SUPPLY CHAIN MANAGEMENT AND LOGISTICS NETWORK DESIGN

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COMPANY ANALYSIS

The Company X produces and distributes **kitchenware for semi-professional and hobby use**, sold in retail chains and specialized shops

Main features identified:

- **Push processes** → The activities are initiated in anticipation of the customer's order, the demand is stable and predictable so, long-term forecasts are made in order to start in advance the process
- **Make-to-Stock** → A manufacturing strategy in which production planning and production scheduling are based on forecasted product demand
- **Possibility to exploit economies of scale** → Standardized products (basic needs, low variety and low margins)
- **Growth Company** → It is expected to grow sales and earnings at a faster rate than the market average
- **Low tradable raw materials** → Woods and resins ordered from several suppliers located close to the existing the factory

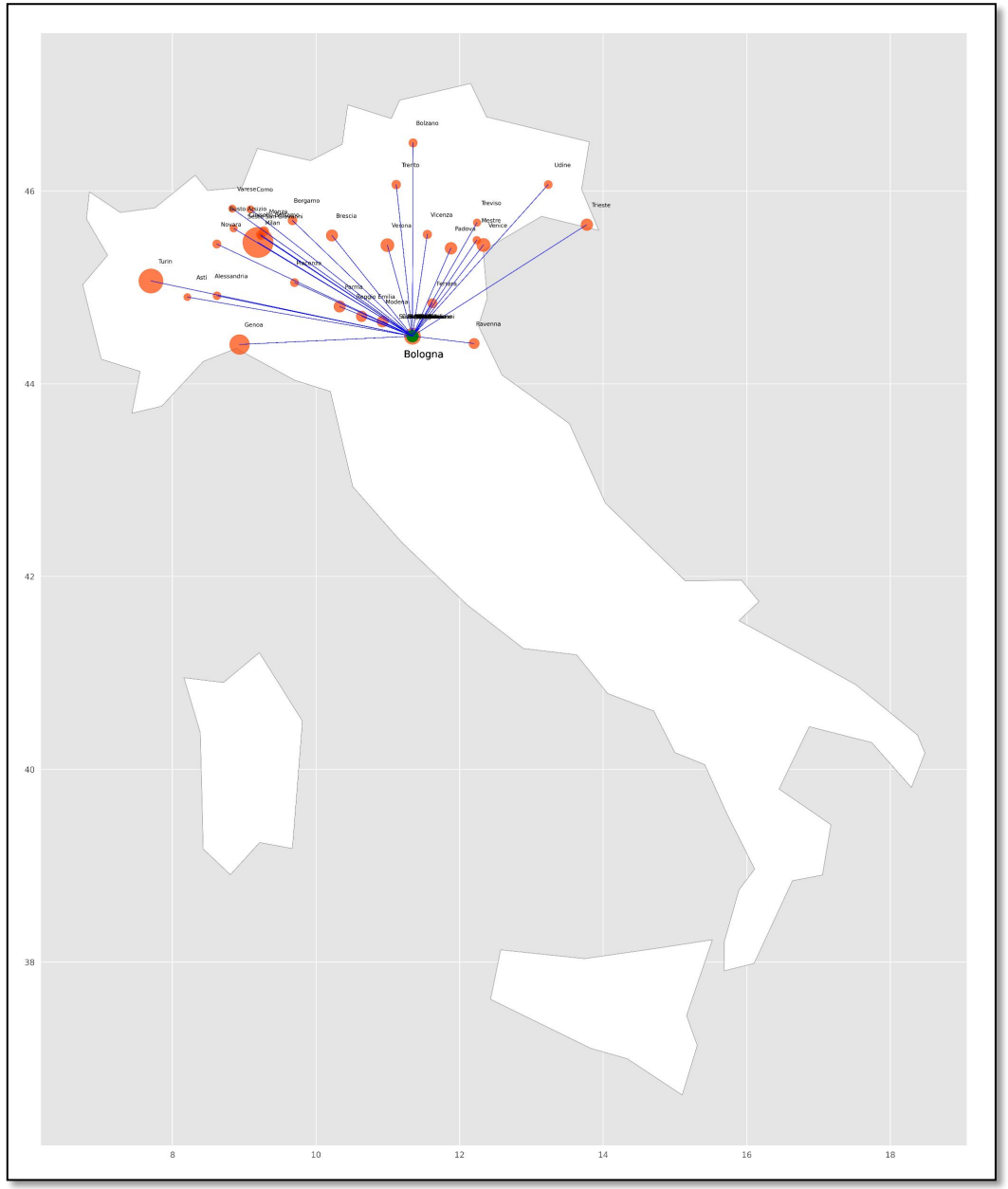
CURRENT STATE

Problem statement:

