"Science Stays True Here"
Journal of Mathematics and Statistical Science, Volume 2015, 122-140 | Science Signpost Publishing

Estimating Optimum Location & Performance of a Branch Network After Mergers & Acquisitions of Financial Institutions

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Abstract

During financial crisis, many banks are reformed in order to become more efficient in the new economic environment. Mergers and acquisitions commonly take place in all financial markets. In this study based on a previous work, in which we proposed the PERFORMANCE algorithm for reconfiguring bank branch network according to the dictates of the market (the optimum number of branches for bank networks, the optimum performance), we add a LOCATION procedure to the algorithm to define, branches' optimum locations. The algorithm reveals a solution by taking into account both operational and relocation costs of branches. The goal of the study is to propose a "decision" tool to policy makers, provide them with a pre- and post- evaluation report of the potential upcoming consolidation of institutions, and aid policy makers in making difficult financial decisions.

Keywords: banks; mergers/acquisitions; branch Location; performance measures.

1. Introduction

During the last decade, the global financial "ecosystem" has dramatically changed. The global economic crises, along with deregulation, the intensive use of information and communication technology (ICT), and volatile interest rates, forced banks and financial institutions to be reorganized to become more competitive and more flexible. A wave of Mergers and Acquisitions between and by large financial

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institutions to become more powerful and to overcome problems such as liquidity, and between medium and small domestic banks to enhance their size, swept over the financial word.

The European banking sector was also modified. The establishment of the single financial European market, its monetary consolidation (the euro), and the creation of mechanism for supervising countries' credit systems combined to magnify the changes in the European financial sector. Mergers and acquisitions of banks, especially in supervised countries, are common. Based on European Banking Structure Report (November 2013) by European Central Bank, the number of credit institutions -including foreign branches- stood at 6,018, calculated on a non-consolidated basis, The number of branches decreases from 186,256 in 2008 to 171,477 in 2012, a reduction of 8,7%. The average number of people served by each bank branch increased from 5,100 in 2008 to 7,000 in 2012.

The merging and the acquisition (M&A) of financial institutions, create smaller branch networks, downsizes in operational costs, changes the institution's performance and new growth strategies. The main goal of M&A is creating an economy of scale and increasing of shareholders' returns on investment.

During acquisitions, according to Madura & Wiant (1994), and Houston & Ryngaert (1994), negative returns are noted for a period of one to three months after the announcement of an acquisition, while Dubofsky and Fraser (1989) stated that positive negative and returns depend on the time period of the acquisition's announcement. During mergers, positive returns are noted for six months before and after the announcement of the merger (Hawawini and Swary, 1990; Trifts and Scanlon 1987).

Many studies explore the ex-ante and the ex-post report of banks' financial conditions (De Young, et al., 2009; Reddy, et al., 2013) and answer questions about economic growth and financial development. Institutional efficiency has also gained the attention of many researchers. Some studies (e.g., Akhavein 1997; De Young, 2009), examine cost and operational efficiency, and conclude that financial synergy is not the same as operational synergy, or that cost efficiency before a merge does not necessary lead to cost efficiency after the consolidation. Halkos et al., (2013) who used Data Envelopment Analysis approach, to estimate the operating efficiency gains of potential banks, state that a merger or acquisition between efficient banks does not guarantee that the resulting bank will be efficient.

The goal of this paper is to propose a two-phase algorithm based on which banks and financial institutions could estimate the performance of their branch networks before proceeding with an acquisition (Phase I). In phase II, we recalculate the optimum performance and estimate the optimum number of branches and their locations after the acquisition is fulfilled. Based on a previous work, in which we determined a linear model for measuring network performance, for identifying necessary modules in branch levels and services that banks could offer to their clients, in this work we go a step further and we propose a model for defining the optimum number of branches, as well as their optimum locations.

