Article 8
İstanbul

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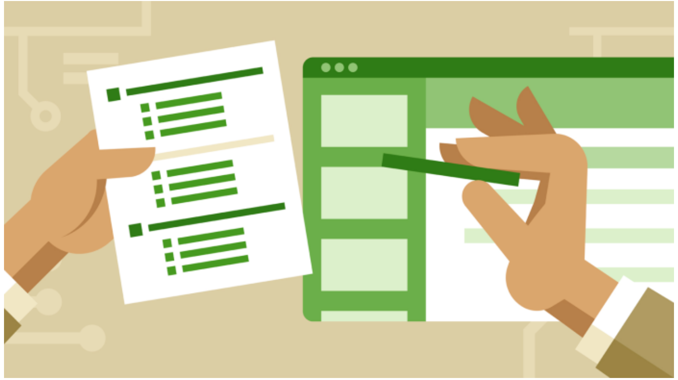


INTRODUCTION

- *Emergency facility location under random network damage: Insights from the Istanbul case*
- F. Sibel Salman, Eda Yücel, 2014
- College of Engineering, Koç University , Istanbul, Turkey
- <u>*Problem:*</u> Locating emergency response facilities (ERF), among a set of potential ones as a part of disaster preparedness strategies
- <u>*Objective:*</u> To satisfy maximum proportion of the demand in case of a disaster (earthquake)

INTRODUCTION

- *Supply points:* Emergency response facilities
- *Demand points:* Relief items requirements through the disaster area with estimated weights
- *Links:* Connection of supply and demand points with respect to paths in the highway system

CURRENT

- *First Stage:* Before a disaster occurs
  - Facilities are located under uncertainty
- *Second Stage:* After a disaster occurs
  - Determine the surviving network
  - Calculate the total demand covered by open facilities by path based approach
- *Path-based Approach*: Pre-determine set of alternative paths between each pair of potential supply and demand nodes so that the surviving path can be used for relief item distribution

CURRENT

- Each link classified as;
  - Surviving (Operable)
  - Failed (Non-Operable)
- Challenges:
  - Vast number of outcomes such as scenarios and possible networks
  - Assessing the likelihoods to scenarios

IMPROVEMENT

Optimization method to select the locations oF emergency response facilities in pre-disaster stage (First-Stage)

- Generated possible disaster scenarios
  - Japan International Cooperation (JICA)
- Calculated survival probabilities of each link according to their vulnerability to a potential disaster
  - (FEMA’s Hazus Risk Assessment Software Program)

IMPROVEMENT

- Spatial proximity + vulnerability → New Distance-Based Dependency Model

<u>DB-Dependency Model:</u>

«Everything is related to everything else, but near things are more related than distant things» (Tobler, first law of geography)

- Systematic approach to translate link-level informations to the network level
- Practical method for simulating distance-dependent correlation between link failures under an expected disaster scenario
- Every edge is negatively influenced by edges within a distance limit to it

IMPROVEMENT

- Comparison of solutions obtained under the situations
  - Dependent link Failures (DF)
  - Independent link failure (IF)
  - No link failure (NF)

- Advantage in;
  - Expected demand coverage compared to assuming independent failures
  - Eliminate the extensive number of unrealistic scenarios and generate scenarios that represents the most likely situations

Problem Description and the Optimization Model

Maximum coverage models are used frequently for emergency facility location when the resources are not enough to cover all demand locations.

Problem Description and the Optimization Model

Decision variables

x_{ij}^s	equals 1, if demand point i is covered by a facility at location j in scenario s; and 0, otherwise.
y_j	equals 1, if a facility is located at node j; and 0, otherwise.
z_i^s	equals 1, if demand point i is covered in scenario s; and 0, otherwise.

Problem Description and the Optimization Model

Parameters

$P(s)$	occurrence probability of scenario s.
d_i	amount of demand at node i.
Q	maximum number of facilities to be opened.
c_{ij}^{s}	equals 1, if demand point i is covered by a facility at location j in scenario s; and 0, otherwise.

