

Parcel Lockers as Decentralized Micro-Hubs: A Comparative Economic Analysis for Last-Mile Delivery in Italy

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INTRODUCTION & AIM

Introduction

The rapid growth of e-commerce has made last-mile delivery (LMD) one of the most costly and complex segments of urban logistics. In this context, parcel lockers (PLs) are increasingly viewed not only as pick-up points, but as decentralized micro-hubs that can improve consolidation, reduce failed deliveries, and enhance operational efficiency. Their economic value depends on territorial density, coverage and local market conditions.

Aim

This study adopts an exploratory comparative economic approach combining territorial locker-density indicators with illustrative investment-cost scenarios to assess the conditions under which parcel lockers become economically attractive for last-mile operators.

Research question

Under which territorial and demand conditions do parcel lockers become economically viable decentralized micro-hubs for last-mile delivery operators?



The **novelty of the study lies in interpreting parcel lockers** not only as delivery points, but as **decentralized logistics micro-hubs** whose economic value depends on territorial penetration, demand density and operational savings.

METHOD

1) Exploratory comparative design

- Four Italian cities: Milan, Rome, Naples and Bari.
- Unit of analysis: city-level territorial penetration of the locker network.
- Proxy indicator: PLs locations per 100,000 residents.
- Data sources: PLs operator city listings and municipal demographic data.



Indicator*

$$\text{Locker Density}_i = (\text{PLs Points}_i / \text{Population}_i) \times 100,000$$

Conceptual mechanism



*The indicator is interpreted as a proxy for the relative territorial penetration of locker-based infrastructure, not as a direct measure of firm profitability.

2) Economic Analysis

Investment Cost vs Operational Savings

Parcel locker deployment requires an upfront investment, so its economic attractiveness depends on whether annualized infrastructure costs are offset by operational savings.

$$\text{Annual Locker Cost} = \frac{\text{CAPEX}}{n} + \text{OPEX}$$

CAPEX is the initial investment and installation cost, n is the useful life of the locker, and OPEX includes maintenance, software, connectivity, energy, and space-related costs.

$$\text{Cost per parcel} = \frac{\text{Annual Locker Cost}}{\text{Annual Parcels handled}}$$

Economic attractiveness is assessed by comparing the estimated cost per parcel under different throughput scenarios with the expected operational savings associated with locker-based delivery consolidation.



RESULTS & DISCUSSION

Results show that relative locker density does not simply follow city size: Bari and Naples display higher penetration than Milan and Rome. The economic scenarios suggest that viability depends mainly on throughput, since higher parcel volumes reduce the annualized cost per parcel and improve the break-even potential.