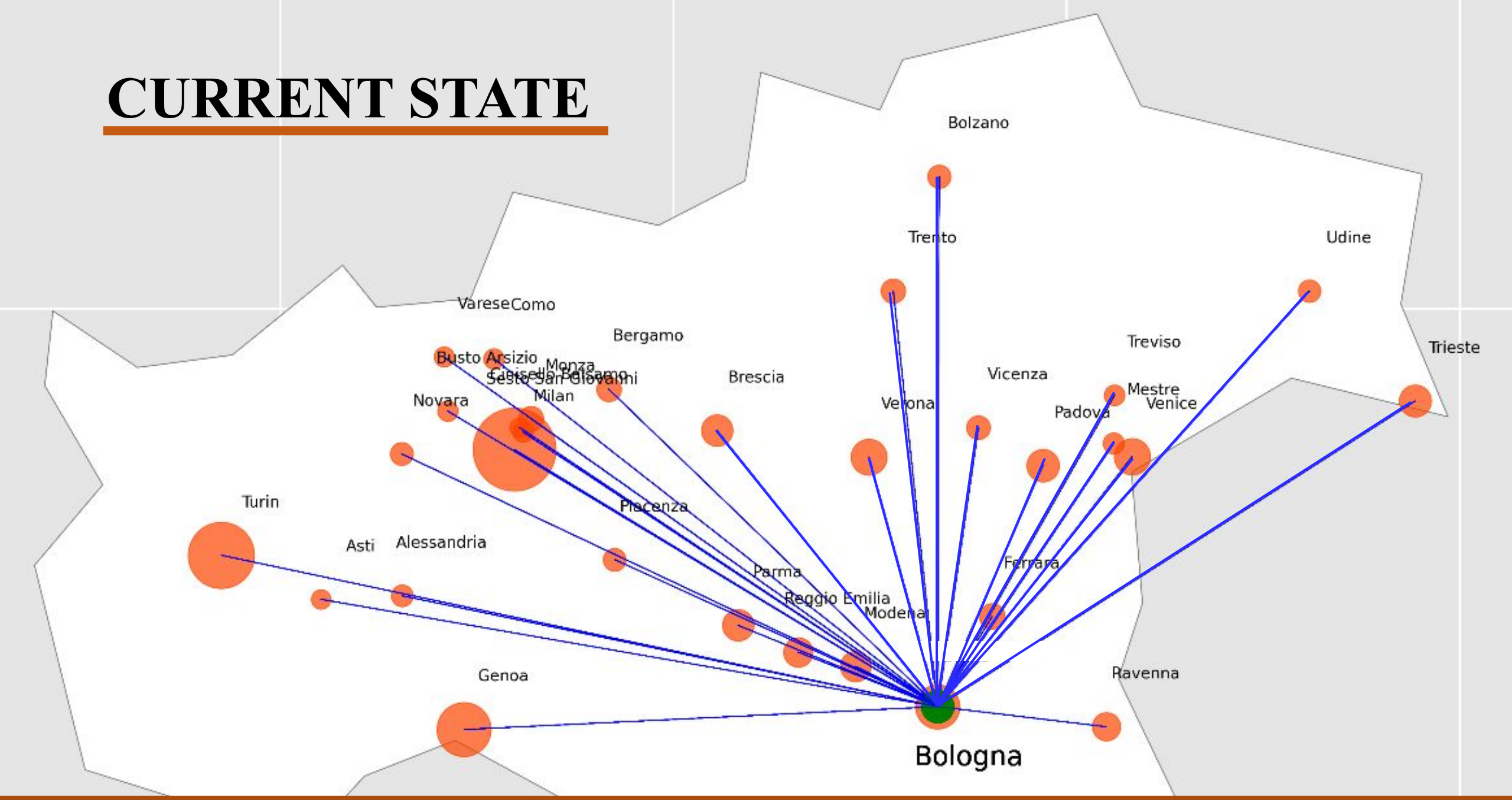
Need a consultation to evaluate an expansion plan for the production and distribution supply chain

Data:

- The company currently serves **30 major customers**
- **Bologna** is the only **plant** in Italy with a **warehouse** attached to it
- **LTL transportation mode** (unit transportation rate: 0.1€/km)
- **Market demand** grows annually by 5% for the next 4 years
- The **capacity** of Bologna's plant available today may be not enough to cover the market demand in the next 3 to 5 years
- The company ships all orders as **palletized load units** (Europallet = max 1500kg)



