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Multi-channel distribution in the banking sector and the branch network restructuring

Silvia Baldassarre [a,*], Giuseppe Bruno [a], Carmela Piccolo [a], Diego Ruiz-Hernández [b]

[a] Department of Industrial Engineering, University of Naples Federico II, P.le Tecchio 80, 80125, Naples, Italy
[b] Management School, University of Sheffield, Sheffield, UK

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ABSTRACT

European banking groups have been addressing the problem of restructuring their branch networks. Indeed, in the light of the recent digital transition of services, they aim to leverage digital channels to deliver basic services and reduce the number of physical facilities to dedicate to more complex and added-value operations. In order to implement the new business model, banking groups are shrinking their internal branch networks and outsourcing basic services to maintain physical proximity to customers unwilling to adopt digital channels. This work aims to formulate a mathematical programming model to support the decision-making process concerning the branch network restructuring. The model is formulated as a hierarchical covering location problem. Three types of branches providing different categories of services are considered. They are organized according to a three-level hierarchical structure, and each level is associated with a covering radius, representing the related accessibility condition to be guaranteed to users. A further category of facilities is considered, namely external facilities, that may support internal ones in providing basic banking services. The objective is to identify the network structure able to serve all the demand for banking services and minimize the total costs. A specific parameter is introduced to regulate the maximum outsourcing level that the bank is willing to achieve. The model is tested by considering a real case study concerning one of the main banking groups in Italy. The obtained results show the capability of the model to provide interesting scenarios and fruitful managerial implications.

1. Introduction

Banking groups across Europe are facing the challenge of restructuring their branch networks. This trend is due to different phenomena.

Firstly, the market strategies pursued during the late 1990s and early 2000s, aimed at improving proximity to customers and gaining market share from competitors, led to a significant proliferation of branches over the territories. This phenomenon was exacerbated, in the following years, by the bank mergers and acquisitions, which produced financial conglomerates with many overlapping branches (Berger et al., 1999).

On the other hand, the diffusion of digital technologies has completely disrupted customers' habits and behaviors. As a result, the traditional "bricks-and-mortar" model, based on the use of physical facilities and face-to-face interactions, is progressively evolving toward the "click-and-mortar" model, in which traditional channels are integrated with digital ones (e.g., internet and mobile banking). Accordingly, banks are rethinking the role of physical proximity and investing in digitalization as a strategic mechanism for achieving competitive advantage (Pennathur, 2001). In the EU-27, individuals using Internet banking have doubled from 2008 to 2021. Denmark, Finland and the Netherlands lead the ranking with more than 91% of internet users, while the lowest-performing countries are Romania and Bulgaria (15%), Greece (42%) and Italy (45%) (Eurostat, 2019).

Although digital channels are expected to increase their diffusion and penetration, the physical branches will keep playing a crucial role. In the new delivery model, they will remain the primary and highly valued point of interaction, providing high-level services that cannot be easily delivered with digital alternatives (Vera, 2017). Indeed, a recent survey shows that digital channels are mainly used for informative and transactional needs (e.g. money transfers, payments), while branches are preferred to handle complex advisory services, such as personal loans (61%) and mortgages (69%) (Deloitte Insight, 2018). Moreover, "traditional clients" (or "branch lovers") who do not adopt digital channels and prefer to patronize physical facilities also to perform basic services still represent 28% of the total demand.

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* Corresponding author.
E-mail addresses: silvia.baldassarre@unina.it (S. Baldassarre), giuseppe.bruno@unina.it (G. Bruno), carmela.piccolo@unina.it (C. Piccolo), d.ruiz-hernandez@sheffield.ac.uk (D. Ruiz-Hernández).

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In the above context, European banking groups are undertaking various restructuring actions with the final aim of reducing network costs and guaranteeing, at the same time, good access to physical and digital channels to customers for service provision. The main strategies being implemented are:

- *Branch closure* to eliminate redundant facilities. In Europe, the downward trend in the number of active branches started in 2008, with a pace of 2.97% closures per year, and it reached the maximal contraction between 2019 and 2020, with a peak of 8.21% (European Central Bank, 2021).
- *Branch specialization* to evolve toward a multi-format system, where different types of branches exist, delivering different categories of services and adopting multiple delivery modes.
- *Outsourcing* to supplement branches in the physical provision of basic banking services (e.g., deposits, withdrawals and bill payments). The goal is to use external facilities, usually located at regularly visited shops (e.g., supermarkets or tobacco shops), to maintain a capillary presence over the territory and guarantee proximity to those customers who prefer physical channels. In this context, outsourcing is mainly intended as a leverage to cut costs, refocusing banks on their core/strategic activities, and a catalyst for digital transformation (Gunasekaran et al., 2015).

By mixing the above strategies, banking groups aim to shrink the network and progressively transform the remaining branches into digital facilities in which staff is dedicated to more complex and added-value operations. In the new model, the physical provision of basic services is consolidated in a lower number of branches or outsourced to external facilities.

This work aims to provide a mathematical programming model to support location-based actions to restructure banking branch networks. We refer to the facility location literature (Laporte et al., 2019) and, specifically, to the research stream dealing with the territorial reorganization of existing facility networks (Bruno et al., 2016). As concerns the applications in the banking sectors, previous contributions have traditionally addressed the problem of optimally locating new branches. This is in line with the trend denoting the sector until the early 2000s, characterized by a significant proliferation of branches. However, as a response to the transformation and the new emerging conditions described above, recently, contributions started to focus on the branch restructuring problem. The actions that are usually taken into account regard facility relocation, closure and capacity resizing (more details will be provided in the following section).

Our work aims to contribute to this literature by introducing a novel Hierarchical Branch Restructuring Problem (HBRP) that considers more complex actions. In particular, in our framework, restructuring decisions involve closing down existing facilities, diversifying branches in terms of provided services, and outsourcing a subset of banking services to third-party providers (TPPs). Four different types of facilities are considered. Specifically, the internal network involves three types of branches arranged in a nested hierarchical structure (Farahani et al., 2014). Furthermore, such a network can be integrated by activating some external points for the provision of basic services. Hence, the model decides (i) how many and which existing branches to close, (ii) which services are offered at the active branches, and (iii) how many and which external facilities to include in the network. Each facility is associated with a covering radius representing a service level to guarantee, and the objective consists of minimizing the total network costs to cover all the demand. The proposed model is applied to the real-world case of an Italian banking group owning a very dense network in most regions. The provided results show how the model is capable to provide interesting scenarios and to support decision-makers in restructuring decisions.

The rest of the paper is organized as follows. First, a literature review regarding the facility location and network restructuring problem with particular attention to applications in the banking sector is reported in Section 2. Section 3 presents the problem description and the formulation of the mathematical model. The case study is presented in Section 4, while the design of the experiments and the results deriving from the application of the model are presented and discussed in Section 5. Finally, Section 6 presents some concluding remarks and ideas for future research.

2. Literature review

According to a recent survey on service facility location problems by Celik Turkoglu and Erol Genevois (2020), the banking sector is one of the most investigated application fields.

In particular, the scientific literature has initially focused on the problem of locating new facilities and expanding the existing networks, consistently with the expansion policies undertaken by banking groups in the late 1990s and early 2000s. Min and Melachrinoudis (2001) propose a chance-constrained goal programming model to locate three types of capacitated facilities arranged in a nested hierarchical network, i.e. Automated Teller Machines (ATMs), branches, and main branches, providing increasingly complex services. The model allocates all the demand considering conflicting goals, i.e., profit and budget availability. Miliotis et al. (2002) propose a two-step methodology combined with GIS techniques to design an effective branch network taking into account the demand area's factors (e.g. geographical, social, and economic) and competition in each area by using appropriate demand-covering models. Xia et al. (2010) formulate an enhanced version of the maximal covering location problem to open new branches that maximize the profit of sited facilities. They consider three types of branches according to their size with different coverage functions. Cinar and Ahiska (2010) use a combination of multi-criteria methods (FAHP, TOPSIS) to select the most appropriate city for opening a branch among six alternatives in Turkey. The authors investigate five main criteria (e.g., demographic, socio-economic) and 21 sub-criteria associated with the bank's mission and strategy. Mimis (2012) develop a methodology to find the optimal location for a number of branches and ATMs to expand an existing nested hierarchical network. The methodology integrates GIS, used to define catchment areas through Voronoi diagrams, and directed tabu search to minimize the average distance travelled by the users. Moreover, many works address the problem of expanding banking networks by locating ATMs (Aldajani & Alfares, 2009; Byers et al., 2012; Kisore & Koteswaraiah, 2017; Wang et al., 2002).

