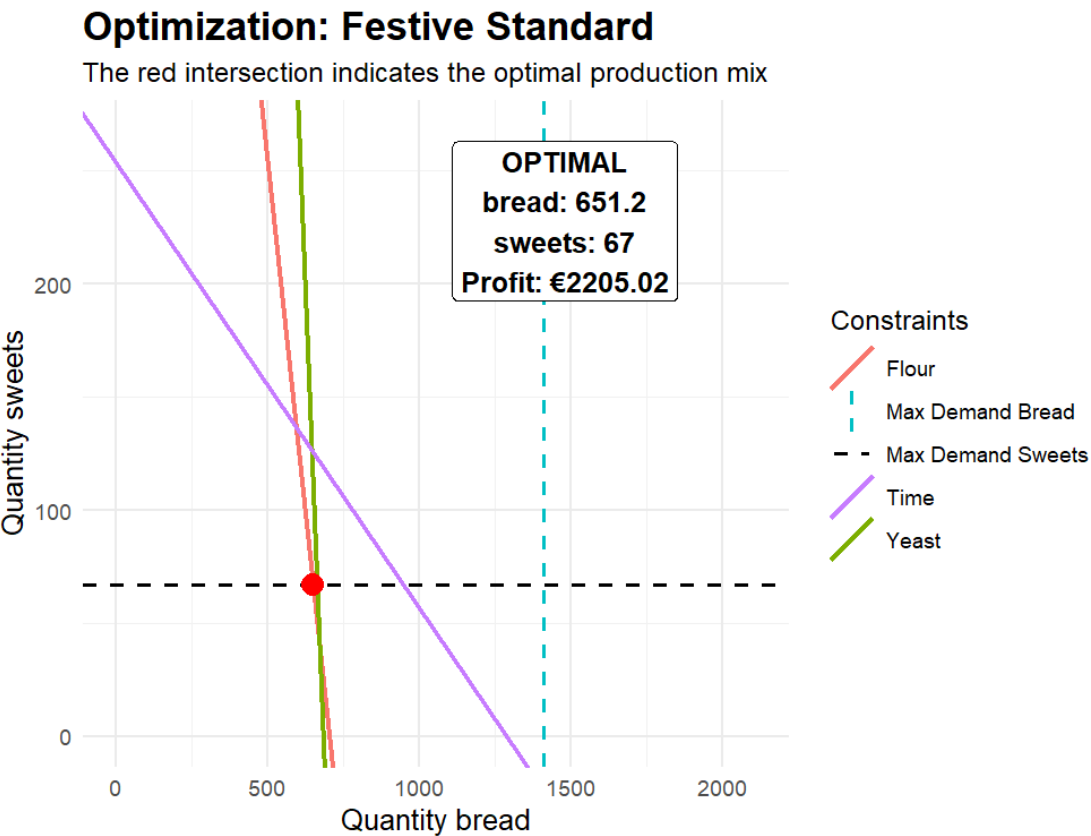


### Optimization: Normal +15%

The red intersection indicates the optimal production mix

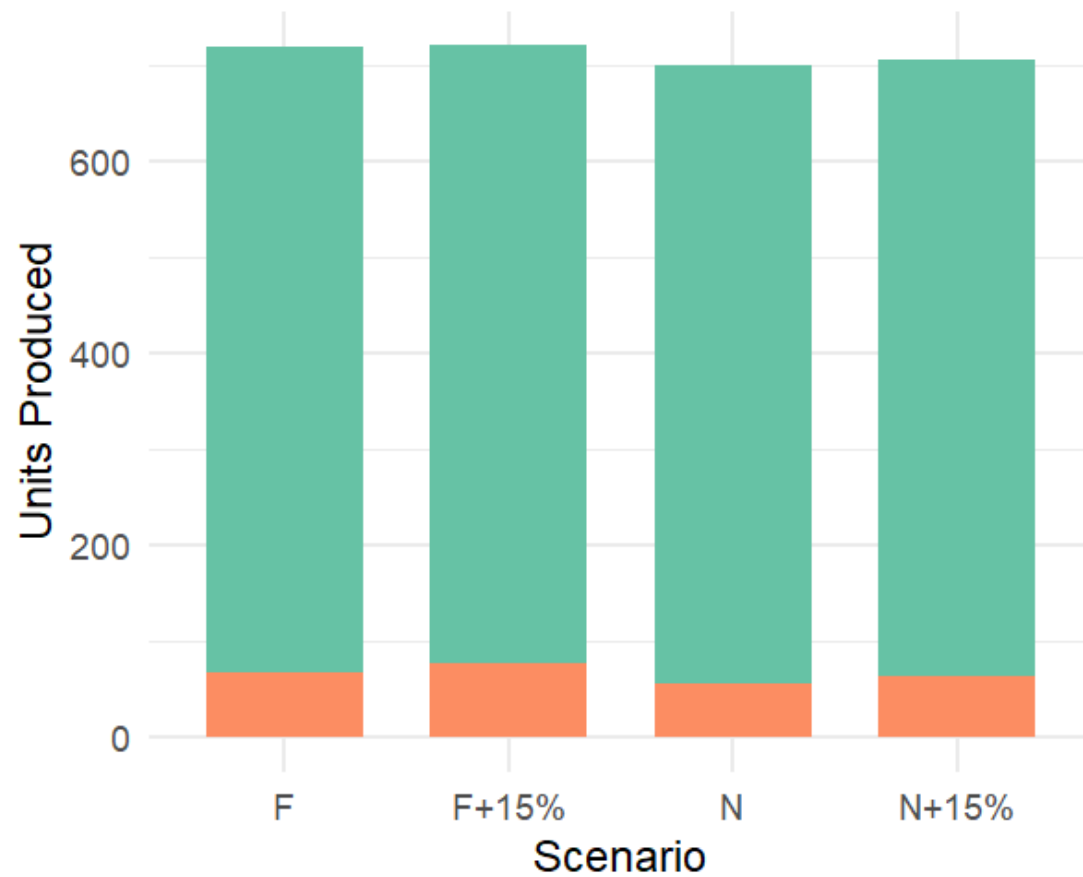


Comparison: Festive vs Festive +15%