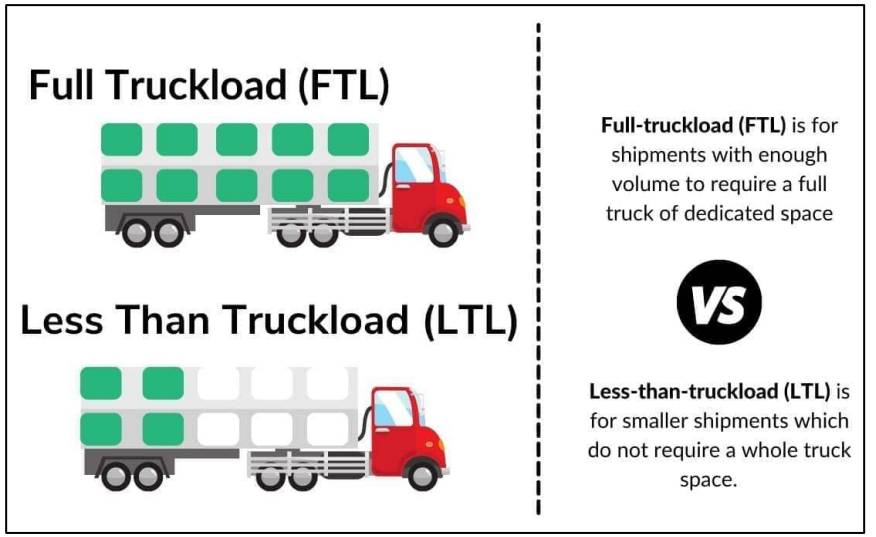
CURRENT STATE



CONSIDERATIONS FOR FUTURE-STATE

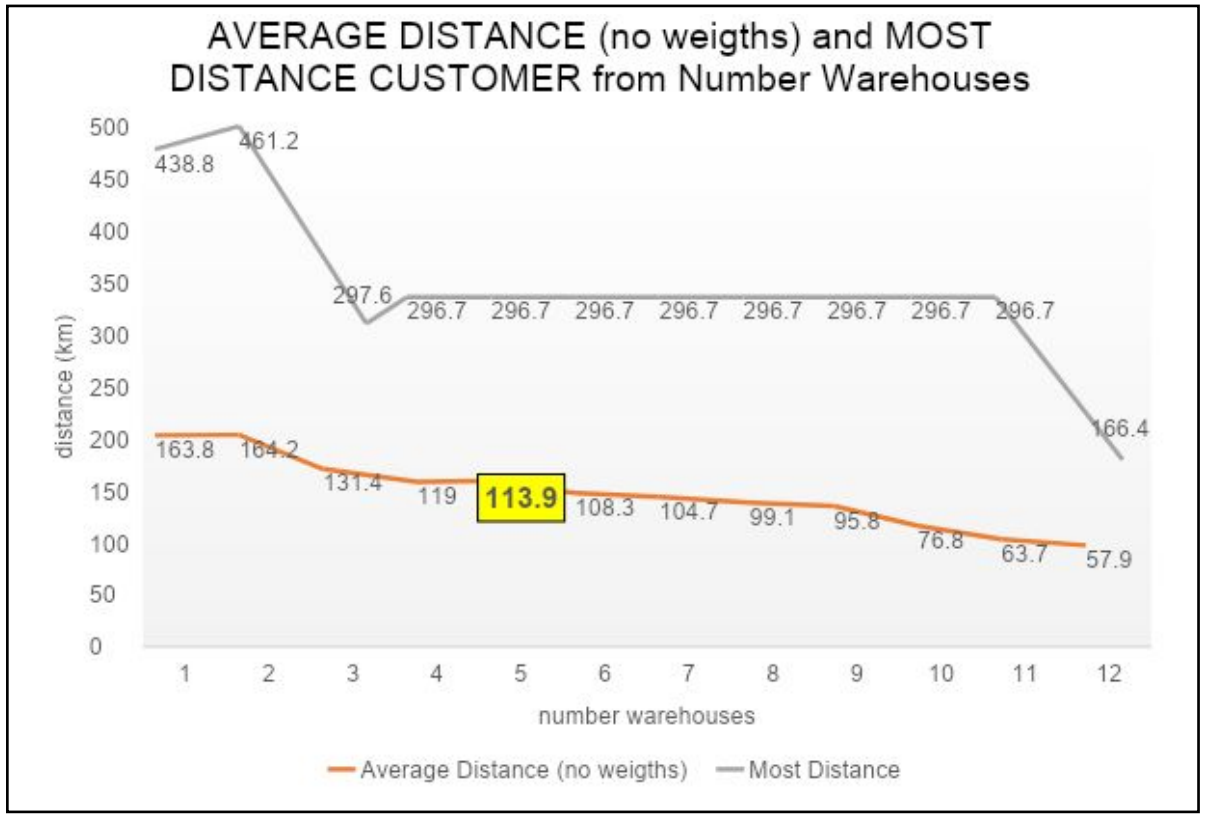
We based on the following **questions** to implement the Future-State case:

1) Is FTL more convenient than LTL as the transportation mode from the PLANT to the WAREHOUSES?
Or is TRAIN LOAD even better?



2) What is the warehouses combination (including the Bologna's one) that allows to minimize the total cost?

AS-IS/ TO-BE	NUMERO WH	TRASP. COST	FIXED COST	DEMAND SATISFIED	ID	TOTAL COST
As is	1	151960	60000	Sì		**211960**
To be	2	-	-	No	-	**0**
To be	3	268244	220000	Sì	2,5,6	**488244**
To be	4	209426	250000	Sì	0,9,5,6	**459426**
To be	5	174113	280000	Sì	0,5,6,9,13	**454113**
To be	6	160876	310000	Sì	0,5,6,9,10,13	**470876**
To be	7	154310	340000	Sì	0,5,6,9,10,11,13	**494310**
To be	8	150024	370000	Sì	0,5,6,9,10,11,12,13	**520024**
To be	9	145773	400000	Sì	0,5,6,9,10,11,12,13,14	**545773**
To be	10	138979	460000	Sì	0,5,6,9,9,10,11,12,13,14	**598979**
To be	11	134850	520000	Sì	0,5,6,7,8,9,10,11,12,13,14	**654850**
To be	12	102201	620000	Sì	0,2,5,6,7,8,9,,10,11,12,13,14	**722201**
To be	13	77873	720000	Sì	0,1,2,5,6,7,8,9,10,11,12,13,14	**797873**
To be	14	62754	820000	Sì	0,1,2,3,4,5,6,7,8,9,10,11,12,13,14	**882754**