Contributions dealing with the branch network restructuring problem can be found starting from the early 2000s due to the transformation that occurred in the reference sector. Morrison and O'Brien (2001) propose a GIS-based spatial interaction model to estimate the impact of removing one or more branches from the network on the basis of the expected number of transactions and customers. Wang et al. (2003) propose a budget-constrained location model for relocating branches in an urban area, with the aim of minimizing the total weighted travel distance for customers. Zhang and Rushton (2008) present a location–allocation model for both opening and closing branches in a competitive environment, maximizing a utility function that considers both the size of the branches and their distance to customers. Basar et al. (2017) propose a multi-objective mathematical programming model aiming at maximizing the transaction volume of located branches while minimizing the cost of relocating branches and the penalties incurred for opening the same type of branches (e.g. retail, entrepreneur, corporate, and commercial) near each other.

Given the increased use of electronic payment methods and card transactions, the ATM location problem is discussed by Denstad et al. (2019). In there, the authors propose a multi-objective linear integer mathematical programming model for relocating ATMs in an existing network.

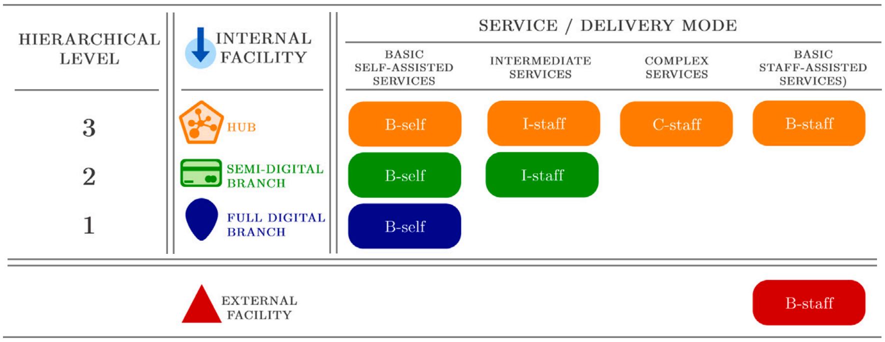


Fig. 1. Partially nested hierarchical structure.

Besides facility relocation and shrinking action, recent literature focuses on more complex restructuring actions, including facility sizing and resizing. Monteiro and Fontes (2006) propose a branch network restructuring problem where facilities can be closed, relocated and/or resized. They formulate a non-linear model aimed at satisfying client needs for banking services at a minimum cost. Ruiz-Hernández et al. (2015) propose the Capacitated Branch Restructuring Problem (CBRP), which deals with the problem of closing redundant capacitated branches and resizing remaining branches in order to maintain a constant service level. Ceding market share to competitors is allowed whenever the restructuring costs are prohibitively expensive. Ruiz-Hernández and Delgado-Gómez (2016) analyze a similar problem assuming uncertainty on the reaction of those clients whose preferred facility gets closed and the likelihood that some of them will migrate to a competitor. Finally, Ruiz-Hernández et al. (2017) address the branch restructuring problem from a game theoretical point of view, where two competing companies are simultaneously engaged in restructuring processes. The authors explore the existence of different types of equilibrium. Yavari and Mousavi-Saleh (2019) present a hierarchical problem for restructuring banking networks; they consider two types of capacitated facilities – main and auxiliary – that serve two different types of customers. The model's objective is to satisfy customers' demand while minimizing the total cost of closing and/or resizing existing facilities and locating auxiliary facilities.

Our work aims to contribute to this literature by considering novel restructuring actions. In particular, besides branch closure, we consider branch diversification and outsourcing. Diversifying internal branches leads to restructuring the internal network in a nested hierarchical structure, where a higher-level facility offers services provided by lower levels in addition to some other exclusive services (Farahani et al., 2014). Such structure is then complicated by the outsourcing strategy, which opens the possibility of integrating the internal network with external facilities. As the external facilities do not offer a subset of services provided by the lowest-level internal facilities, the emerging structure cannot configured as a four-level nested hierarchical structure. Instead, they offer a subset of services provided by the facilities at the top of the internal hierarchy; hence, the final emerging structure can be considered as partially nested (more details will be provided in the following section). In this scenario, the addressed hierarchical covering problem is more complex due to the multifaceted and interrelated characteristics of banking services.

In the following section, we describe the Hierarchical Branch Restructuring Problem (HBRP) and its assumption (Section 3.1); then, the mathematical formulation is presented in (Section 3.2).

3. The Hierarchical Branch Restructuring Problem (HBRP)

3.1. Problem description

In this section, we introduce the HBRP addressed in this work and its mathematical formulation. As anticipated above, we consider three main actions: (i) the shrinking of the existing network, (ii) the diversification of remaining branches, and (iii) the outsourcing of a subset of banking services. The final aim of banking groups is to completely transform the service delivery model by relying on the opportunities provided by digital technologies. In particular, banks intend to push the transition toward a new concept of the branch, where basic services (i.e., deposits, withdrawals, receipt payments) are delivered solely through the support of automatic devices while the staff is dedicated to more complex and added value operations. However, in order to meet the demand of *traditional clients*, who still need staff assistance to perform basic services, the physical provision of such services will be consolidated in a lower number of facilities or outsourced to external (non-banking) facilities. The latter, by nature, are shops regularly visited by clients where they may receive all the support from operators.

In order to introduce the branch typologies, let us consider three broad categories of financial services: (i) *basic services* (B), e.g., deposits, withdrawals, receipt payments, pay bills, (ii) *intermediate services* (I), e.g., loans and mortgages, safe deposit boxes, financial advice, investments and credits and (iii) *complex services* (C), e.g., dedicated to enterprises and corporations, including other banks, loans beyond a large amount. While intermediate and complex services always require physical interaction with the staff, the basic services may be delivered with (B-staff) or without (B-self) staff assistance.

In the final configuration of the network, we distinguish three main types of *internal facilities*, on the basis of the delivered services and the adopted delivery channels:

- *Full digital branches*, providing basic services solely through digital channels (B-self). In other words, they are points equipped with automatic devices that allow clients to receive basic services without staff assistance;
- *Semi-digital branches*, providing intermediate services (I-staff) beside the services provided by full digital branches (B-self);
- *Traditional Branches or Hubs*, providing the full gamma of services and delivery modes. In addition to services provided by semi-digital branches (B-self and I-staff), they provide complex services (C-staff). Moreover, clients may receive basic services assisted by staff (B-staff) or automatic machines (B-self).

The internal facility network is arranged according to a 3-level nested hierarchical structure, as shown in Fig. 1. The hierarchy is nested in the sense that a higher-level facility provides all the services provided by a lower-level one plus (at least) one additional service.

As the consolidation of the physical provision of basic services (B-staff) risks to leave uncovered a significant portion of demand (traditional clients), banking groups are adopting the outsourcing strategy to guarantee their proximity to the network. Such a strategy consists of selecting existing facilities within the network of brick-and-mortar retailers to be integrated into the network. The inclusion of external facilities in the network configures the final hierarchy as a *partially*

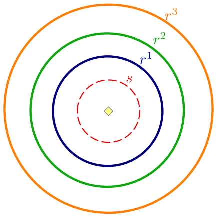
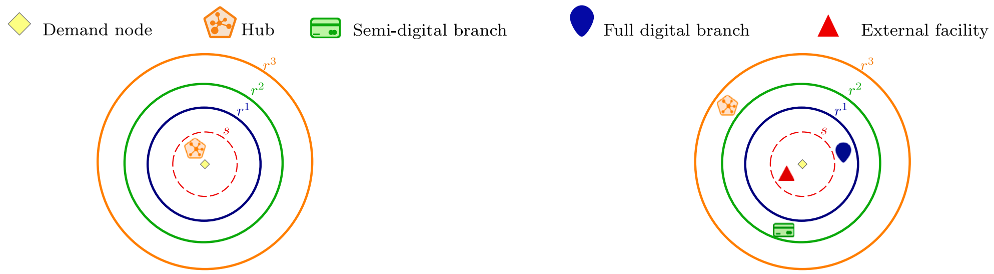


Fig. 2. Arrangement of covering radii.



(a) Full coverage within s by a hub.

(b) Coverage within s by an external facility and within r^k by internal facilities ($k \in \{1, 2, 3\}$).

Fig. 3. Coverage examples.

nested hierarchy, as shown in Fig. 1. Indeed, they provide a subset of services provided by the top-level facilities of the internal hierarchy (i.e. the hubs).

The proposed HBRP is formulated as a hierarchical covering model aimed at deciding (i) the location and number of the internal facilities that will be kept open; (ii) the type of service they will provide and the delivery mode (i.e. full digital branches, semi-digital branches, or hubs); and (iii) the number and the location of external facilities to be activated. The objective is to minimize the total costs. The outsourcing level is constrained by the model, leaving banking groups the possibility to fix an upper bound on the level of services to outsource.

Each hierarchical level k is associated with a covering radius r^k, representing the maximum distance customers are willing to travel to receive the services provided by a facility of level k or higher (nested hierarchy). It holds that $r^1 < r^2 < r^3$. In addition, a fourth covering radius s is introduced to represent the distance customers are willing to commute to reach a facility providing B-staff (i.e., hubs or external facilities). This parameter can be considered influenced by the propensity of customers to adopt digital channels. The lower the propensity, the higher should be the proximity to guarantee to customers. Hence, in this transitional phase, s may be considered smaller than the other covering radii, as shown in Fig. 2 (i.e. $s < r^1 < r^2 < r^3$), but we may expect that it will increase as the digitalization of banking users reaches a more mature phase.