The remainder of this paper is organized as follows, Section 2 presents a brief literature review on bank efficiency and methods for locating branches in a bank's geographical area. Section 3 briefly presents our previous work and the proposed methodology for allocating branches. Section 4 outlines the algorithm for determining optimum bank's efficiency, the optimum number of branches, and their optimum locations. Section 5 describes an example from the Greek banking sector. Section 6 discusses the results and suggests areas for further research.

2. Literature Review

This section is separated into two parts. In the first part, we present studies related to bank performance. More specifically we present studies that identify factors that improve bank efficiency and methods that are used today for measuring the performance of either of a bank branch or a bank network. The second part describes the importance of branch locations and presents methods for allocating branches in a specified geographical area.

2.1 Bank Performance

Bank performance has been recognized as an interesting topic in academic and business literature. Many and different factors affect the performance of banks; these include factors related to financial data (e.g., number of deposits, number of accounts, interest rates of deposit and lending accounts, ROE, ROA), factors related to institution human resources (e.g., number of tellers, number of specialized representatives), and factors representing the demographic characteristics of the area in which a bank branch is located (e.g., population, local industry). Traditional measures of bank profitability, such as return on assets (ROA) and return on equity (ROE) are also covered in literature (Hannan and Prager, 2004; Mukuddem-Peterson et al., 2008;). The calculation of these measures is related to the allocation of assets, equity, and net income.

Statistical methods are usually applied for measuring bank's performance. These techniques typically make use of a bank's financial and operating data in order to estimate its performance. Methods such as univariate analysis (Beaver 1966), discriminant and multiple discriminant analysis (Lee et al., 1996), logistic regression and factor analysis (West, 1985), multiple regression analysis (Boufounou, 1995), and econometric models (Ravi and Ravi, 2007) are utilized to predict either the profitability of a bank or the probability of its bankruptcy.

Other publications determined the performance goals by using specified methods of data analysis in order to define the factors or variables that influence the performance measures of a bank branch (e.g., Avkiran, 1999; Hartman, 1999). Oral and Yolalan (1990) addressed the relationship between efficiency and profits via Data Envelopment Analysis models for analyzing both efficiency and profitability. Hensel (2003) pointed out that branch efficiency has a very clear positive effect on profit.

2.2 Bank Branch Location

The development of a bank or financial institution depends on its ability to operate new branches in new or developing markets and to offer new and innovative product and services to its clients. Banks have to satisfy customers' needs through traditional and web channels, while at the same time rethinking the regional range of each branch to avoid overlapping.

According to Soenen (1974), locating bank branches signifies the definition of the trading area, the collection of the raw data within an area, the translation of the data into actual potential, and the final decision-making process. Domschke et al. (1985) assumed that location problems are characterized by four components: (a) the definition of the area (b) facilities (c) the profiles of the customers served by these facilities, and (d) a formulation that measures the distances between customers and facilities. The proper location of branch offices may prevent overlapping banking services within the trading area of potential competitors, thereby increasing future market shares. A good decision may ease financial pressure on the banking operation, because the proper location of a new bank branch reduces capital investment costs, such as leasing costs or property taxes (Krammer, 1996).

Bank branch location approaches are formulated as linear programming problems, as problems of multi-criteria analysis, of neural networks or as data envelopment analysis problems (Boufounou 1995; Cornuejois, et al. 1977; Hopmans 1986). Mins (1989) identified the major factors for deciding where to locate bank branches: unit operating costs, the competition in the area under examination, and the reachability of the region (e.g. trains, airplanes, roads). McAvoy (2005) used probability choice models in which cities the Reserve Board Organization Committee would locate its branches; the results show that cities were chosen based on socio economic characteristics, population, and the recent growth of the national banking system.

3. Problem Description

Consider that the management team of a financial institution or a bank wants to evaluate the current bank's network performance. Before proceeding with a merger with or acquisition by or of another bank, the management team must consider the institution's current efficiency and in its future prospects. In this section, we first briefly describe the mathematical formulation of bank performance and then present the mathematical formulation for allocating branches in a specified area. We claim that the decision to be acquired by one or more institutions must take into account the conditions of the network's current performance, the elimination of branches, and the cost of relocating branches to avoid overlapping.