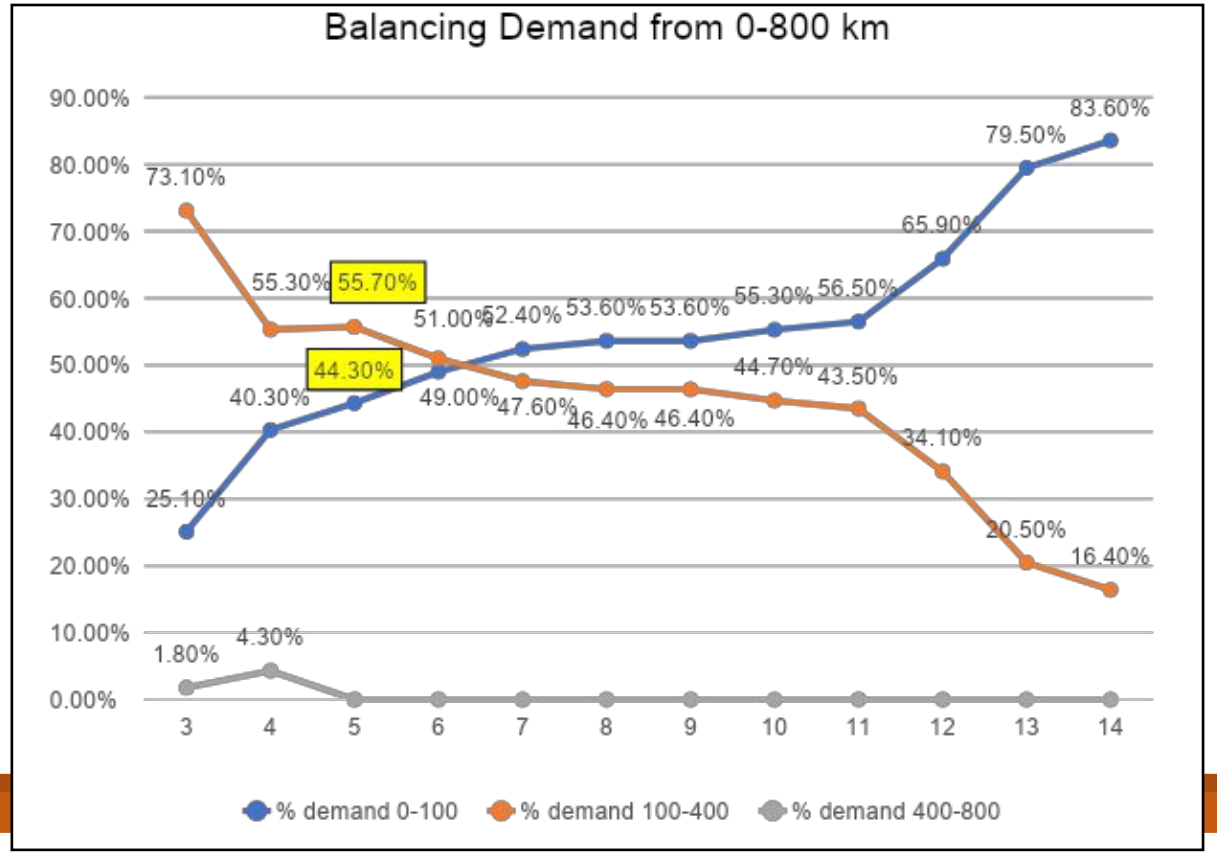


3) What is a sub-optimal number of warehouses that allows to minimize the average distance but, at the same time, that doesn't increase much the total cost?

- Maximization of service level (average distance = 113,9 km and most distance customer = 296,7 km) and minimization total cost

4) How can we obtain the balancing of customers' demand? What is the sub-optimal solution to have a good service level?

- Balancing the demand 55,7% until R = 100km and the other part (44,3%) until R = 400km



OPTIMIZATION MODEL

Uncapacitated facility location problem (UFLP)

$$\min_{x,y}\left(\sum_{w\in W}\sum_{c\in C} u_{wc}\cdot d_{wc}\cdot D_c\cdot x_{wc}+\sum_{w\in W} k_w\cdot y_w\right)$$

AS-IS/ TO-BE	NUMERO WH	TRASP. COST	FIXED COST	DEMAND SATISFIED	ID	TOTAL COST
As is	1	151960	60000	Sì		**211960**
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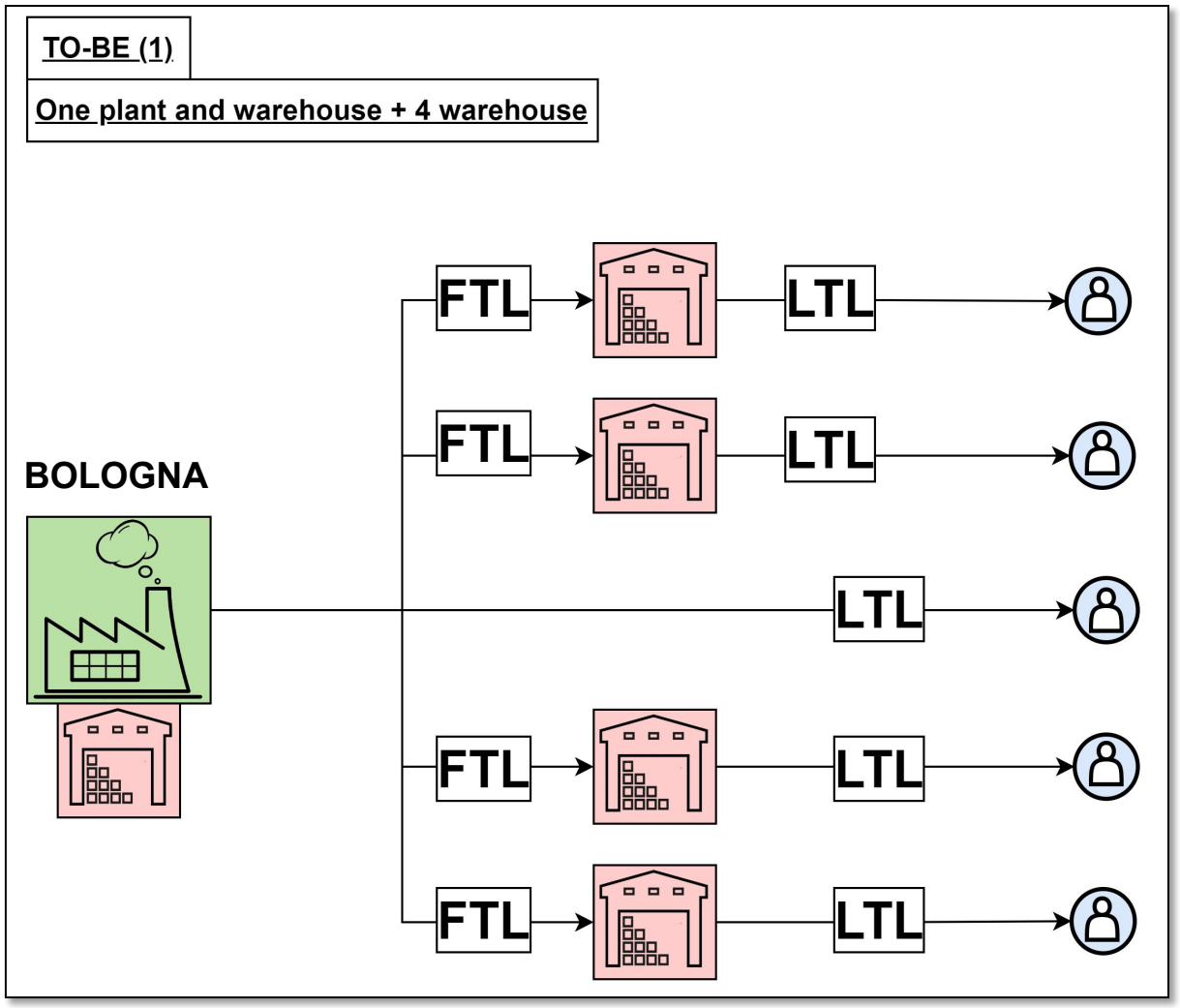
To be	14	62754	820000	Sì	0,1,2,3,4,5,6,7,8,9,10,11,12,13,14	**882754**