Problem Description and the Optimization Model

- According to our experiments on a realistic large-scale network with nearly 250 nodes and 10,000 links, a workstation with Xenon E5220 @ 2.27 Ghz processor and 48 GB of memory could not afford to solve the model for 700 scenarios.
- As network size gets larger this calculation requires extremely high computation time and memory allocation. One practical approach to alleviate the computational difficulty is to solve the stochastic program over a sample of scenarios
- Larger samples provide better estimation accuracy, while making the solution of the sample average approximation problem computationally challenging.

Solution Method

- Exact calculation of network reliability measures over the entire possible scenarios is NP-hard.
- Two possibilities as independent failure case (IF) and dependent failure case (DF).

Solution Method

Independent failure case (IF): We generate each scenario s by independent Bernoulli trials for each link $(i,j) \in L$ with its survival probability, i.e., p_{ij}. Each time, we generate a new random number

Solution Method

Dependent failure case (DF): We model failure dependency among links in line with the *Vulnerability-Based dependency* (VB-dependency) model of Günneç and Salman [20]. In VB-

Solution Method

We propose a tabu search algorithm that searches the neighborhood of a current solution defined by the open/close status of the potential ERF locations.

Solution Method

- In our algorithm we represent the selected facility locations by a binary vector.
- A feasible solution is modified to obtain feasible neighboring solutions by keeping the number of open facilities at Q.

The Application

- Istanbul was devastated by an earthquake in 1999
- There’s a chance that Istanbul will be hit by an earthquake in the future
    - Estimations show 500,000 households could be in need of shelter

AKOM

- Disaster Coordination Center (AKOM)
- Plans to establish facilities to pre-position relief items.
- Facilities as supply and coordination points from where relief items will be distributed to local distribution points in the affected area.