A demand node can be covered for B-staff within s either by a hub or by an external facility. In the first case, the demand node is fully covered and may receive all the services within s (Fig. 3(a)). In the second case, basic services are provided by external facilities within s whilst internal facilities of appropriate level must be located within adequate distances to satisfy the demand for other banking services (Fig. 3(b)).

As concerns the other problem parameters, we assume that the cost ω_j^k of a given internal facilities j depends on the hierarchical level and that it rises as the gamma of provided services increases ($\omega_j^1 < \omega_j^2 < \omega_j^3$). The outsourcing cost is mainly related to the agreement with external facilities. Moreover, we assume that the latter facilities are capacitated as banking services are not their primary activity, and it is reasonable to consider that they have limited operability. The outsourcing mechanism is regulated by the parameter α^{ext} (*maximum outsourcing degree*) representing the maximum fraction of demand the bank is willing to outsource for B-staff services. The decision-maker may calibrate such a parameter as leverage to restructure the internal network. For instance, a bank interested in keeping its own physical presence on the territories would set a low α^{ext} in combination with a small s. Conversely, by allowing a high outsourcing degree (i.e., a larger value of α^{ext}), the bank may push the consolidation of its internal network to a greater extent. Moreover, the parameter α^{ext} may somehow also represent the risk the bank is willing to run by outsourcing services to third parties for the sake of consolidation. Indeed, besides great opportunities, outsourcing may increase exposure to operational risks, resulting in financial losses and reputation damages (Gewald & Dibbern, 2009). Hence, banks are required to define transparent outsourcing policies and adopt strategies to monitor and prevent risks (European Banking Authority, 2019). In this sense, an appropriate calibration of α^{ext} may be useful to find trade-off solutions between cost-efficiency goals and the minimization of outsourcing risks.

3.2. Mathematical formulation

On the basis of the above assumptions, we introduce the following notation that will be used through this and subsequent sections:

Sets	
I	Set of demand nodes;
K	Set of hierarchical level of internal facilities. $K = \{1, 2, 3\}$;
J^{int}	Set of internal facilities;
J^{ext}	Set of external facilities that are eligible for activation.
Parameters	
ω_j^k	Cost of internal facility $j \in J^{int}$ of level k;
γ_j	Cost of external facility $j \in J^{ext}$;
d_{ij}	Distance between node i and facility $j \in J^{int} \cup J^{ext}$;
r^k	Covering radius of level k, with $r^k < r^{k+1}$, $k \in \{1, 2\}$;
s	Covering radius for B-staff services;
C_j	Capacity of external facility $j \in J^{ext}$;
τ_i	Demand for B-staff services from node $i \in I$;
α^{ext}	Maximum fraction of demand the bank is willing to outsource for B-staff services.

Covering sets

N_i^k	Set of internal facilities accessible to demand node i within r^k ($N_i^k = \{j \in J^{int} : d_{ij} \le r^k\}$);
M_i^{ext}	Set of external facilities $j \in J^{ext}$ accessible to demand node i within s ($M_i^{ext} = \{j \in J^{ext} : d_{ij} \le s\}$);
M_i^3	Set of internal facilities $j \in J^{int}$ accessible to demand node i within s ($M_i^3 = \{j \in J^{int} : d_{ij} \le s\}$).

Decision variables

y_j^k	Binary variable equal to 1 if an internal facility of level k is located at $j \in J^{int}$ and 0 otherwise;
z_j	Binary variable equal to 1 if external facility $j \in J^{ext}$ is integrated into the network and 0 otherwise;
v_i	Binary variable equal to 1 if demand node i is internally covered, i.e. by hubs, within s for B-staff services and 0 otherwise;
x_{ij}	Fraction of demand from $i \in I$ that is covered by the external facility $j \in M_i^{ext}$ to receive B-staff services.

With this notation, we can write the MILP formulation of the hierarchical branch restructuring problem as follows:

$$\min \sum_{k\in K}\sum_{j\in J^{int}} \omega_j^k y_j^k + \sum_{j\in J^{ext}} \gamma_j z_j \tag{1}$$

$$\text{s.t.} \sum_{j\in N_i^k}\sum_{t=k}^{3} y_j^t \ge 1 \qquad \forall i \in I,\ k \in K \tag{2}$$

$$\sum_{j\in M_i^3} y_j^3 \ge v_i \qquad \forall i \in I \tag{3}$$

$$\sum_{j\in M_i^3} y_j^3 \le |M_i^3| v_i \qquad \forall i \in I \tag{4}$$

$$\sum_{j\in M_i^{ext}} x_{ij} = 1 - v_i \qquad \forall i \in I \tag{5}$$

$$x_{ij} \le z_j \qquad \forall i \in I, j \in M_i^{ext} \tag{6}$$

$$\sum_{k\in K} y_j^k \le 1 \qquad j \in J^{int} \tag{7}$$

$$\sum_{i\in I} \tau_i v_i \ge (1-\alpha^{ext}) \sum_{i\in I} \tau_i \tag{8}$$

$$\sum_{i\in I} \tau_i x_{ij} \le C_j \qquad \forall j \in J^{ext} \tag{9}$$

$$y_j^k \in \{0,1\} \qquad \forall k \in K, j \in J^{int} \tag{10}$$

$$z_j \in \{0,1\} \qquad \forall j \in J^{ext} \tag{11}$$

$$v_i \in \{0,1\} \qquad \forall i \in I \tag{12}$$

$$x_{ij} \ge 0 \qquad \forall i \in I, \forall j \in M_i^{ext} \tag{13}$$

The objective function (1) minimizes the costs of the facility network. The first term is associated with the internal network; the second term accounts for the contribution of external facilities.

Constraints (2) guarantee that each demand node $i \in I$ is covered within distance r^k by a facility of at least level k. Constraints (3)–(6) guarantee that all demand nodes are covered for B-staff services. In particular, a demand node $i \in I$ is internally uncovered when no hubs are located within s (constraints (3)); conversely, a demand node i is internally covered if at least one hub is located within s (constraints (4)). If no hubs are located within s from node $i \in I$, the demand generated from i for B-staff services must be spread among activated external facilities located within distance s from node i (constraints (5) and (6)). Constraints (7) allow internal facilities $j \in J^{int}$ to assume only one level. Constraint (8) defines the lower bound on the portion of demand for B-staff services that the bank wants to manage internally through hubs. External facilities' capacity is assigned by constraints (9). Lastly, expressions (10)–(13) describe the nature of the decision variables.

In the following sections we present the results obtained when applying the HBRP to a local network of a large banking institution in Italy.

4. Italian scenario and case study

The Italian banking scenario was chosen as an illustrative example to implement and test the HBRP proposed in Section 3. In the last decades, Italian banking groups have launched strong restructuring policies to resize their branch networks and closed almost 37% of branches from 2008 to 2021 (Banca d'Italia, 2022). Despite the high number of closures, the Italian branch network remains oversized. Indeed, the average number of inhabitants per branch is 2719 against 3227 for EU-27 and 24,230 for the Netherlands in 2021 (European Central Bank, 2021). Moreover, as anticipated in Section 1, Italy, especially in the Southern regions, presents a significant digital divide compared to the other European and Western countries (Bruno et al., 2023). As a result, in Italy, the branch restructuring process is at an early stage, and a strong effort has still be done in this direction.

In the described context, we consider one of the leading Italian banking groups owning the largest branch network on the national territory. The region of interest is the city of Naples (Southern Italy), where the bank holds the densest branch network compared to competitors. Such a bank has undertaken an intensive restructuring during the last years, based on closures and diversification of branches according to different degrees of digitalization with a resulting classification of internal facilities similar to the one we propose in Fig. 1.

In order to show the evolution of the branch network, we report in Fig. 4 the spatial distribution of the bank's internal facilities from 2010 to 2019, considering 2014 as a midterm year. In addition, Table 1 reports the transition matrices describing the closures and the transformations of internal facilities with respect to each pair of the considered years (2010–2014, 2014–2019). The diversification strategy allows solely to downgrade facilities in terms of provided services, i.e., hubs can be transformed into semi-digital or full digital branches, and semi-digital branches into full digital ones.

In 2010, the bank's network counted 17 full digital branches, 6 semi-digital branches and 77 hubs (Table 1(a)). In the period 2010–2014 the restructuring mainly involved the closure and the transformation of hubs: 2 out of 77 were downgraded to full digital branches, and 32 were downgraded to semi-digital branches; moreover, 17 hubs were closed. As a result, the semi-digital branches increased from 6 to 36 and the full digital branches from 17 to 20.