CONSTRAINTS

1) Each customer must be allocated to at least one warehouse
2) Each customer can be allocated to a warehouse if and only if this is active
3) $xwc \in \{0,1\} \ \forall \ w\in W, c\in C$
4) $ywc \in \{0,1\} \ \forall \ w\in W, c\in C$

OPTIMAL SOLUTION	
Minimum cost	**N° optimal WH**
454113	5
OPEN WAREHOUSES	
Rome	4829
Genoa	3937
Bologna	4532
Catania	1689
Andria	1420

FUTURE STATE 1 – THEORETICAL MODEL



PROS

- Exploit **economies of scale in production** using one plant
- Exploit **economies of scale in transportation** using FTL
- Ensure **flexibility** by using LTL for the last mile delivery
- Use train load (BO-RM) to ensure **speed**, **full train load** and **low logistic risk**

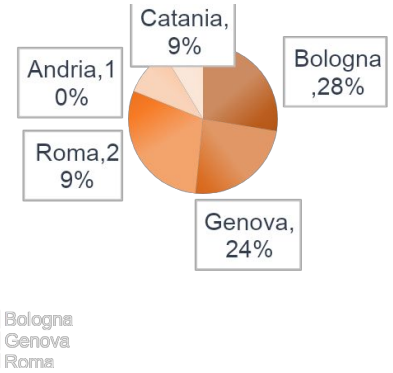
CONS

- **Low service level** for South-Italy customers
- **High risk** of blocking production and distribution

