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Optimal Agricultural Credit Association Branch Office Locations

Timi M. Scaletta and Jeffrey R. Stokes

Since the farm financial crisis of the 1980s, Farm Credit System banks continue to merge and consolidate to enhance competitiveness. Two mixed-integer programming models of AgChoice Agricultural Credit Association (ACA), a recently merged ACA in Pennsylvania, were developed to determine the optimal number, location, and territory of branches. The approach suggests useful information can be determined regarding the reconfiguration process after bank mergers, especially given the fact that the current AgChoice ACA configuration is available for comparison purposes.

Key Words: Agricultural Credit Association, compromise programming, Farm Credit System, location model, mixed-integer programming

JEL Classifications: C61, G21, Q14

Mergers and acquisitions in the banking sector are common and have led to fewer, larger banks. Agriculture has not been sheltered from this trend—consolidation has occurred among commercial and Farm Credit System (FCS) banks. In the latter's case, increased competition from commercial banks and the farm financial crisis of the 1980s are two often-cited reasons for some of the restructuring and consolidation that has occurred in recent years. After the Agricultural Credit Act of 1987, the separation of land and production lending was ended with the merger of many Production Credit Associations and Federal Land Banks to create Agricultural Credit Associations (ACAs). Innovations in FCS structure continue today with the recent advent of national charters.[1]

Many factors contribute to the motivation for consolidation such as improvements in allocative and technical efficiency and the ensuing reduction in total operating expenses (Rose). Ellinger and Neff advised that consolidations in the banking industry will mitigate inefficiencies through the process of better resource allocation. Consolidations also allow for the elimination of duplicate facilities, staff, and other less productive resources, which can result in significant cost savings (Rose).

In response to banking mergers, several efficiency studies of commercial and agricultural banks have been conducted. For example, Rhoades analyzed 898 bank mergers over the

Timi M. Scaletta is adjunct instructor, Frostburg State University, Frostburg, MD and former graduate student, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University. Jeffrey R. Stokes is assistant professor, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park, PA.

[1] National charters imply the removal of geographic boundaries for FCS direct lender associations, and proponents argue that they offer the potential of lowering the cost of credit and improving service for customers. However, to a large extent, it will be some time before the full implications are known. In the interim, anecdotal evidence suggests limited banking activity has commenced outside banks' more traditional territories.

years 1981–1986 to measure efficiency. Shaffer used frontier analysis to determine the cost impact of large U.S. commercial bank mergers. Dias and Helmers used nonparametric data envelopment analysis to determine that large bank's primary source of productivity improvement has been technical change and innovation. Others investigations of agricultural bank efficiency include research by Featherstone and Moss and Neff, Dixon, and Zhu.

Although all of the mentioned studies empirically quantified efficiency, no studies have examined the process of becoming more efficient through consolidation from a managerial perspective—that is, from the perspective of those in charge of reconfiguring a system of banks brought about by merger or consolidation. Merging alone does not necessarily result in improved efficiency, because costs have to be reduced through the elimination of duplicate services. Arguably, branch offices are a duplicate service, which implies that the FCS might improve operations by adjusting the number and size of branches that comprise the system in response to changing agricultural credit market structure.

Three Pennsylvania ACAs recently merged, and the outcome provides an excellent opportunity to model the decision process in a normative fashion and compare model and actual outcomes. The central purpose of this research is to examine alternative ACA configurations to learn more about the post-merger reconfiguration process facing bank management. To accomplish this objective, a model is developed to determine the optimal number, size, and location of branch offices under a profit maximization objective. Although FCS banks do seek to be profitable, one cannot overlook the fact that the FCS is organized as a cooperative, which implies that service maximization is a potentially competing objective. Therefore, a compromise programming model is also specified that seeks solutions that balance the profit seeking motive of the FCS with the service-seeking motive of any cooperative entity. Model results are then compared with actual consolidation evidence after the recent ACA mergers in Pennsylvania.