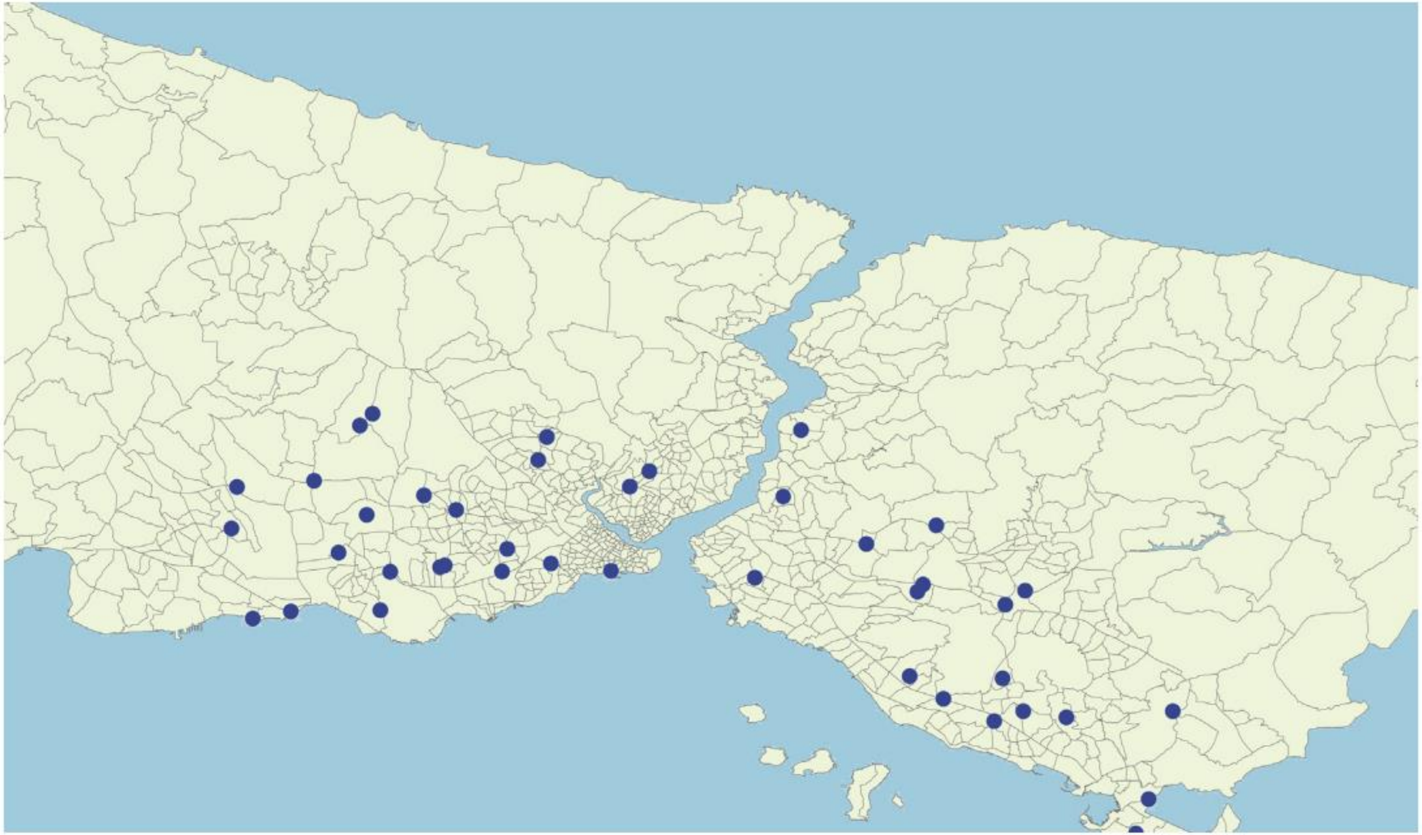


Fig. 1. Potential ERF locations and the neighborhoods.