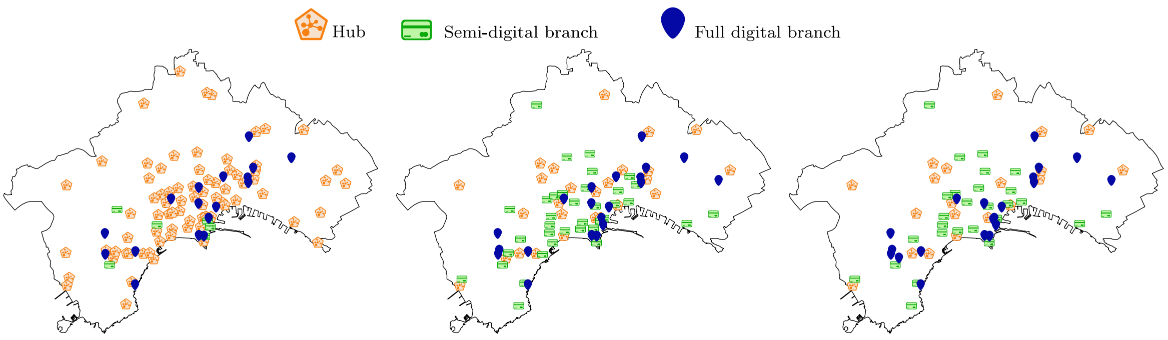
In the second period 2014–2019, the bank restructuring plan (Table 1(b)) involved a massive closure of banking facilities - 3 full digital branches, 9 semi-digital branches and 4 hubs - and the downgrading of 2 hubs (1 to semi-digital branch and 1 to full digital branch), and of 1 semi-digital branch to full digital branch.

Despite the evolution of the network above, the process is still at an early stage of development and requires additional efforts. Thus, the mathematical model we propose is suitable for providing scenarios for future restructuring.

4.1. Test instance

As mentioned above, we tested the model on a real-world case study in an urban context. The study area is represented by the city of Naples, where the banks holds 19 full digital branches, 27 semi-digital branches and 20 hubs in 2019 (*network as is*). Naples is the third city in the country for population and one of the most densely populated, with 962,003 resident inhabitants in 2011 in an area of 117.27 km^2. In order to apply the model to the study area, we discretized the demand space into 3836 nodes corresponding to the centroids of the populated census tracts of the city (set of demand nodes I). We considered the census tracts since they are the lowest level of territorial aggregation adopted for statistical purposes by the Italian Statistical Institute (ISTAT), and, therefore, they represent a trade-off between the held of a realistic representation of demand and its manageability issue (ISTAT, 2011).

All the distances we refer to hereafter, including the distance d_{ij} between the demand node $i \in I$ and the generic facility $j \in J^{int} \cup J^{ext}$, are network distances.



(a) 2010 (b) 2014 (c) 2019

Fig. 4. Bank's network form 2010 to 2019 in the city of Naples.

Table 1
Bank's restructuring from 2010 to 2019 in the city of Naples.

⬠ Hub 🟩 Semi-digital branch ● Full digital branch ✕ Closures ↓ Internal facilities

			2014			
		✕	●	🟩	⬠	
2010	17 ●	0	17	▨	▨	
	6 🟩	1	1	4	▨	
	77 ⬠	17	2	32	26	
	100 ↓	**18**	**20**	**36**	**26**	**82** ↓

(a) 2010-2014

			2019			
		✕	●	🟩	⬠	
2014	20 ●	17	3	▨	▨	
	36 🟩	9	1	26	▨	
	26 ⬠	4	1	1	20	
	82 ↓	**16**	**19**	**27**	**20**	**66** ↓

(b) 2014-2019

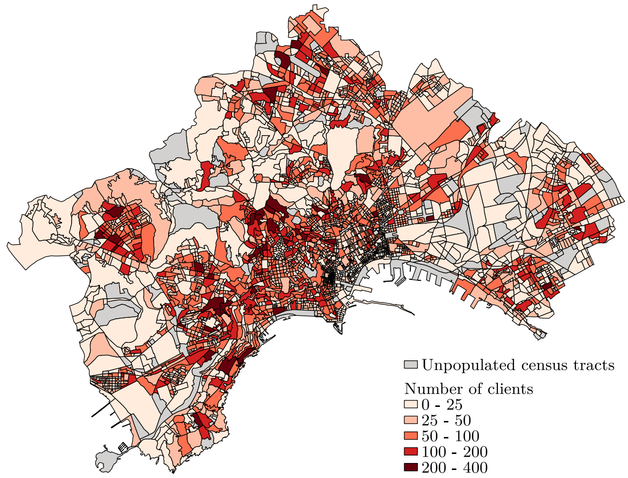


Fig. 5. Simulated spatial distribution of clients in Naples.

Table 2
Facilities' costs from uniform distribution per facility type.

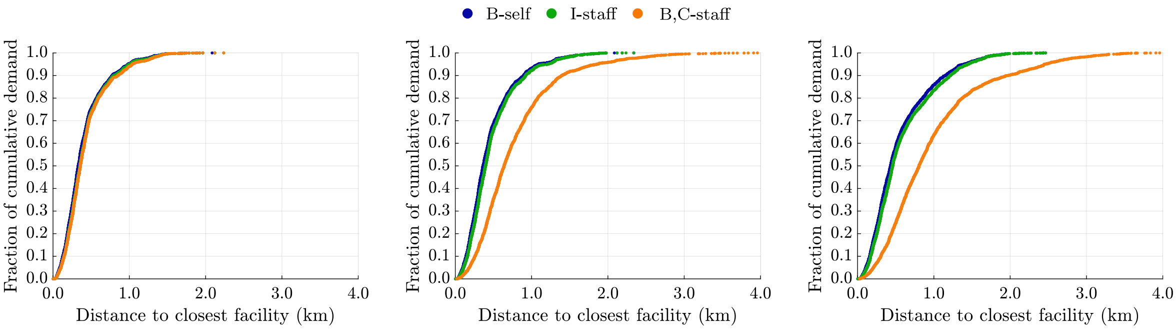
Facility type	Uniform distribution bounds
Hub	[800, 1000]
Semi-digital branch	[480, 600]
Full digital branch	[80, 100]
External facility	[8, 10]

In order to estimate the demand for B-staff services, we used data provided confidentially by another banking institution operating in a similar context. In particular, assuming a dependence between the number of clients and the distance to the closest branch, such data were used to calibrate a regression model that was used to simulate the spatial distribution of clients in our study area (Fig. 5).

Before applying the mathematical model to the selected case, we are interested in performing a preliminary analysis of clients' accessibility to banking services, i.e., basic services that are self-assisted (B-self) or staff-assisted (B-staff), intermediate services (I-staff), and complex services (C-staff) as in Fig. 1. In particular, we assume that each client patronizes the closest facility for each required service and compute the accessibility as in Bruno et al. (2021). Our aim is to analyze how accessibility conditions to the banking network have changed after the restructuring implemented between 2010 and 2019 and to define the baseline to calibrate the covering radii.

Fig. 6 shows the distributions of the accessibility in 2010, 2014 and 2019, also reporting accessibility distances for each quartile. The three accessibility curves coincide almost entirely in 2010 (Fig. 6(a)) given the predominant presence of hubs (77 over 100 internal facilities). The closure of 17 hubs during 2010–2014 leads to a deterioration in clients' accessibility to B-staff and C-staff – from 0.36 km to 0.64 km for 50% of the demand and from 2.24 km to 3.96 km for the total – while accessibility to B-self and I-staff are mostly unaffected due to the stable number of the other facilities (Fig. 6(b)). After the network adjustments made in 2014–2019, the accessibility conditions to the different services have generally slightly worsened in the light of a more widespread action of closures (Fig. 6(c)). The higher deterioration of +0.26 occurs at the third quartile (75% of the demand) for B,C-staff (from 0.98 km to 1.24 km) while the overall maximum accessibility distances (100% of the demand) – equal to 2.34 km for B-self and I-staff, and 3.96 km for B,C-staff – does not suffer an actual decline. Based on the actual accessibility conditions in 2019, covering radii are calibrated (see Section 5).

In addition to the internal facilities, we considered 623 additional points in the network of retail shops as potential locations for external facilities (J^{ext}). Selecting possible external points to be included in the network represents a crucial issue to address, as it involves multiple arrangements with different retailers with different characteristics. In our test instance, we considered an enlarged and not-constrained set of external points. Either way, the decision-maker has complete control over filling this set based on the outsourcing policies to undertake.



	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.21	0.23	0.24
50%	0.33	0.35	0.36
75%	0.50	0.50	0.53
100%	2.10	2.24	2.24

(a) 2010

	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.23	0.26	0.42
50%	0.37	0.40	0.64
75%	0.58	0.61	0.98
100%	2.34	2.40	3.96

(b) 2014

	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.27	0.29	0.50
50%	0.43	0.46	0.81
75%	0.73	0.79	1.24
100%	2.46	2.46	3.96

(c) 2019 (network as is)

Fig. 6. Evolution of clients' accessibility to the bank's services form 2010 to 2019 in Naples.