Background

In 1999, Northeastern, PennWest, and York Farm Credit ACAs, three of the four ACAs that served the credit needs of Pennsylvania farmers, consolidated to form AgChoice Farm Credit, ACA. Prior to the merger, the three ACAs served the financial needs of 52 Pennsylvania and 4 West Virginia counties. Of concern during the consolidation was the necessity of AgChoice to continue serving the credit needs of these counties. However, not all branches would remain open after the proposed merger, and those persons overseeing the consolidation were faced with the difficult decision of how to reconfigure the system in Pennsylvania to achieve service and profitability objectives. AgChoice "... consolidated from 18 branches to 10 regional branch centers with the desire to provide equal or better service at a lower cost ..." (AgChoice). Figure 1 shows the locations of the original 18 branches operating from the three ACAs.

As noted above, prior to the merger, customers had access to at least 18 branches for their credit needs. The likelihood that one of the branches was within a reasonable distance was greater than the present situation. Although decreasing the number of branches likely reduces some costs, it likely also increases others, such as the costs incurred from loan officer travel. Also, the increased distance between a branch and a potential customer may have an adverse impact on loan demand. Customers discouraged by the inconvenience of a long drive to a branch may choose a more convenient local bank.

Decisions regarding where to locate branches must be made carefully, to ensure that the marginal costs of consolidation are no larger than the marginal benefits of consolidation. As the configuration of the system changes, the number of personnel required to service loan demand also needs to be adjusted. Because AgChoice has already made the decision of how many and where to operate its regional branch centers, solutions from any

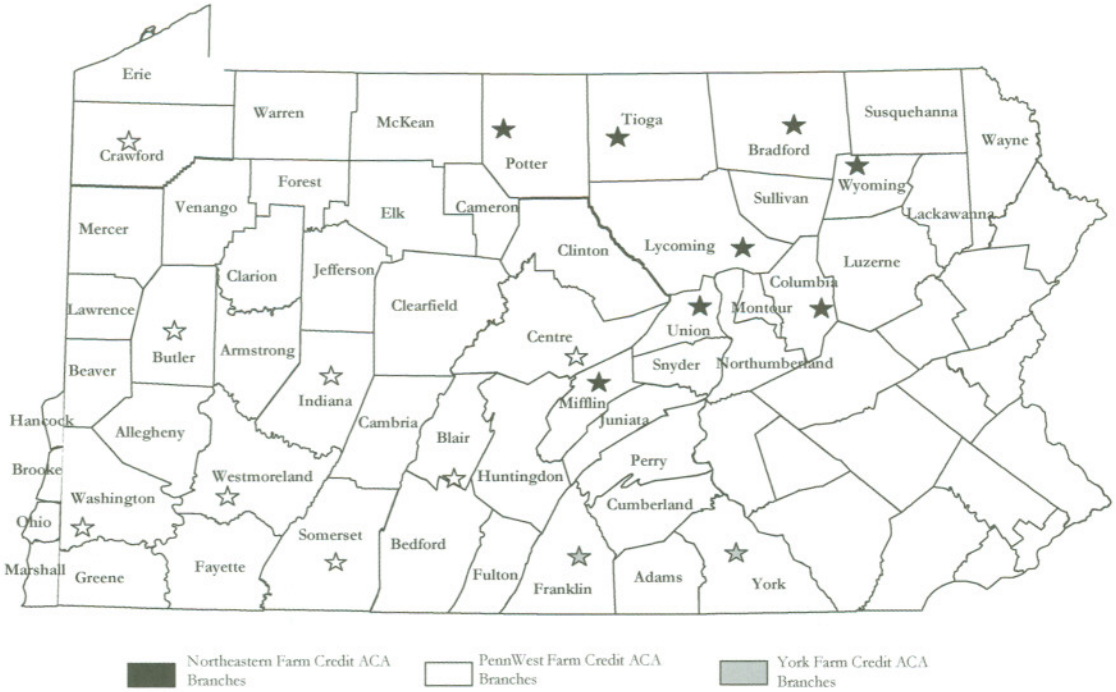

Figure 1. Locations of Northeastern, PennWest, and York Farm Credit ACAs Branches Prior to Consolidation

model to determine the optimal configuration can be compared on the basis of the stated goals to AgChoice's present situation. Such a comparison provides an unique opportunity to scrutinize AgChoice's present configuration relative to a model solution. This information is useful for better understanding the drivers of consolidation and how quantitative models can be used to aid decision makers in a normative sense.