3.1 Network's Performance

Consider a network of bank branches. The bank's network performance can be expressed as the end result of the performance of the n bank branches of the network (i is an index of the bank branches and takes values between 1 to n).

Branch performance is expressed as the weighted sum of performance variables (i.e. total average deposit balance per branch, number of deposit accounts, lending balances, financial investments, etc. Performance variables are described by y_k^i, where m is an index of the performance variables and takes values between 1 to m. Each performance variable is explained by a number of factorial variables, which expresses controllable bank characteristics and non-controllable characteristics, which are related to geographical area data. All factorial variables are represented by x_j^i where j is an index of the factorial variables and takes values from 1 to l. To be consistent with previous segmentation about controllable and non controllable variables, we assume that l equals d and d' where d is the number of controllable and d' the number of non-controllable factors ($l = d + d'$).

The strength of the relationship between performance variables and factorial variables is identified by regression coefficients, when we regress y_k^i to x_j^i.

Finally, the summation of each factorial variable in the whole network is bounded by known parameters, upper and lower bounds, which are imposed by the bank's management team.

Based on the above the Performance of the network is expressed by:

$$\text{Network Performance} = \sum_{k=1}^{m}\sum_{i=1}^{n} w_k^i * y_k^i = \sum_{k=1}^{m}\sum_{i=1}^{n} w_k^i * \left(\sum_{j=1}^{l} a_i^{jk} * x_j^i + C_k^i \right) \quad (1)$$

where a_i^{jk} are the regression coefficients when we regress the *k*-th performance variable on x_j^i factorial variables of the i-th bank branch and C_k^i is the constant term of the regression analysis.

To determine the optimum performance of the bank network we solve the maximization linear problem, in which equation (1) is the objective function and the constraints are all the regression equations and inequalities described above. Mathematical formulation of the LP problem can be be found in more detail in *Ioannou* et al.'s work (2002) and in **Appendix I**.

3.2 Bank Branches Allocation

Having determined the optimum performance of the bank network, which signifies the optimum number of branches that operate within the network and the optimum mix of services that each should provide, we continue by defining the optimum location of each branch.

Suppose that, after optimization, the network operates optimally with n' branches $(n' \leq n)$. The total number of customers that the network should serve remains stable, but the number of customers that each branch could serve changes because of branch elimination. Once branches are optimally located, customers travel to them to satisfy their banking needs. The distances between customers and branches must be minimized.

The scope of this section is the mathematical formulation of the bank branch location problem, in a way such that the sum of the differences between the distances of the old and new branch locations, multiplied by the operational costs of each bank branch, is minimized.

As the number of bank branches is already known from the previous step of network's performance optimization, the *median location problem* seems to be a good approximation. Basic assumptions for the proposed mathematical formulation are as follows:

Assumption 1: The cost of locating a bank branch is the same no matter where the branch will be located.

Assumption 2: Customers will travel along the shortest path between their houses or jobs and the bank branches.

Assumption 3: The area has been divided into a number of sites equal to number of branches that operate in the area after the solution of performance optimization problem.

$$\min RC = \min \sum_{i,r} c_i d_{ir} z_{ir} \qquad (2)$$

Subject to

$$\sum_{r \in P} z_{ir} = 1, \quad i = 1,2,...,n \qquad (3)$$

$$z_{ir} \leq q_r, \quad r = 1,2,..., p, \quad i = 1,2,...,n' \qquad (4)$$

$$\sum_{r \in R} q_r = p, \quad r = 1,2,..., p \qquad (5)$$

$$z_{ir}, q_r \in \{0,1\} \qquad (6)$$

where

RC Relocation Cost

the variables are:

q_{ir}: location which equals to 1, if the bank branch is located at site r and 0 otherwise

z_{ir}: allocation variable which equals 1, if the ith branch is assigned to a bank branch site p

The subscripts are:

i refers to bank branches and takes values between 1 and n'

n the number of bank branches

r refers to the number of sites and takes values between 1 and p

R is a set of branches sites

p number of bank branches sites

The parameters are

d_{ir}	distance between the existing position of the i-th bank branch and its new potential location at r. Some of them could be zero indicating that the branch will not be relocated
c_i	cost associated with the bank branch operation

The objective function (2) minimizes the sum of differences between distances among the old and new positions of the branches multiplied by operational cost.