As concerns facilities' costs, we randomly generated them from different uniform distributions. The bounds for each distribution increase according to the hierarchical levels, as shown in Table 2. Finally, we assume that the capacity of each external point is equal to the average of the B-staff services performed per month by a branch with only one bank counter operator ($C_j = 1200\ \forall j \in J^{ext}$).

In the following, we apply the model proposed in Section 3.2 to the 2019 network and produce several restructuring scenarios by varying some crucial parameters.

Table 3
Maximum accessibility distances (d_{acc}, in km) to services by levels and demand classification in the network as is and corresponding setting of covering radii (r^k, in km).

Demand nodes	B-self		I-staff		C-staff			
	d_{acc}	r^1	d_{acc}	r^2	d_{acc}	r^3		
Central	1.98	2.00	1.98	3.00	3.78	5.00	7.00	9.00
Remote	2.46	3.00	2.46	4.00	3.96	6.00	8.00	10.00

5. Application of the model to the case study

In this section, we discuss the results obtained by applying the proposed model to the case study described in Section 4. As the problem under investigation involves a network that has been partially restructured, we assumed that a facility already downgraded cannot be upgraded anymore; i.e., for instance, a full digital branch cannot be converted into a semi-digital branch. At this aim, we adapted the model presented in Section 3 to prevent internal facilities from being upgraded.

We applied the proposed model by varying some crucial parameters in order to present a comparative analysis of several restructuring scenarios that may provide helpful insights to the decision-maker.

The restructuring actions considered by the model are (i) the closure and (ii) the diversification of internal facilities, and (iii) the outsourcing of basic banking services. The decision maker may be interested in pushing one action rather than another and controlling their extent. To this end, we identified the covering radii (s and $r^k,\ k \in K$) and the maximum outsourcing degree (α^{ext}) as the calibrating parameters to implement an action-driven restructuring. For instance, the bank may be more conservative and preserve a high level of internalization by fixing a low value of α^{ext} or, conversely, massively shrink the internal network by increasing it. Furthermore, we decided to vary s and r^3 to analyze the model response to the conflicting targets of complex services consolidation (r^3) and basic services capillarity (s).

As regards the covering radii r^k, we can reasonably assume that clients' distance perception and travelling willingness to access banking services depends on their residential area. Indeed, clients living in the suburbs and isolated areas are usually willing to travel longer distances than those who live in urban neighborhoods, where services and activities are more concentrated. Therefore, we defined an agglomeration index to classify the demand nodes into *central* and *remote*, depending on mutual distances between them. Specifically, for each demand node, we computed its average distances from the closest ten nodes; those demand nodes within the 90th percentile of the global distribution were considered central (3467) and the remaining ones remote (369). Accordingly, we associated to each of these groups two distinct covering radii r^k for each hierarchical level k, namely $r^k_{central}$ and r^k_{remote}. In order to properly calibrate these covering radii, we referred to the accessibility conditions of clients to the different sets of banking services in the *as is* scenario. In Fig. 7, we report the accessibility distributions stratified by the demand node classification into central (Fig. 7(a)) and remote (Fig. 7(b)). As expected, clients in urban nodes have better access to services than those in remote nodes. As the restructuring aims to shrink the existing internal network, the current accessibility conditions are expected to worsen. Therefore, we set the values of covering radii above the corresponding maximum accessibility distances to different levels of services, as reported in Table 3.

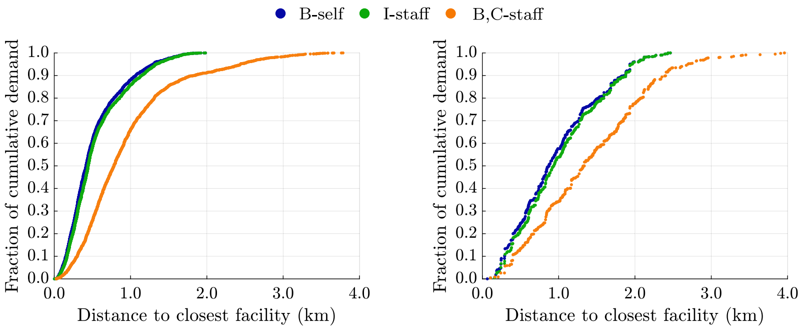
As concerns s, different considerations have been made. Since the outsourcing action aims to guarantee physical proximity to clients and build customer loyalty, we set s smaller than the actual maximum accessibility to BS-self ($s < r^1_{central}$). In particular, we tested $s = 1.0$ km and $s = 1.5$ km.

The maximum outsourcing degree α^{ext} may not be chosen regardless of the covering radii setting. Indeed, to obtain a feasible solution, α^{ext} should be greater than a certain lower bound ($LB(\alpha^{ext})$). This lower bound is computed as the fraction of B-staff services required by clients who find the closest hub beyond s in the initial configuration of the network:

$$LB(\alpha^{ext}) = f(s) = \sum_{i \in \hat{I}} \tau_i \Big/ \sum_{i \in I} \tau_i \tag{14}$$

where $\hat{I} = \left\{ i \in I : \min_{j \in J^3} d_{ij} > s \right\}$.

On the other hand, the bank will always internally handle a certain percentage of B-staff services, as the model locates at least one hub.



	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.26	0.28	0.49
50%	0.42	0.44	0.78
75%	0.68	0.72	1.19
100%	1.98	1.98	3.78

(a) Central demand nodes

	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.51	0.58	0.82
50%	0.88	0.94	1.34
75%	1.32	1.93	1.93
100%	2.46	2.46	3.96

(b) Remote demand nodes

Fig. 7. Clients' accessibility to the bank's services in the network as is.

Table 4
Bounds of α^{ext} (covering radii in km).

	$LB(\alpha^{ext}) = f(s)$	$UB(\alpha^{ext}) = f(s, r^k_{central}, r^k_{remote})$		
		$r^3_{central} = 5.00$ $r^3_{remote} = 6.00$	$r^3_{central} = 7.00$ $r^3_{remote} = 8.00$	$r^3_{central} = 9.00$ $r^3_{remote} = 10.00$
$s = 1.00$	0.40	0.89	0.95	0.92
$s = 1.50$	0.20	0.77	0.92	0.90

Hence, an upper bound on the maximum outsourcing degree $UB(\alpha^{ext})$ can be found. At this aim, we solve a relaxed problem that does not allow outsourcing and locates only internal facilities to cover clients at the minimum cost (Ω = (1), (2), (7), (10)). The solution obtained, namely $\sigma(\Omega)$, defines the located hubs (y_j^{3*}). The upper bound of α^{ext} is computed as the fraction of B-staff services required by clients who find within s the closest hub located by the relaxed problem:

$$UB(\alpha^{ext}) = f(s, r^k_{central}, r^k_{remote}) = 1 - \sum_{i\in\tilde{I}} \tau_i \bigg/ \sum_{i\in I} \tau_i \qquad (15)$$

where $\tilde{I} = \{i \in I \,:\, \min_{y_j^{3*}\in\sigma(\Omega)} d_{ij} \leq s\}$.

Based on the lower and upper bounds, listed in Table 4, we varied starting from $LB(\alpha^{ext})$ and increasing it with a step 0.1 until reaching the step in correspondence of $UB(\alpha^{ext})$ or immediately higher. Indeed, all the solutions obtained with $\alpha^{ext} \geq UB(\alpha^{ext})$ are identical. For instance, if $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, setting $\alpha^{ext} = 1$ is precisely the same of setting $\alpha^{ext} = 0.92$ ($UB(\alpha^{ext})$).

We generated 44 test problems for each combination of the above parameters that have been solved using CPLEX in limited computational time. This is advantageous for all practitioners interested in solving the model with a commercial solver within a limited time frame.

5.1. Illustrative results

In this section, illustrative scenarios are compared by varying the parameters s and α^{ext} to analyze the emerging balance between internal and external networks. For each scenario, we report the network configuration map, the transition matrix explaining the transformation of internal facilities, the number of activated external facilities, and some key indicators. The latter are: (i) the cost of the overall network (internal and external); (ii) the outsourcing degree, i.e. the percentage of B-staff services handled by external facilities, $\left(\sum_{i\in I} \tau_i(1-\upsilon_i)/\sum_{i\in I} \tau_i\right)$; (iii) the average capacity utilization, i.e. the average percentage of B-staff services handled by external facilities $\left(\sum_{i\in I, j\in M_i^{ext}} \tau_i x_{ij}/\sum_{j\in J^{ext}} C_j z_j\right)$.