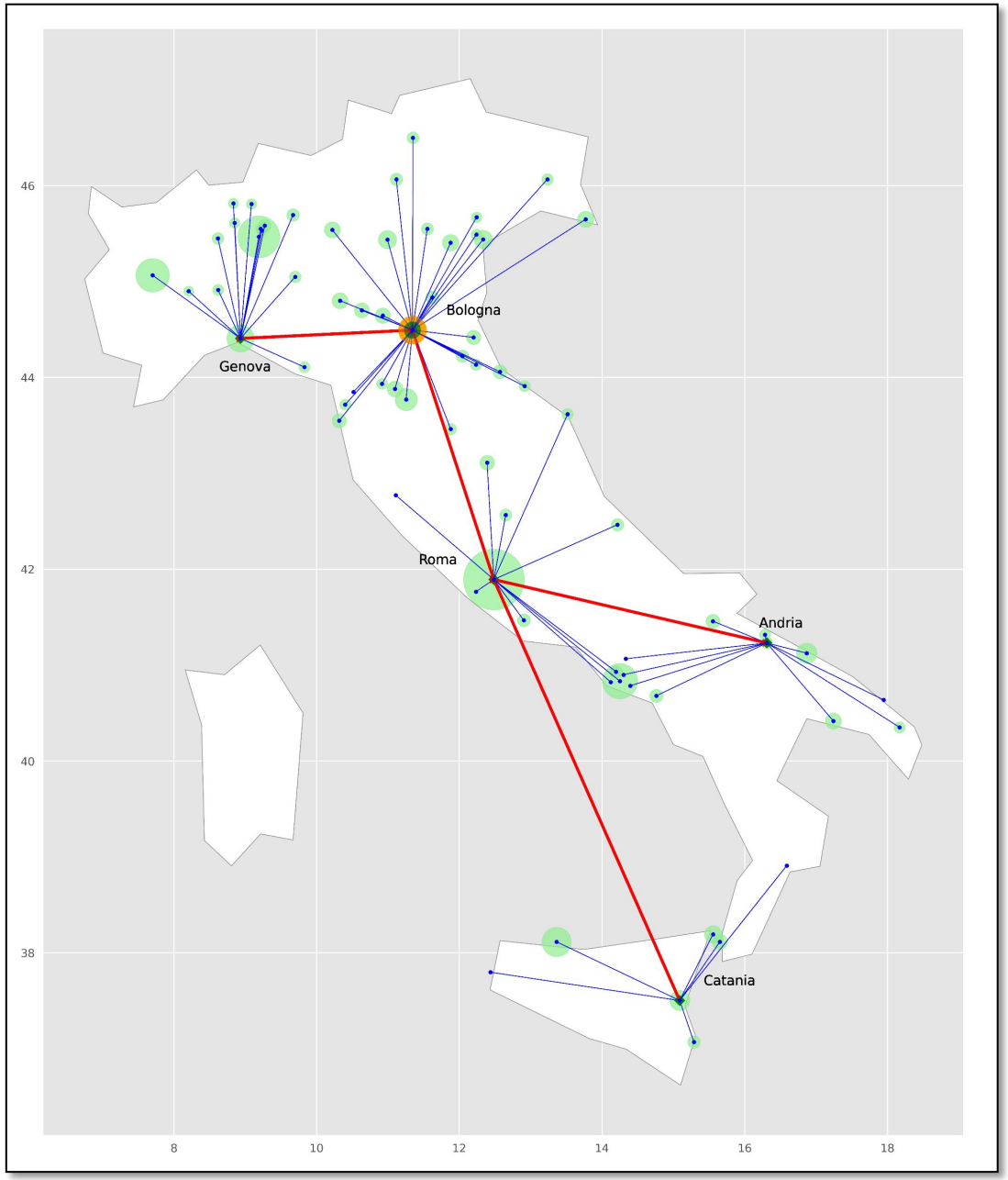
FUTURE STATE 1

MARKET DEMAND SATISFACTION

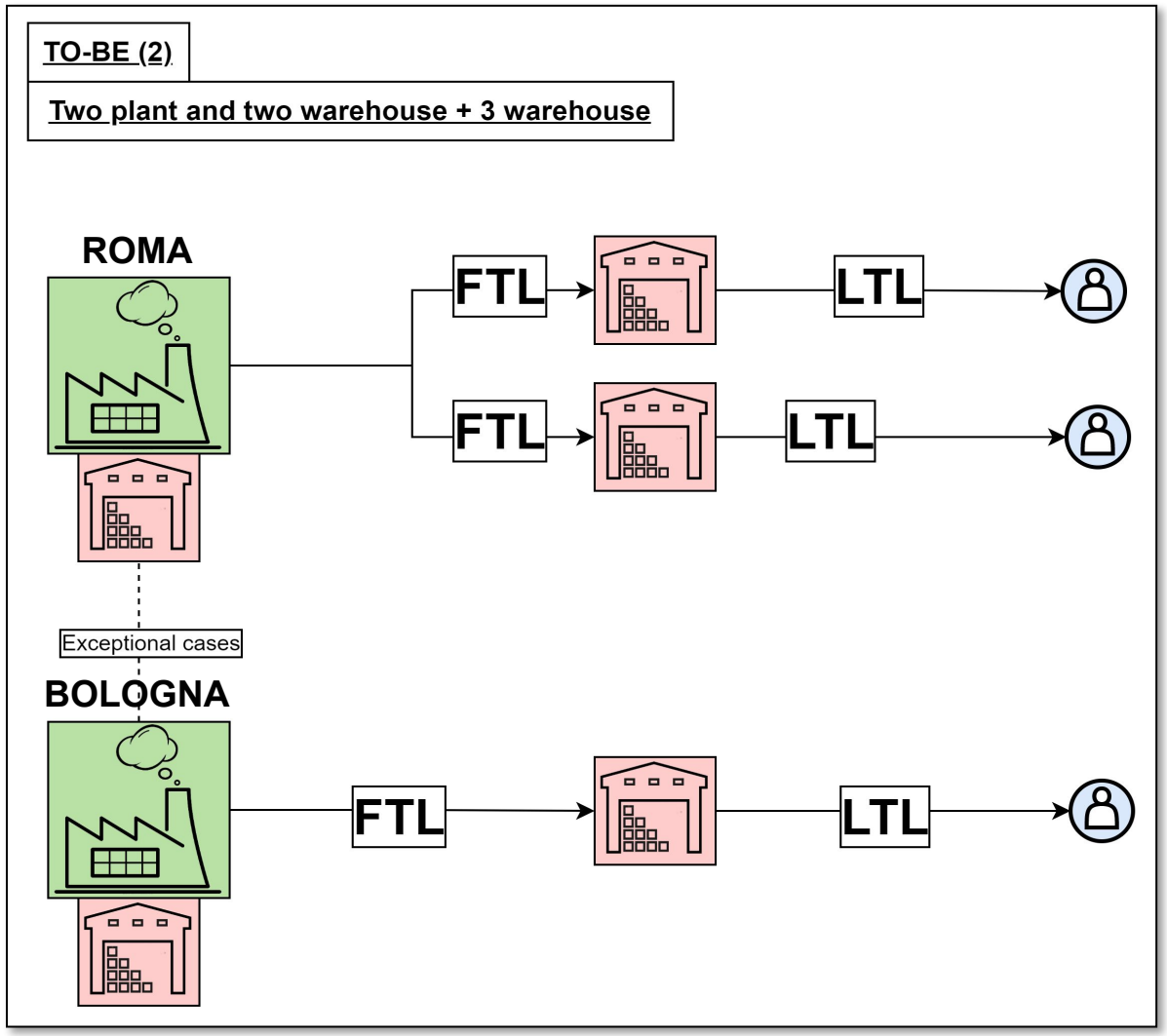
About 80% of market demand covered bythe woarehouse in Bologna, Genova and Roma



COSTS	Sub-optimal	Sub-optimal modified
Total cost of unit transport Rome,Catania,Andria	71372	121200
Rome-Catania; Rome-Andria		24245
Total cost of trasnport of Sud Italy	71372	145445
Total cost of transportation Nord Italy	15130	13363
Total differencial cost	**86501**	**158808**



FUTURE STATE 2 – THEORETICAL MODEL



PROS

- Exploit **economies of scale in transportation** using FTL
- **Low risk** of blocking production and distribution
- Possible **customization** of products
- Ensure **flexibility** by using LTL for the last mile delivery
- Train load (BO-RM) for exceptional cases