The constraint set (3) states that each branch is located exactly to one bank branch site.

The constraint set (4) allows the i-th bank branch to be allocated to the site r, if there is another open bank branch in that location.

Constraints set (5) refers to the number of bank branches to be located.

Constraints set (6) define the nature of the variables.

4. The LOCATION PERFORMANCE Algorithm

We have thus far described the mathematical formulation for calculating the performance of a bank network and bank branch allocation. Two linear problems -a maximization problem for evaluating the optimum performance of whole network and the optimum number of branches- and one minimization problem -for evaluating the minimum cost for allocating branches in a specified area- have been set up. In this section we develop a solution approach based on two different criteria for estimating the optimum number of branches and the optimum location of branches in a specified area.

As mentioned above *Ioannou* et al. (2002) developed the PERFORMANCE algorithm. This algorithm calculates the Performance of each branch and of the whole network. The branch with the lowest performance score is the merger candidate. Then algorithm calculates the difference O_t, which is the network performance minus fixed operating costs for n branches. It then resolves the problem with n-1 branches and recalculates the above difference O_{t-1}. If $O_{t-1} > O_t$ a new elimination is suggested; otherwise, the procedure terminates and the algorithm gives the optimum number of branches and the optimum mix of services. More detail on the PERFORMANCE algorithm can be found in **Appendix II**).

In this study we provide the algorithm with some additional steps regarding the Branch Allocation problem.

Step 1: Read n', p, d_{ir}, c_i

Step 2: Define branch sites r where other bank branches are already operates

Step 3: Solve the linear programming minimization problem

Step 4: Define the optimum location for each branch (which branch goes to which site)

Step 5: Calculate the overall optimum Relocation Cost (RC) for the network

Step 6: Branch Relocation Procedure

Step 6.1: Find the number (g) of states with no branches after relocation.

Step 6.2: Resolve the allocating problem with $p-g$ states and recalculate Relocation cost $(RC)'$

Step 6.3: If $(RC)' < (RC)$ THEN a new relocation is suggested, so

RETURN to Step 3;

OTHERWISE

keep the solution (founded in Step 5) since the optimum location of branches has been defined, procedure terminates and go to the next step

Step 7: Terminate the algorithm and give the number of branches, the location of the branches, and the mix of services, the optimum performance for the network and the optimum relocation cost

The LOC-PERFORMANCE Algorithm uses two linear models to define optimum performance, the optimum number of branches, and their optimum locations. Although the assumptions and simplifications that we have made may provide an “almost “optimal solution, the algorithm’s results make a very good prediction about bank performance and branches locations before and after the consolidation of institutions.

5. Example

In this section an illustrative example from the Greek banking sector is presented. Two Greek banks were consolidated, and we examine the improvement in bank’s performance and identify the optimum number and location of branches in a specified geographical area. The example is indicative (only ten branches). As performance variables, total average deposit balance, number of new deposit accounts,average of lending balance, number of new lending accounts, balance of financial investments had been used, while population,average Family Income,number of small business establishments for each branch area,number of small business establishments for each branch area,number of corporate business establishments, number of Tellers in the branch,number of specialized sales representatives,number of SME representatives,number of corporate representative, had been used as factorial (controllable and non controllable variables).

Table I below presents the number of iterations, and the optimum performance, as provided in our previous work. (More details at *Ioannou et al*, 2002)

Table I: Optimum Performance and Eliminated Branches

State	Performance	Operating Cost	O_t
Initial	58194380947	3100000000	31257808667
Optimized–10 branches	62257808667	31000000000	31851234231
3rd Iteration (no branch 4) –7 branches	54642412046	21700000000	

We have now determined that the optimum number of branches is seven. Their optimum performance is shown in Table II.