## Optimal Production Mix

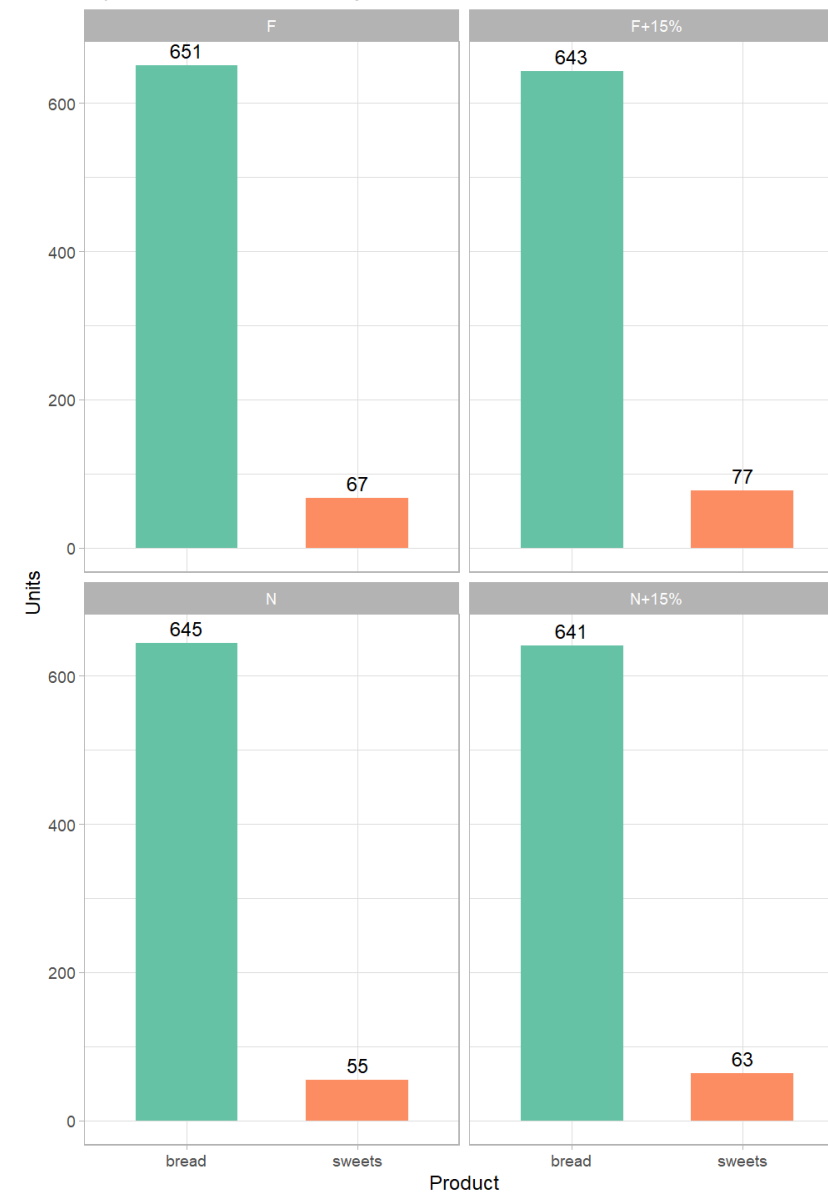
Comparison across all scenarios



Product

- bread
- sweets

## Optimal Production Mix by Scenario



# 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.