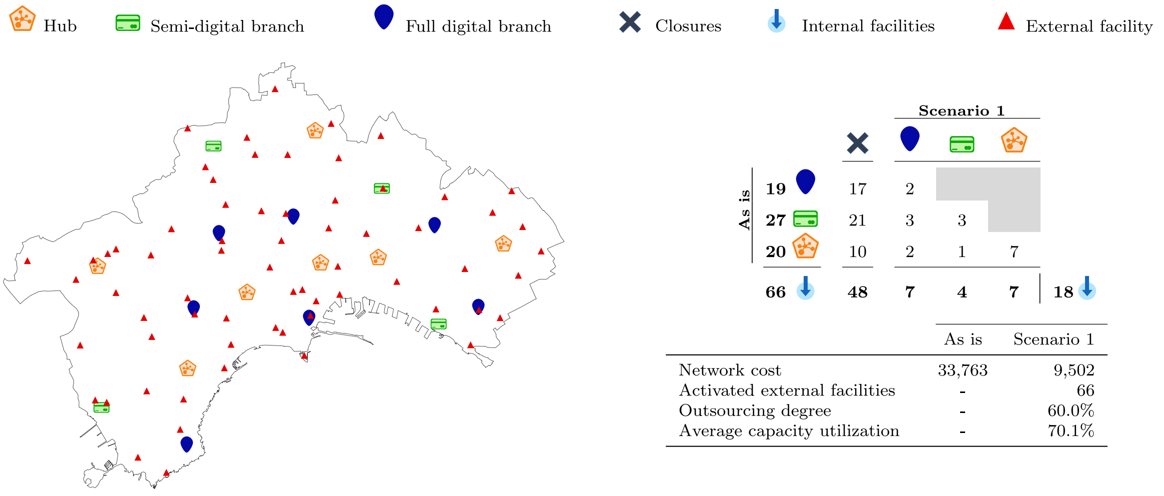
Fig. 8 shows a first scenario produced by the model by setting $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, and $\alpha^{ext} = 0.6$. The internal network has significantly shrunk, with the closure of 48 out of 66 facilities, with a substantial reduction of costs. The new scenario includes 7 full digital branches, 4 semi-digital branches, and 7 hubs, while 66 external facilities are activated.

Fig. 9 shows a second scenario obtained by increasing the covering radius s from 1.0 km to 1.5 km. Although the total number of internal facilities compared to scenario 1 is the same (18), the network configuration is completely different. Indeed, fewer hubs remain open (3 instead of 7), and, as a consequence, more semi-digital (6 instead of 4) and full digital branches (9 instead of 7) have been located. Furthermore, fewer external facilities are activated (50 instead of 66), which are more saturated in terms of capacity utilization (92.1% instead of 70.1%).

A last illustrative scenario is provided in Fig. 10 using $\alpha^{ext} = 1$ and $s = 1.0$ km. With respect to scenario 1, the model activates 23 additional external facilities (89 instead of 66) and leaves open only 2 hubs instead of 7 at a lower overall cost. As in the previous scenario, this leads to a different internal configuration with 6 semi-digital branches and 9 full digital branches, differently located. The activated external facilities absorb almost the total demand of B-staff services with an outsourcing degree equal to 91.5%, slightly below the $UB(\alpha^{ext})$; they are also exploited almost entirely with a capacity utilization equal to 95.4% on average.

Besides the spatial configuration of the network, a comparative analysis of clients' accessibility in the illustrative scenarios is provided (Fig. 11). The accessibility to services provided (exclusively) by internal facilities is obtained as described in Section 4.1. Instead, in order to compute the accessibility to B-staff services, we assume that clients are covered by a hub (if present within s) or by the closest activated external facility according to the capacity.

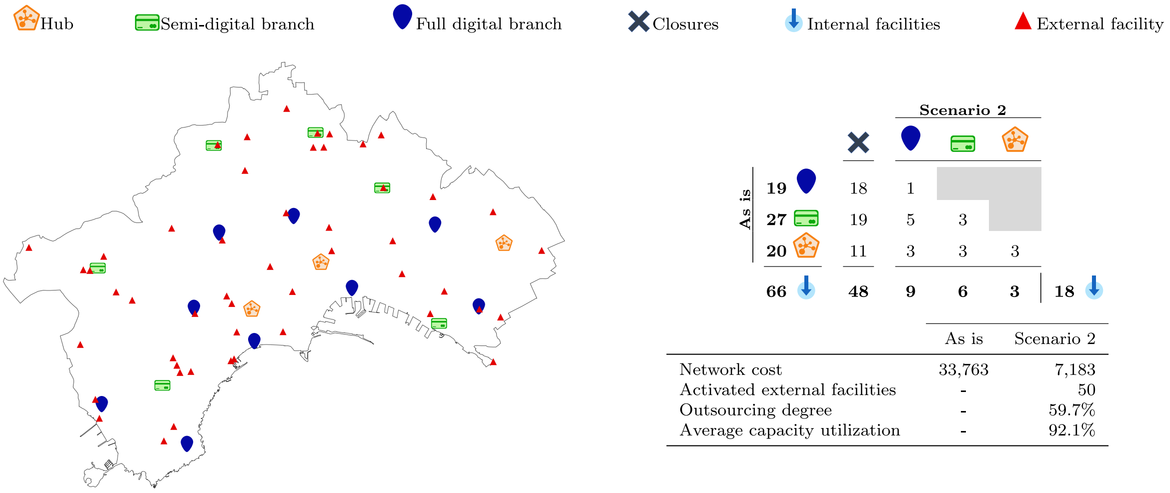
Comparing accessibility to the network as is (Fig. 11(a)) of scenario 1 (Fig. 11(b)), each client has access to B-staff within 1 km instead of 4 km – and 50% of demand within half such a distance (0.51 km) – thanks to external facilities. Moreover, the accessibility to I-staff is the one that gets worse the most, recording an increase of 0.79 km at the fourth quartile. In contrast, the accessibility to C-staff does not deteriorate substantially, given the strict value of $\alpha^{ext} = 0.6$. Clients, indeed, are covered within just over 4 km, albeit r_i^3 is (much) larger.



			Scenario 1			
		✕	📍	💳	⬠	
As is	**19** 📍	17	2			
	27 💳	21	3	3		
	20 ⬠	10	2	1	7	
	66 ↓	**48**	**7**	**4**	**7**	**18** ↓

	As is	Scenario 1
Network cost	33,763	9,502
Activated external facilities	-	66
Outsourcing degree	-	60.0%
Average capacity utilization	-	70.1%

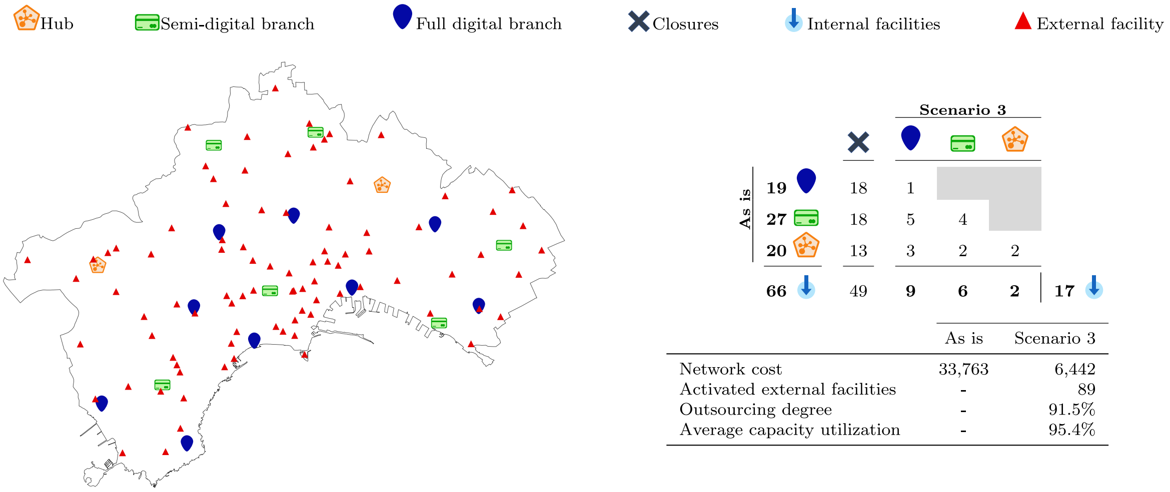
Fig. 8. Restructuring scenario 1: $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 0.6$.



			Scenario 2			
		✕	📍	💳	⬠	
As is	**19** 📍	18	1			
	27 💳	19	5	3		
	20 ⬠	11	3	3	3	
	66 ↓	**48**	**9**	**6**	**3**	**18** ↓

	As is	Scenario 2
Network cost	33,763	7,183
Activated external facilities	-	50
Outsourcing degree	-	59.7%
Average capacity utilization	-	92.1%

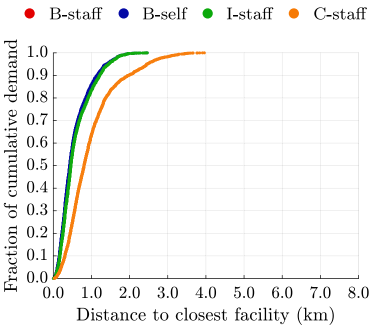
Fig. 9. Restructuring scenario 2: $s = 1.5$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 0.6$.