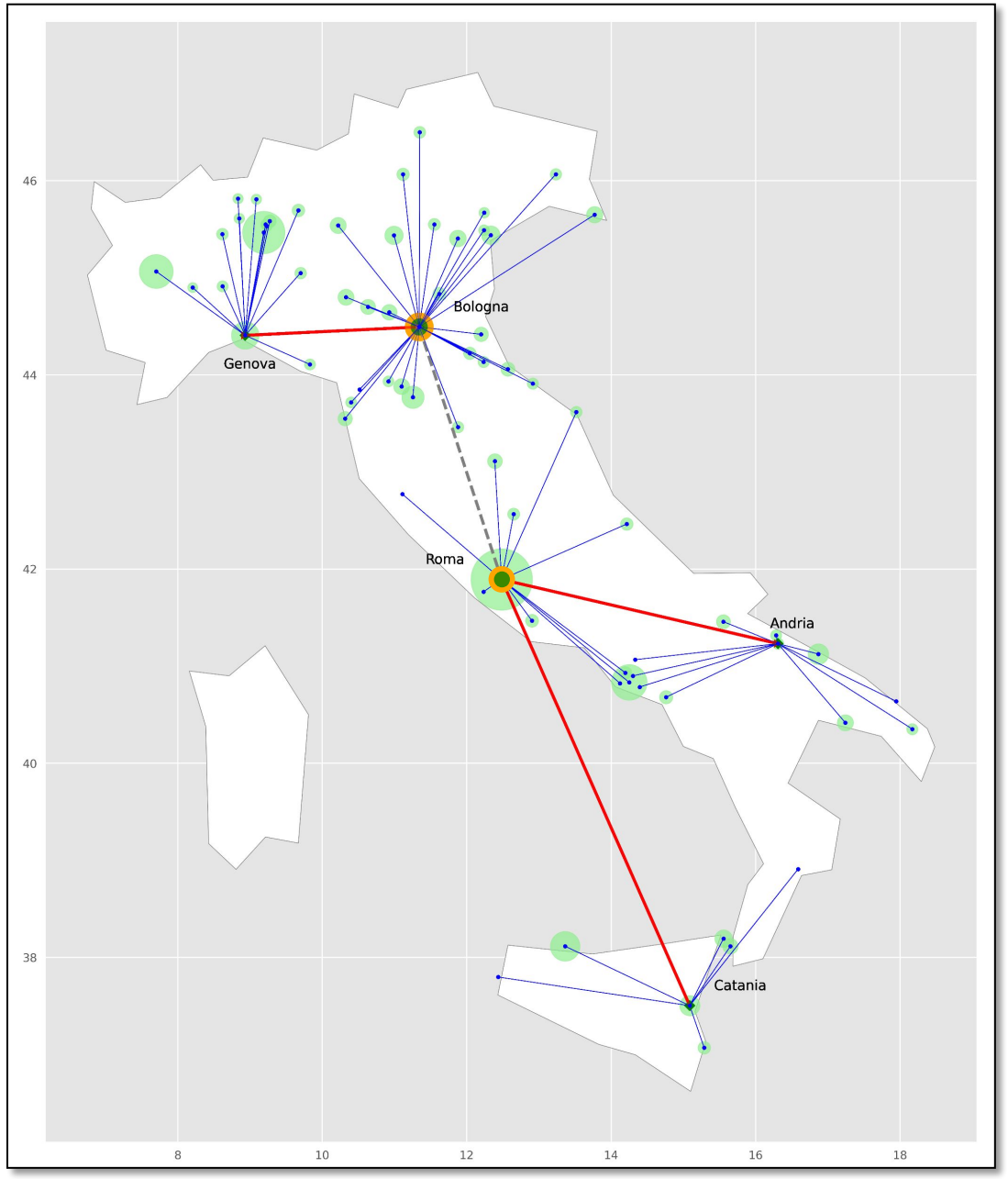
CONS

- **Less possibility** to leverage **economies of scale in production**
- **Opening** and **management costs** increase

FUTURE STATE 2

COSTS	Sub-optimal	Sub-optimal modified
Total cost of unit transport Rome,Catania,Andria	71372	40000
Rome-Catania; Rome-Andria		24245
Total cost of unit transport South-Italy	71372	
Total cost of transportation North-Italy	15130	13363
Total differencial cost*	**86501**	**77608**

* «differencial» because they don't include the transportation costs between warehouses and the customers, these routes are still traveled using LTL.



ROBUSTNESS ANALYSIS

Robustness analysis is necessary to understand if our **solutions change** and, if they change, in what **range**, under **conditions of uncertainty**.

Doing this, we have considered **an underestimate increase of the market demand** during a year.

More in detail, we have changed this information from 5% to 7% (also 10% for the 2° solution).
At the end of the 4° year, the results are the following:

ALTERNATIVE #1

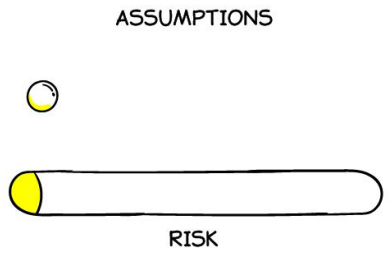
- 7% of increase: everything runs except capacity constraint of Rome warehouse:
  - Market demand of south-Italy: 10.405 units
  - Rome's warehouse capacity: 9.000