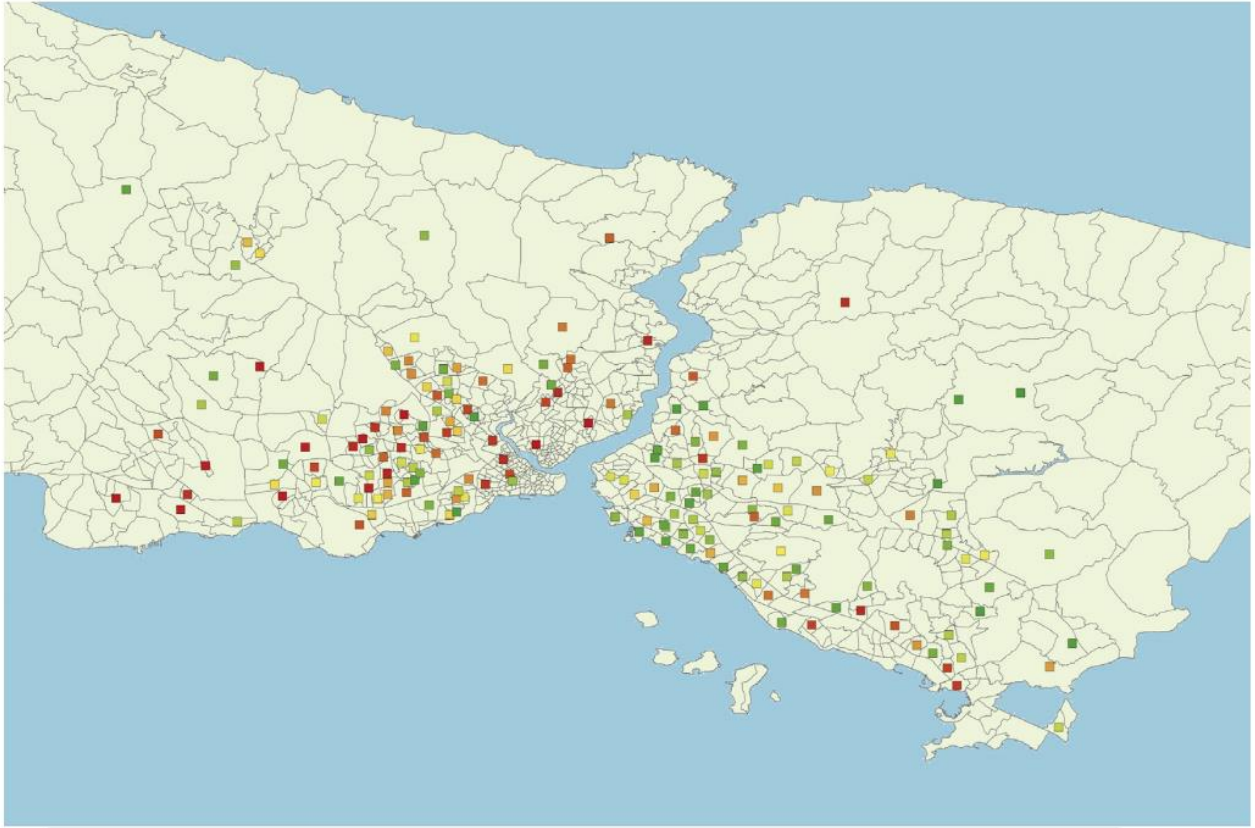


Fig.2. Identified demand points in Istanbul (green: low, red: high population)

Fig. 4. 40 road junction points in Istanbul.

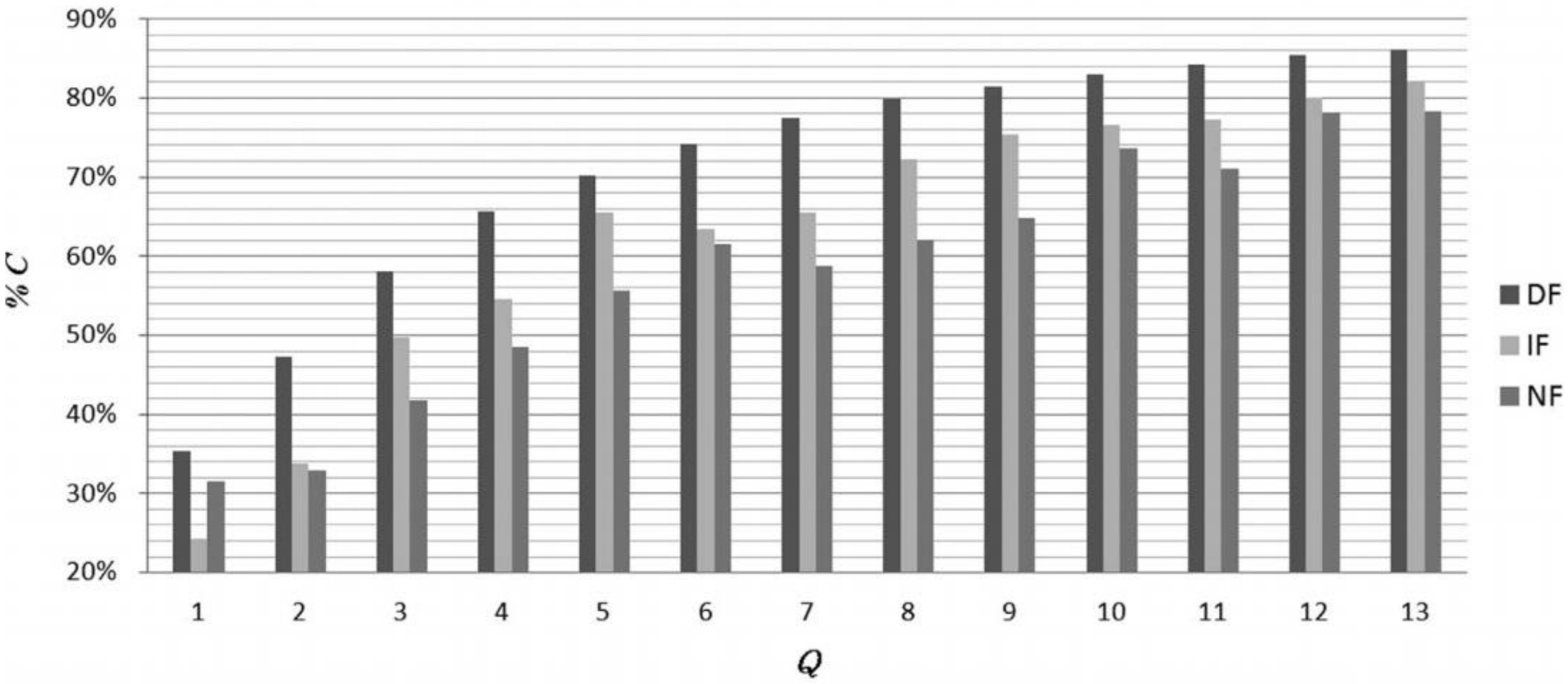


Fig. 7. %C for varying Q for DF, IF, and NF cases.