			Scenario 3			
		✕	📍	💳	⬠	
As is	**19** 📍	18	1			
	27 💳	18	5	4		
	20 ⬠	13	3	2	2	
	66 ↓	49	**9**	**6**	**2**	**17** ↓

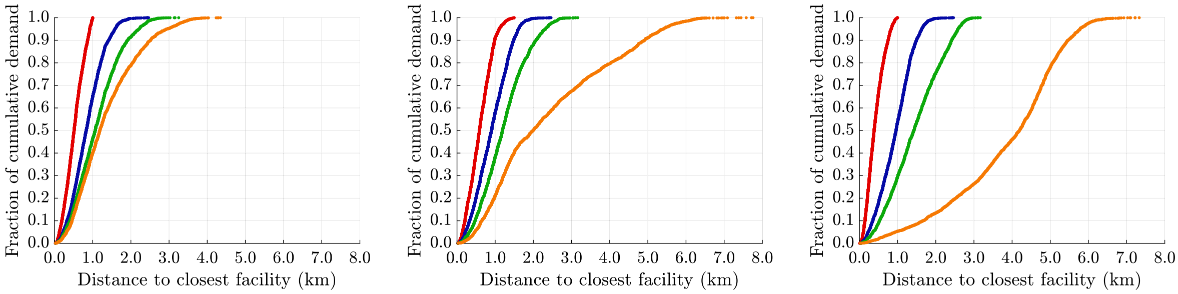
	As is	Scenario 3
Network cost	33,763	6,442
Activated external facilities	-	89
Outsourcing degree	-	91.5%
Average capacity utilization	-	95.4%

Fig. 10. Restructuring scenario 3: $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 1$.



	Distance to service		
Demand	B-self	I-staff	B,C-staff
25%	0.27	0.29	0.50
50%	0.43	0.46	0.81
75%	0.73	0.79	1.24
100%	2.46	2.46	3.96

(a) Network As is



	Distance to service			
Demand	B-staff	B-self	I-staff	C-staff
25%	0.33	0.54	0.65	0.73
50%	0.51	0.83	1.07	1.19
75%	0.71	1.13	1.50	1.84
100%	1.00	2.46	3.25	4.34

(b) Scenario 1: $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 0.6$

	Distance to service			
Demand	B-staff	B-self	I-staff	C-staff
25%	0.37	0.57	0.78	1.09
50%	0.59	0.91	1.19	1.99
75%	0.82	1.25	1.62	3.56
100%	1.50	2.46	3.17	7.76

(c) Scenario 2: $s = 1.5$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 0.6$

	Distance to service			
Demand	B-staff	B-self	I-staff	C-staff
25%	0.24	0.62	0.91	2.91
50%	0.38	0.96	1.42	4.19
75%	0.57	1.25	1.98	4.90
100%	1.00	2.46	3.17	7.33

(d) Scenario 3: $s = 1.0$ km, $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km, $\alpha^{ext} = 1$

Fig. 11. Restructured network: clients' accessibility to services.

Considering scenario 2 in Fig. 11(c), we can notice that, as expected, the increase of s worsens the accessibility to B-staff. However, the most significant effect is on the accessibility curve to C-staff provided by hubs, which is smooth and shows a decrease in slope at 1.5 km (s). Indeed, 50% of demand is covered within about 2 km (1.19 km in scenario 1), while each client is covered within slightly below 8 km (equal to r^3_{remote}).

An even more significant worsening to C-staff occurs by increasing α^{ext} (Fig. 11(d)), where the lower number of hubs leads to a very slow-growing curve. For instance, the accessibility distance of 50% of demand is more than double, equal to 4.19 km.

5.2. Summary results and managerial implications

The comparative analysis of all produced scenarios (Tables 5 and 6) may provide valuable restructuring insights to the decision-maker. Among others, we aim to demonstrate how decision-makers may evaluate the effects of various outsourcing policies by leveraging the identified critical parameters.

The direct outcome of increasing α^{ext} is the reduction of the network cost and the number of hubs. The provision of B-staff services is delegated to an increasing of external facilities. For instance, let note how in Table 5(a), increasing α^{ext} from its minimum value 0.4 to the maximum 1.0, the presence of external facilities becomes more significant, passing from 56 to 83. Contextually, the number of hubs drops from 14 to 4. Consequently, the overall layout of the internal facility network also changes. Indeed, the number of semi-digital and full digital branches adapts to the hub network, increasing from 2 to 5 and from 5 to 8, respectively.

The covering radius s rules the proximity extent the bank desires to establish with their clients through hubs and external facilities. By increasing s, the recourse to outsourcing becomes less significant. In Table 6(a), where $s = 1.5$ km, we can see how the maximum outsourcing level ($\alpha^{ext} = 1.0$) can be reached through a lower number of external facilities, which are 63 instead of 83 in the previous (Table 5(a)), where $s = 1.0$ km.

Moreover, the number of external facilities is also affected by the covering radius r^3. Indeed, if we push toward a strong consolidation of the hubs, we constrain client to access complex services within larger distances. Hence, the banks need to outsource B-staff services further and activate more external facilities. For example, by considering $\alpha^{ext} = 1.0$ and $s = 1.0$ km, 2 hubs are kept open (Table 5(c)) instead of 4 (Table 5(a)) with the activation of 6 additional external facilities (from 83 to 89).

Table 5

Bank's network restructuring: $s = 1.0$ km.

(a) $(r^3_{central}, r^3_{remote}) = (5.0, 6.0)$ km

	$\alpha^{ext}=0.2$	$\alpha^{ext}=0.3$	$\alpha^{ext}=0.4$	$\alpha^{ext}=0.5$	$\alpha^{ext}=0.6$	$\alpha^{ext}=0.7$	$\alpha^{ext}=0.8$	$\alpha^{ext}=0.9$	$\alpha^{ext}=1.0$
⬠ Hubs	n.a.	n.a.	14	9	7	5	4	4	4
▭ Semi-digital branches	n.a.	n.a.	2	4	4	5	6	5	5
● Full digital branches	n.a.	n.a.	5	5	7	8	7	8	8
↓ Internal facilities	n.a.	n.a.	21	18	18	18	17	17	17
✕ Closures	n.a.	n.a.	45	48	48	48	49	49	49
▲ External facilities	n.a.	n.a.	56	60	66	69	77	83	83
Network cost	n.a.	n.a.	14,275	10,997	9,502	8,505	8,040	7,659	7,659
Outsourcing degree	n.a.	n.a.	40.0%	49.7%	60.0%	69.7%	79.1%	88.6%	88.6%
Av. Cap. utilization	n.a.	n.a.	55.0%	63.8%	70.1%	77.9%	79.3%	82.4%	82.4%

(b) $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km

	$\alpha^{ext}=0.2$	$\alpha^{ext}=0.3$	$\alpha^{ext}=0.4$	$\alpha^{ext}=0.5$	$\alpha^{ext}=0.6$	$\alpha^{ext}=0.7$	$\alpha^{ext}=0.8$	$\alpha^{ext}=0.9$	$\alpha^{ext}=1.0$
⬠ Hubs	n.a.	n.a.	14	9	7	5	3	2	2
▭ Semi-digital branches	n.a.	n.a.	2	4	4	4	6	7	6
● Full digital branches	n.a.	n.a.	5	5	7	9	9	9	9
↓ Internal facilities	n.a.	n.a.	21	18	18	18	18	18	17
✕ Closures	n.a.	n.a.	45	48	48	48	48	48	49
▲ External facilities	n.a.	n.a.	56	60	66	73	75	80	89
Network cost	n.a.	n.a.	14,275	10,997	9,502	8,091	7,410	6,927	6,577
Outsourcing degree	n.a.	n.a.	40.0%	49.7%	60.0%	69.8%	78.8%	86.4%	94.7%
Av. Cap. utilization	n.a.	n.a.	55.0%	63.8%	70.1%	73.7%	81.0%	83.3%	82.1%

(c) $(r^3_{central}, r^3_{remote}) = (9.0, 10.0)$ km

	$\alpha^{ext}=0.2$	$\alpha^{ext}=0.3$	$\alpha^{ext}=0.4$	$\alpha^{ext}=0.5$	$\alpha^{ext}=0.6$	$\alpha^{ext}=0.7$	$\alpha^{ext}=0.8$	$\alpha^{ext}=0.9$	$\alpha^{ext}=1.0$
⬠ Hubs	n.a.	n.a.	14	9	6	5	3	3	2
▭ Semi-digital branches	n.a.	n.a.	2	4	5	4	6	5	6
● Full digital branches	n.a.	n.a.	5	5	7	9	9	9	9
↓ Internal facilities	n.a.	n.a.	21	18	18	18	18	17	17
✕ Closures	n.a.	n.a.	45	48	48	48	48	49	49
▲ External facilities	n.a.	n.a.	56	60	65	73	77	87	89
Network cost	n.a.	n.a.	14,275	10,997	9,188	8,091	7,307	6,914	6,567
Outsourcing degree	n.a.	n.a.	40.0%	49.7%	59.5%	69.8%	78.3%	88.2%	92.4%
Av. Cap. utilization	n.a.	n.a.	55.0%	63.8%	70.6%	73.7%	78.5%	78.2%	80.1%

n.a.: Infeasible solution $\left(\alpha^{ext} < LB(\alpha^{ext})\right)$;

▨: Solution with $\alpha^{ext} > UB(\alpha^{ext})$;

Outsourcing degree: Percentage of basic staff-assisted services handled by activated external facilities.