AgChoice Location Model

The agricultural economics literature has a history involving the use of location models, most of which can be traced to Stollsteimer. Research extending Stollsteimer's model for making location decisions includes Chern and Polopolus, Kloth and Blakley, Hilger, McCarl, and Uhrig, and Ziari et al.

A mixed-integer programming model of AgChoice branch locations is developed by assuming system profit maximization is the primary goal. The feasible region is defined by a set of combinatorial constraints that impose conditions on where branches can be located, as well as on the assignment of the counties that AgChoice serves to the branch locations the model chooses to open. The size of the branches is also determined both in terms of geographic area served by the branch as well as the size in terms of employees and facility space.

Objective Function[2]

Profit maximization is assumed to be the primary ACA goal with the objective function

$$(1)\quad \max P = [(e - z)fV + (g - z)mV + (u - z)cV] - \left[bM + (t + o)\sum_{j=1}^{J} O_j + s\sum_{j=1}^{J} S_j + a\sum_{j=1}^{J} A_j + r\sum_{j=1}^{J} F_j\right].$$

[2] Refer to Tables 1 and 2 for a guide to the notation that follows.

Table 1. Summary of Model Notation

Subscripts	
i	Counties
j	Branches
Decision variables	
Y_j	Binary integer variable indicating operation of branch j
X_{ij}	Binary integer variable indicating county i is assigned to branch j
O_j	Integer number of loan officers employed at branch j, general integer
Other variables	
M	Total number of branch managers
S_j	Number of support personnel at branch j
A_j	Number of clerical personnel at branch j
V	Total loan volume for entire system of branches ($)
L_j	Total loan volume at branch j ($)
F_j	Square footage required for branch j
γ_j	Number of counties restricted from being assigned to branch j
R	Total farm mortgage loans for AgChoice
N	Total production and intermediate term loans for AgChoice
C	Total other loans for AgChoice
Parameters dependent on counties	
l_{ij}	Loan volume branch j receives from county i ($)
β_{ij}	Distance between county i and branch j (miles)
ϕ_{ij}	= One for all i and j, used to count number of counties

Equation (1) measures the profit, P, associated with operating branches in AgChoice's system. Total loan volume for AgChoice is denoted by V, which is apportioned among three loan categories: percentage of farm mortgage loans is denoted by f, and percentage of intermediate term loans and other loans are denoted by m and c. Revenue is earned through interest income on all loans where e denotes the average interest rate for farm mortgage loans, g is the average rate for intermediate term loans, and u is the average rate for other loans. The average cost of loan funds to AgChoice is denoted by z.

The remaining terms appearing in Equation (1) are all costs related to how the system is configured and represent employee salaries, travel expenses, and facility rental fees. Employee salaries consist of those relating to a branch manager, loan officers, support personnel, and clerical employee wages (denoted b, o, s, a, respectively) and the total number of each type of employee, which are decision variables denoted by M, O_j, S_j, and A_j, respectively. The subscript j indexes branches and there are a maximum of 56 (i.e., $J = 56$). Each loan officer is assumed to travel a fixed amount and the annual travel expense per loan officer is denoted t.[3] The total square footage of each branch j is denoted F_j, and the rental rate per square foot is denoted by r. The rental rate includes all the fixed costs of operating a facility expressed on a square footage basis.

Loan Volume Constraints

The feasible region is defined by numerous constraints, which are now discussed in detail. The following constraint calculates total loan volume for AgChoice

$$(2) \qquad V = \sum_{j=1}^{J} L_j,$$

[3] When it is optimal to do so, the model can choose to use additional loan officers as opposed to forcing existing loan officers to travel more than some maximum amount. The determination of the number of each type of employee is carried out through equations discussed below.

where L_j is the loan volume for the jth branch in AgChoice's region (i.e., a county where the model elects to locate a branch office of the bank) and V is as defined in Equation (1). No counties were eliminated a priori from consideration as a county where a branch could be located.