How many ERFs to Open?

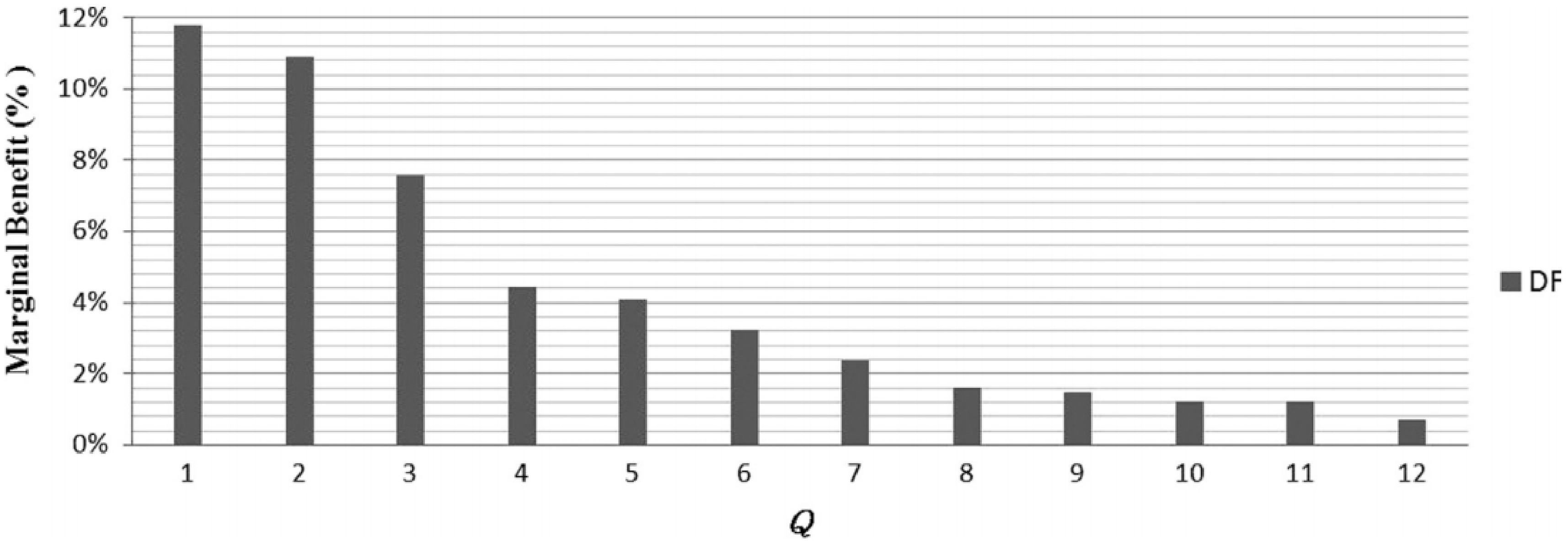
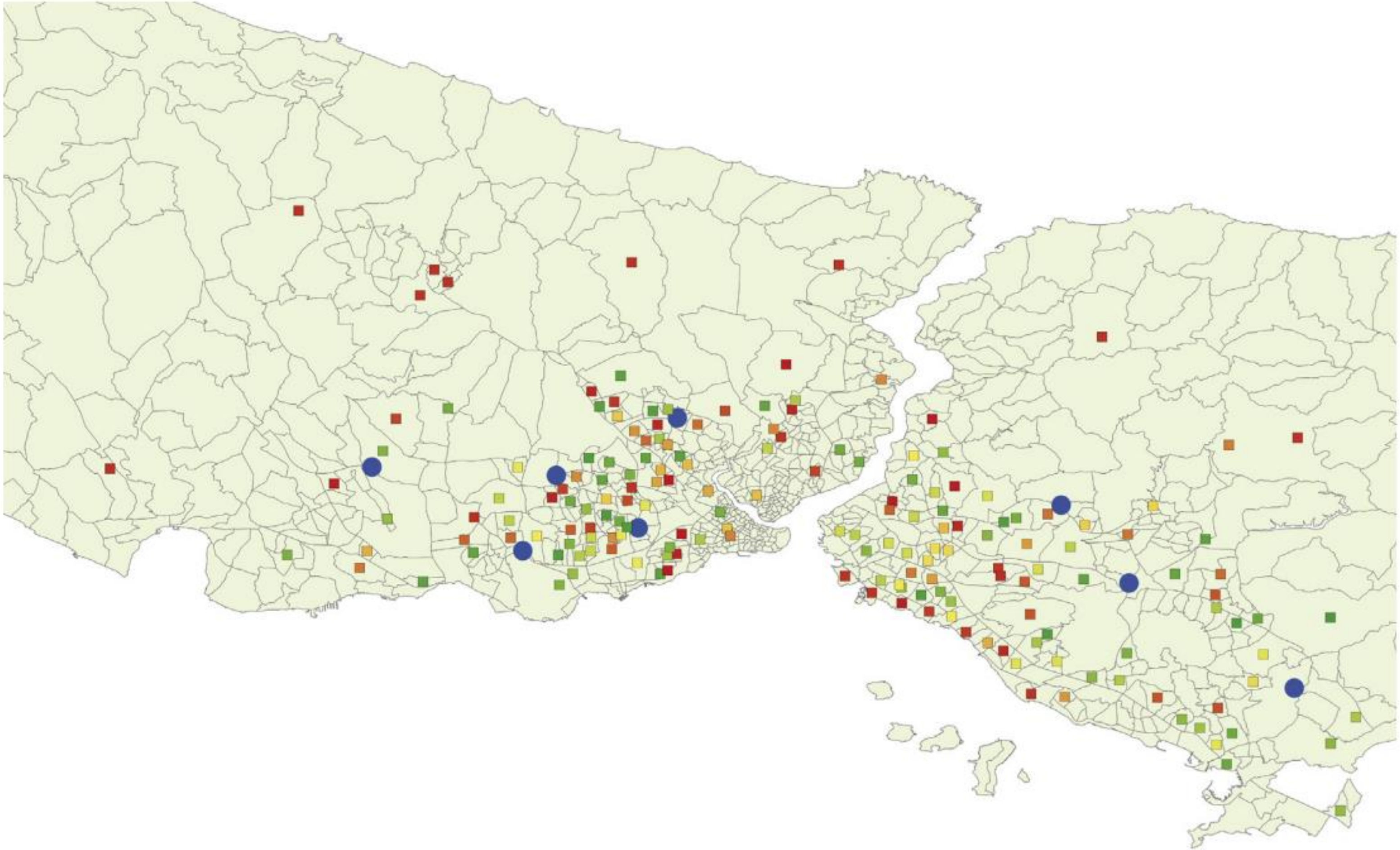


Fig. 8. Marginal benefit of opening a new ERF for varying Q in the DF case.

Table 5
Analysis on the coverage distance limit for Istanbul's network for Model C.

R	DF		IF			NF		
	C	$\%C$	C_{IF}	C	$\%C$	C_{NF}	C	$\%C$
5	42,428	21	91,221	25,721	13	116,003	20,874	11
10	110,608	56	154,547	94,228	48	176,742	86,213	44
15	157,522	80	174,566	136,939	69	178,644	134,858	68
20	179,975	91	187,301	177,129	90	192,810	159,579	81
25	187,334	95	192,599	181,598	92	193,540	177,403	90
30	191,076	97	193,796	189,370	96	193,540	181,882	92
Total number of links: 9587					Total demand: 197,342			



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