Figure 1. Relative Locker Density

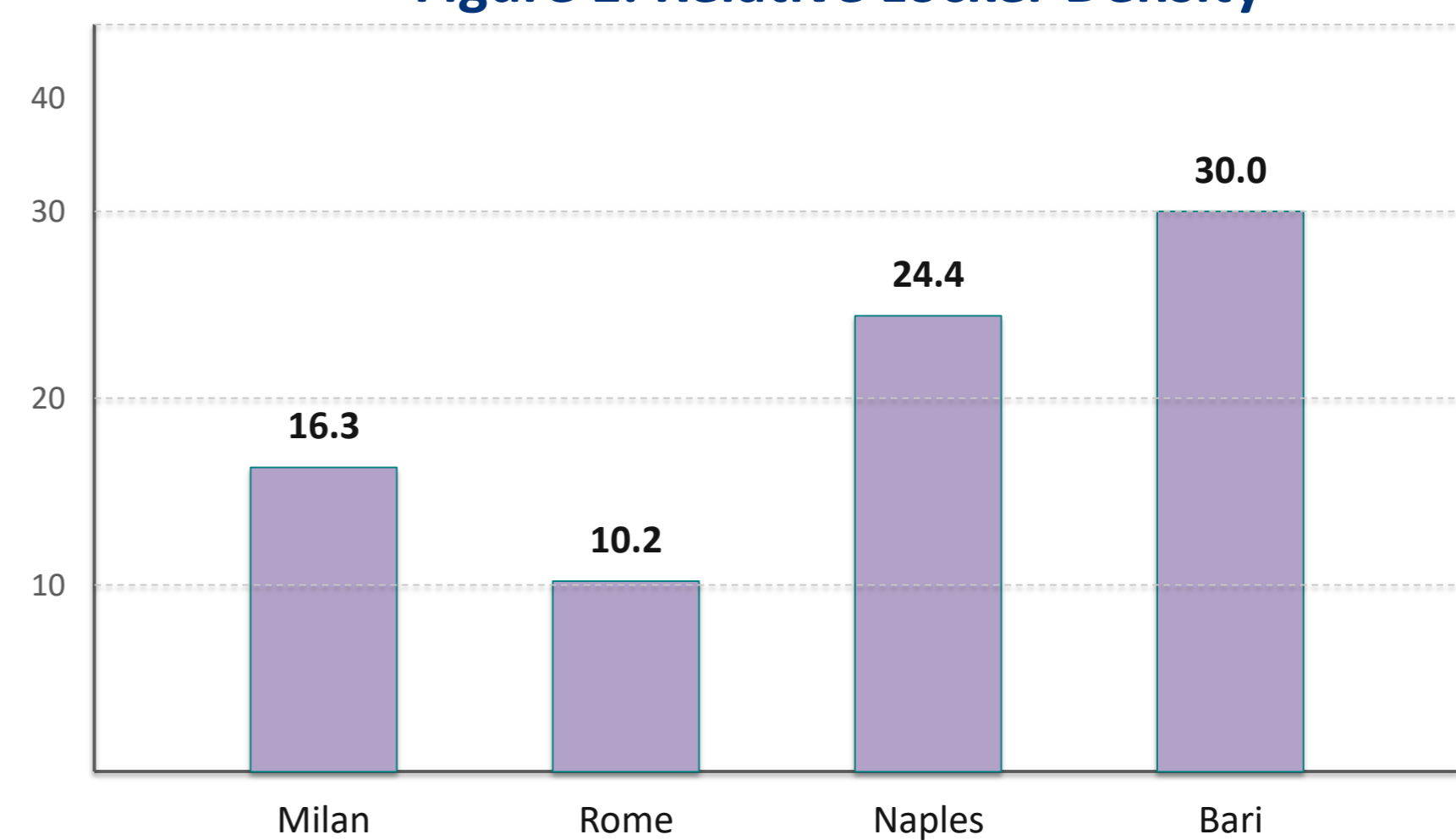


Figure 1 shows that relative locker density varies significantly across the four cities considered. Bari and Naples display the highest number of PLs points per 100,000 residents, while Milan and especially Rome show lower relative coverage. This suggests that parcel locker deployment is shaped not only by absolute city size, but also by local network penetration and territorial investment strategy.

Table 1. Break-Even Scenarios for Parcel Locker Investments

Cost scenario	Use level (parcels/day; annual volume)	Annualized total cost (€/year)	Cost per parcel (€/parcel)	Economic reading
Moderate investment CAPEX €15k OPEX €3.5k/year	Low use 20/day; 7,300/year	€6,500	€0.89	Break-even only if savings are high
	Medium use 30/day; 10,950/year	€6,500	€0.59	More viable
	High use 35/day; 12,775/year	€6,500	€0.51	Stronger investment case
Higher investment CAPEX €25k OPEX €5k/year	Low use 20/day; 7,300/year	€10,000	€1.37	Weak unless volumes or savings increase
	Medium use 30/day; 10,950/year	€10,000	€0.91	Selective attractiveness
	High use 35/day; 12,775/year	€10,000	€0.78	Attractive if savings exceed unit cost

The table clarifies the break-even logic: at the same annualized cost, higher parcel throughput lowers the cost per parcel. The **investment becomes attractive** only when operational savings per parcel exceed the estimated unit cost.

CONCLUSION

Parcel lockers should therefore be interpreted not as universally efficient solutions, but as **territorially selective logistics infrastructures** whose economic viability depends on demand density and operational consolidation effects.

FUTURE WORK / REFERENCES

Future research

Extend the dataset to multiple operators, more cities, e-commerce demand proxies, accessibility indicators and direct operational cost data.

Selected references

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