Table II: Optimum Performance of the remaining branches

Branch	**Performance**
$\mathbf{u_1}$	7,032,422,801
$\mathbf{u_2}$	7,869,001,373
$\mathbf{u_3}$	9,784,830,030
$\mathbf{u_7}$	7,285,282,503
$\mathbf{u_8}$	10,162,252,153

u_9	6,665,181,418
u_{10}	5,917,042,681

We proceed now to the branches allocation phase. According to *Steps 1 & 2* we need to define the operating cost (c_i) of each branch, which equals to 3,100,000 monetary units (Table I), the distances (d_{ir}) between the center of each site r and the i-th branch, (shown in Table III) and the number of sites; since the optimum number of branches in the area under examination is seven, we divide the area into seven sites (p =*7*)).

Table III: Distances in km

Branches	**Sites**						
	r_1	**r_2**	**r_3**	**r_4**	**r_5**	**r_6**	**r_7**
u_1	0	10	8	3	4	7	8
u_2	6	0	4	3	8	12	7
u_3	2	4	0	12	6	1	11
u_7	5	2	1	2	4	6	0
u_8	3	1	2	0	2	1	6
u_9	4	6	7	10	11	0	7
u_{10}	12	1	3	4	0	6	3

In solving the linear programming problem (*Step 3*), we arrive at the following results for the allocation variables z_{ir} that determine the location of each branch in the location area.

Table IV: Solution

	r_1	r_2	r_3	r_4	r_5	r_6	r_7
u_1	1	0	0	0	0	0	0
u_2	0	1	0	0	0	0	0
u_3	0	0	1	0	0	0	0
u_7	0	0	0	0	0	0	1
u_8	0	1	0	0	0	0	0
u_9	0	0	0	0	0	1	0
u_{10}	0	1	0	0	0	0	0

From the above results we conclude with the optimum locations of the branches, we define which branches remain in their original locations and which branches need to be relocated.

Table V: Optimum Location

Branch	Initial Site	New Site	Condition
u_1	r_1	r_1	Stable
u_2	r_2	r_2	Stable
u_3	r_3	r_3	Stable
u_7	r_7	r_7	Stable
u_8	r_4	r_2	Relocation
u_9	r_6	r_6	Stable
u_{10}	r_5	r_2	Relocation

The results show that five out of seven branches must remain at the same locations, while the remaining two need to be relocated. The minimum cost for this relocation is 6,200,000 monetary units (*Step 4*).

It is interesting that, although the area in which the branches were initially located and operated was divided in seven sub- areas, sub-areas r_4 and r_5 have been identified by the model as areas that were not necessary for the bank to operate a branch. The branches in the other regions sub-areas could serve the populations of these sub-areas, with customers choosing the shortest path to reaching a branch (Step 6.1). Region 2 seems to be the area with the maximum number of branches; three branches (2, 8 and 10) are located there after solving the problem. This is in consistent with constraint (4), which allows the i-th bank branch to be allocated to the site r, even though another branch is located and operates in this sub-area.

In proceeding to Step 6.2, we resolve the problem, without sites 4 and 5 and recalculate the Relocation Cost and the optimum locations of branches. Table VII presents the new locations of the branches.

Table VI: Optimum Locations

Branch	**Sites (1st iteration)**	**Sites (2nd iteration)**	**Condition 2nd iteration**
$\mathbf{u_1}$	r_1	r_1	Stable
$\mathbf{u_2}$	r_2	r_2	Stable
$\mathbf{u_3}$	r_3	r_3	Stable
$\mathbf{u_7}$	r_7	r_7	Stable
$\mathbf{u_8}$	r_2	r_6	Relocation
$\mathbf{u_9}$	r_6	r_6	Stable
$\mathbf{u_{10}}$	r_2	r_2	Stable
Relocation Cost	6.200.000	6.200.000	

Since $(RC)'=(RC)$ there is no need to relocate branch 8, which remains stable at site r_2, as it is defined in the first iteration, its optimum location has been identified.