Av. Cap. utilization: Percentage of employed capacity of activated external facilities on average.

The presented results show that banks interested in restructuring their networks by adopting the proposed strategies have to find a trade-off between savings and risks.

On the one hand, consolidating the internal network may result in a substantial increase in savings. Indeed, the outsourcing strategies represent a great opportunity to cut costs and refocus banks toward core activities. Nevertheless, it has to be carefully evaluated as it may expose the bank to security and operational risks (Gewald & Dibbern, 2009; Gunasekaran et al., 2015). Moreover, consolidation comes to the detriment of proximity to clients, which can be maintained by relying on external facilities instead of solely on the bank's branches. Beyond the security and operational risks, entrusting banking services to third-party providers may compromise the reputation of the bank and threaten customers' loyalty.

On the other hand, banks may reduce the exposure to such risks by keeping a capillary presence with their own branches. Nonetheless, following the ongoing trend of branch closures and investing in digital channels in the sector, banks have to progressively consolidate the internal network in order to remain competitive and position themselves for sustainable growth and succeed in a highly competitive marketplace.

Finally, it is worth highlighting that banks willing to adopt outsourcing strategies are called to develop robust risk management frameworks, select their partners carefully and define appropriate strategies to monitor and supervise them (e.g., implement effective security protocols) to prevent potential risks, such as personal data misuse. At this end, the optimal location of potential external points to be activated remains a relevant problem to be addressed. Indeed, beyond the discussed critical parameters (α^{ext}, s and r^3), the outsourcing policies may constrain the scenarios produced by our model as it takes as an input the set of potential external points (J^{ext}). Nonetheless, this does not infringe on the generality of the model, which provides a valuable

Table 6
Bank's network restructuring: $s = 1.5$ km.

(a) $(r^3_{central}, r^3_{remote}) = (5.0, 6.0)$ km

	α^{ext}=0.2	α^{ext}=0.3	α^{ext}=0.4	α^{ext}=0.5	α^{ext}=0.6	α^{ext}=0.7	α^{ext}=0.8	α^{ext}=0.9	α^{ext}=1.0
Hubs	12	9	6	5	5	4	4	4	4
Semi-digital branches	2	2	4	5	5	6	5	5	5
Full digital branches	5	7	8	8	7	7	8	8	8
Internal facilities	19	18	18	18	17	17	17	17	17
Closures	47	48	48	48	49	49	49	49	49
External facilities	23	29	34	40	48	58	63	63	63
Network cost	12,238	9,035	8,471	8,216	8,042	7,757	7,470	7,470	7,470
Outsourcing degree	19.0%	29.3%	38.2%	46.8%	57.3%	69.7%	76.4%	76.4%	76.4%
Av. Cap. utilization	63.8%	78.0%	86.7%	90.2%	92.0%	92.7%	93.5%	93.5%	93.5%

(b) $(r^3_{central}, r^3_{remote}) = (7.0, 8.0)$ km

	α^{ext}=0.2	α^{ext}=0.3	α^{ext}=0.4	α^{ext}=0.5	α^{ext}=0.6	α^{ext}=0.7	α^{ext}=0.8	α^{ext}=0.9	α^{ext}=1.0
Hubs	12	9	6	5	3	3	2	2	2
Semi-digital branches	2	2	4	4	6	6	7	7	6
Full digital branches	5	7	8	9	9	9	9	9	9
Internal facilities	19	18	18	18	18	18	18	18	17
Closures	47	48	48	48	48	48	48	48	49
External facilities	23	29	34	40	50	56	60	60	74
Network cost	12,238	9,936	8,471	7,800	7,183	7,036	6,736	6,736	6,442
Outsourcing degree	19.0%	29.3%	38.2%	47.0%	59.7%	68.4%	74.0%	74.0%	91.5%
Av. Cap. utilization	63.8%	78.0%	86.7%	90.6%	92.1%	94.1%	95.1%	95.1%	95.4%

(c) $(r^3_{central}, r^3_{remote}) = (9.0, 10.0)$ km

	α^{ext}=0.2	α^{ext}=0.3	α^{ext}=0.4	α^{ext}=0.5	α^{ext}=0.6	α^{ext}=0.7	α^{ext}=0.8	α^{ext}=0.9	α^{ext}=1.0
Hubs	12	9	6	4	3	2	2	2	2
Semi-digital branches	2	2	4	6	6	7	7	6	6
Full digital branches	5	7	8	8	9	9	9	9	9
Internal facilities	19	18	18	18	18	18	18	17	17
Closures	47	48	48	48	48	48	48	49	49
External facilities	23	29	34	41	48	52	60	75	75
Network cost	12,238	9,935	8,471	7,782	7,117	6,818	6,736	6,431	6,431
Outsourcing degree	19.0%	29.3%	38.2%	49.8%	58.6%	64.2%	74.0%	89.9%	89.9%
Av. Cap. utilization	63.8%	78.0%	86.7%	93.7%	94.1%	95.3%	95.1%	92.4%	92.4%

n.a.: Infeasible solution $\left(\alpha^{ext} < LB(\alpha^{ext})\right)$;
▨ : Solution with $\alpha^{ext} > UB(\alpha^{ext})$;
Outsourcing degree: Percentage of basic staff-assisted services handled by activated external facilities.
Av. Cap. utilization: Percentage of employed capacity of activated external facilities on average.

decision-support aid. Indeed, banks may first decide which points are eligible for outsourcing according to their internal policies (*ex-ante decision*) and then use the model to determine which arrangements activate among the eligible ones. Otherwise, they may first use the model to identify the best locations among an enlarged and not-constrained set of external points and then decide their eligibility for outsourcing through a benefit-cost analysis (*ex-post decision*).

6. Conclusions

The banking sector has been overwhelmed by the digital transformation. As a result, the distribution channels that customers use to interact with banking groups have evolved, leading the latter to redefine their business models and the configuration of their facility networks to consolidate them while maintaining an adequate proximity level, especially to less digitalized users.

In this work, a new model has been presented, aiming at restructuring banking branch networks to downsize them and meet the emerging needs of customers. In coherence with the most adopted strategies, the model considers four types of hierarchical facilities. The implemented strategies are closing existing branches, diversifying active branches regarding provided services, and outsourcing basic services. Such strategies have not previously been addressed in the literature, and our restructuring problem turns out to be more complex due to the multifaceted and interrelated characteristics of banking services. A specific parameter (α^{ext}) is introduced to regulate the outsourcing degree that the bank is willing to achieve. The objective is to identify the configuration of the facility network able to serve all the demand within given distances and minimize the total costs.

The model was tested on a real-world case study of a banking group in the Italian scenario. Three critical parameters – the covering radii r^3 and s, and the maximum outsourcing degree α^{ext} – have been identified to manage and control the restructuring strategies. In order to support the decision maker in the decision-making process, we conducted extensive experimentation by varying these parameters to present different scenarios. The obtained results show the capability of the model to provide fruitful managerial implications depending on the goals and service levels the bank intends to guarantee.

As regards the case study under investigation, more accurate results could be obtained by considering real facilities' costs. Therefore, due to the unavailability of data, a project should be seeded to evaluate such costs (e.g., fixed costs, employees, and the type of agreement between the bank and external facilities).

Moreover, an interesting perspective and research direction may involve a multiperiod version of the problem to allow the bank to gradually consolidate the internal network while outsourcing services according to the proximity constraints that can progressively be relaxed according to users' digitalization.

Finally, an additional improvement in the problem definition could involve the contextual presence of different facilities, also of the same hierarchical level, within the covering radii that cooperate to cover the demand (Berman et al., 2009).

Although the model has been developed for the banking sector, the proposed approach can be generalized and adapted to other business sectors. Therefore, the managerial implications of the work could be more significant.

CRediT authorship contribution statement

Silvia Baldassarre: Conceptualization, Data curation, Methodology, Validation, Visualization, Writing. **Giuseppe Bruno:** Conceptualization, Data curation, Methodology, Validation, Visualization, Writing. **Carmela Piccolo:** Conceptualization, Data curation, Methodology, Validation, Visualization, Writing. **Diego Ruiz-Hernández:** Conceptualization, Data curation, Methodology, Validation, Visualization, Writing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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