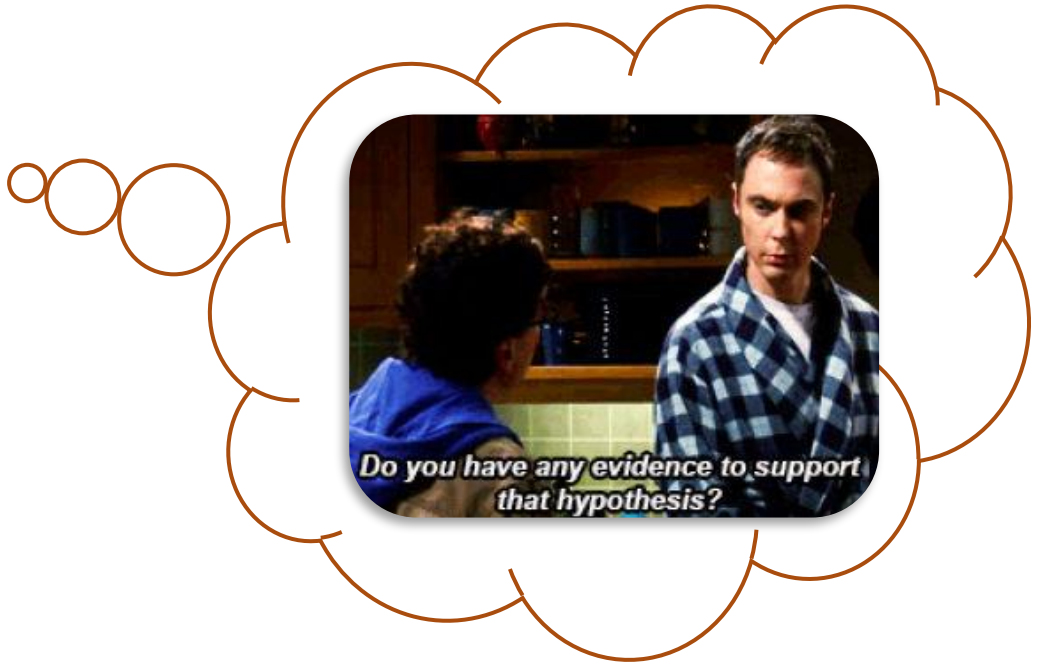
ALTERNATIVE #2

- 7% of increase: 21.506 units
- 10% of increase: 24.021 units*

Considering a maximum capacity of 28.000 units, in this solution the market demand is always covered.
*Notes: the number of units refers always to 4° year (maximum demand).

ASSUMPTIONS





CURRENT STATE

- Central warehouse attached to the production plant (**no distance**)
- **Distance matrix** as a proxy of the real distances
- **Uncapacitated** production plants

CURRENT and FUTURE STATE

- **FTL transportation mode** (unit transportation rate: 0.5€/km)
- Each scenario uses the optimal configuration that foresees **5 optimal warehouses**
- **One railway wagon** → 50.000 kg/wagon → 50000 kg/wagon ÷1500kg/pallet = **33 pallet/wagon**
- **A full train = 30 wagons** → 50.000 kg/wagon * 30 = 1.500.000 kg/train → 1.500.000/1500kg/pallet = **1000 pallet/train**
- **1500 units = 1 pallet → 1500kg /1500 u = 1kg/u**

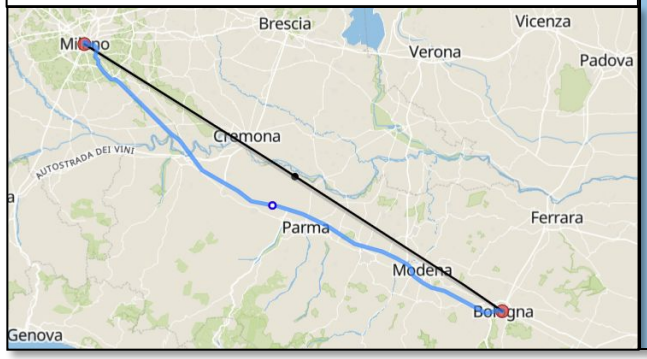
COMPARISON MODEL-REALITY

Each modelization contains some **assumptions** to simplify the reality but, some of them are **more realistic** than others.

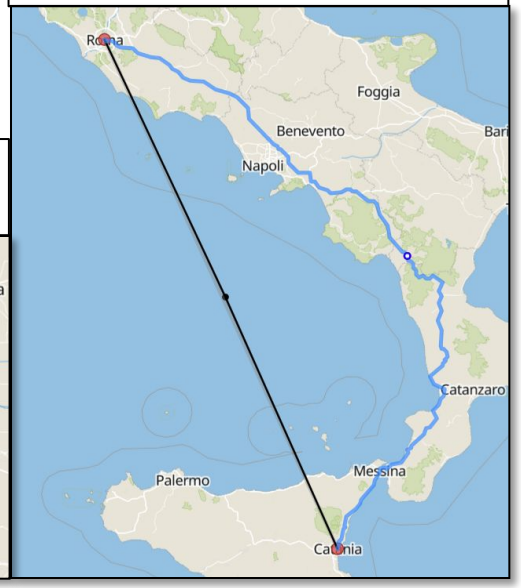
See below some examples:

Distance matrix →

Distance matrix: 200,54 km
Real distance: 214,44 km



Distance matrix: 536,86 km
Real distance: 787,15 km



Uncapacitated production plants →

FUTURE STATE 1 – BOLOGNA PLANT:

TOT. DEMAND AS-IS IN 2022 = 6817

TOT. DEMAND TO BE IN 2022 = 16407

TOT. DEMAND TO BE IN 2026 = 19943

+ 292,5% DEMAND IN 4 YEARS FOR ONE PLANT

Cost of opening a new plant →

DIFFICULTIES IN PREDICTING PLANT'S COST

EXAMPLE 1: 1.500.000 € fixed cost/plant

EXAMPLE 2: 5.000.000 € fixed cost/plant

* sources (Fleischmann, Moritz, et al.)

REFERENCES

We consulted some literature research and websites to validate the proposals and the linked assumptions for your case

- Li, Li, and Lothar Schulze. "Uncertainty in logistics network design: a review." *World Congress on Engineering 2012. July 4-6, 2012. London, UK.*. Vol. 2189. International Association of Engineers, 2010. **(the introduction of paper)**
- Jeet, Vishv, Erhan Kutanoglu, and Amit Partani. "Logistics network design with inventory stocking for low-demand parts: Modeling and optimization." IIE Transactions 41.5 (2009): 389-407. **(the introduction and literature review)**
- Fleischmann, Moritz, et al. "The impact of product recovery on logistics network design." Production and operations management 10.2 (2001): 156-173 **(assumption of opening costs)**
- Cost of transport by train: https://www.mercitaliarail.it/content/dam/mercitalia-rail/allegati/Listino%20Prezzi_2019.pdf
- Train capacity: https://gs1it.org/content/public/f3/bd/f3bdfc89-c566-444a-9b03-50774f0a0b10/documento_tecnico_trasporto_ferroviario.pdf

Thanks for your attention