The initial geographical area has totally been reconfigured. The whole performance of the bank network changed and is actually optimized, the number of branches has changed, the number of services that they offer to their clients has also changed and finally, and the locations of the branches have been revised.

6. Conclusion- Further Research

In this paper we have developed a mathematical framework, which consists of two linear models. The goal of the model is the reconfiguration of a bank branch network. The proposed algorithm has two phases. In *Phase I, the* model determines the optimum number of branches within the network and the optimum services that each, should provide. In *Phase II*, the model defines the optimum location of each branch of the reconfigured bank network. The two models and the proposed algorithm define the values of the variables to improve performance and relocation costs, allowing comparison between iterations each time. Two basic assumptions are made: (a) the geographical areas in which branches were initially located were divided into a number of potential sites equal to the number of branches after the eliminations, and (b) the cost of operation is the same for all branches. The model has been tested on a sample masked data of a Greek bank and the results imply that through the proposed approach the model can provide valuable suggestions to the bank's management team.

Today, as mergers between and acquisitions of financial institutions become the norm, we suggest the proposed model as a valuable framework for estimating the size of the emerged network, identifying the offered services and suggesting locations for branches.

Further research implies the consideration of competitive bank branches that operate in the same geographical area with the network of examined branches, different operational and relocation costs for each branch, and the division of the area based on Euclidian centers. In other words, in future work, it will be necessary to determine the smallest circle of the area for each branch, that encloses all possible demand points.

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Appendix I

Mathematical Model for Branch Optimization

The performance of bank network where *n* branches are located is formulated as follows:

$$\max \sum_{i=1}^{n} \sum_{k=1}^{m} w_k^i y_k^i \tag{1}$$

Subject to

$$y_k^i = \sum_{j=1}^{l} a_i^{jk} * x_j^i + C_k^i \qquad \forall i \in I, k \in K \tag{2}$$

$$x_j^i = \sum_{j' \in J, j' \neq j} b_{j'}^i * x_{j'}^i + M_j^i \qquad \forall i \in I, j \in J \tag{3}$$

$$\sum_{i\in I'} x_j^i \le \sum_{i\in I''} x_j^i \qquad I' \cap I'' = \varnothing \tag{4}$$

$$x_j^{low} \le \sum_{i=1}^{n} x_j^i \le x_j^{up} \qquad \forall j \in J \tag{5}$$

$$x_j^i \ge 0 \qquad \forall i \in I, j \in J \tag{6}$$

Appendix II

PROGRAM PERFORMANCE

VAR *n, m, l ,i, j, k: integer*

y_k^{i0}, x_j^{i0}, w_k^i : *real*

BEGIN

!{find the direction of the relationship among performance and factorial variables}

For j:=1 to k

For i:=1 to n

Regress y_k^{i0} on x_j^{i0}

end

end

!{find the relation between controllable and non-controllable variables, define limits}

For i:=1 to n

Regress x_j^{i0} on themselves

Write equations or inequalities of x_j^{i0} between different branches

Write upper and lower for each x_j^{i0}

end

!{evaluate initial performance}

For i: =1 to n

calculate the performance BP^{i0} (for each branch)

end

Evaluate the whole performance BP^0 of the community

!{evaluate optimum performance}

For i: =1 to n

calculate the performance $BP^{i,\text{ optimum}}$

end

!{Branch Elimination Procedure}

For i: =1 to n

Define min($BP^{\text{i, optimum}}$)

O_t:=BP^{optimum} – Operating Fixed Cost for the *n* branches

end

Write down the new equations after elimination

Solve the problem with *n*-1 branches

For i: =1 to n-1

O_{t+1}:=BP^{optimum} – Operating Fixed Cost for the *n-1* branches

end

If $O_{t+1}>O_t$ THEN

a new elimination is suggested

RETURN to previous step

OTHERWISE

Write the optimum solution

end

END