Each branch's loan volume is determined by the loan volume from each of the counties in its territory. Mathematically,

$$(3) \quad L_j = \sum_{i=1}^{I} X_{ij} l_{ij} \quad \forall j.$$

Equation (3) determines each branch loan volume (L_j) as the sum of all loan volumes, l_{ij}, branch j receives from each county i in its assigned territory. The parameter l_{ij} is the percentage of the total loan demand of county i that can be captured if a branch is located in county j. Conversations with AgChoice personnel indicate that this percentage depends on the distance between county i and branch j. The greater the distance the less the percentage of loan demand of county i that branch j can capture. The binary decision variable X_{ij} indicates county i is assigned to branch j when X_{ij} equals to one, otherwise X_{ij} equals zero.

Logical Constraints

If a branch is operating from a given county, constraints are needed to insure that the branch county itself is appropriately assigned (i.e., a county with a branch cannot be assigned to another branch county). More specifically,

$$(4) \quad X_{ij} = Y_j \quad \forall i = j,$$

where Y_j is a binary variable that equals 1 when branch j is in operation and 0 otherwise. As shown, Equation (4) holds only for instances where i is equal to j. That is, if $Y_j = 1$, meaning a branch is in county j, $X_{ij} = X_{jj} = 1$, meaning that county j is assigned to that branch.

Through a discussion with a branch manager and a regional vice president of AgChoice, it was suggested that a limit exists on the distance between a county and the branch the county is assigned. Too many miles between a branch and the counties assigned to that branch puts a strain on loan officers who travel to customers' homes, as well as a burden on customers trying to visit the branch office. These factors can have a negative impact on loan volume and customer satisfaction. Therefore, a maximum distance between a branch and the counties assigned to that branch is imposed on the model.

Taken together, Equations (5) and (6) prevent counties from being assigned to branches that are not selected by the model to be in operation. Equation (5) tallies into the variable γ_j the number of counties that are restricted by distance from being assigned to a given branch j (i.e., they are too far away)

$$(5) \quad \sum_{i=1}^{I} \phi_{ij} = \gamma_j \quad \forall \beta_{ij} > v, \quad \text{and} \quad \forall j.$$

Here, β_{ij} represents the distance between county i and branch j, whereas ϕ_{ij} is a counting parameter equal to one for all i and j. A maximum distance, v, is imposed on the model such that any county i with an associated distance to county $j(\beta_{ij})$ exceeding v is precluded from being assigned to branch j. Therefore, Equation (5) represents a convenient way of summing up all the counties that cannot be assigned to branch j. An accounting constraint that calculates the maximum number of counties that can be assigned to a given branch j, given γ_j above is accomplished by letting

$$(6) \quad \sum_{i=1}^{I} X_{ij} \leq (\omega - \gamma_j) Y_j \quad \forall j.$$

Equation (6) maintains the number of counties assigned to a branch j cannot exceed the difference between ω, the total number of counties included in the model, and γ_j.

County i can also be assigned to one and only one branch j. This feature is accomplished with the following set of constraints

$$(7) \quad \sum_{j=1}^{J} X_{ij} = 1 \quad \forall i.$$

Last, the maximum distance requirement imposed on the model from above also suggests that

(8) $X_{ij} = 0 \quad \forall \beta_{ij} > v.$

Equation (8) states that each county i with an associated distance from branch $j(\beta_{ij})$ greater than v cannot be assigned to branch j.

Employee and Facility Size Constraints

AgChoice employs several types of employees. During discussions with AgChoice management, it became apparent that the key personnel are the loan officers, and the other types of employees are articulated in terms of loan officers. All employee types are classified into four categories of employees: branch managers, M, loan officers, O_j, support personnel, S_j, and clerical employees, A_j. Each branch in operation must have a minimum number of loan officers, which implies

(9) $L_j \leq \eta O_j \quad \forall j.$

Equation (9) implies that there is a minimum number of loan officers, O_j, that each branch j must employ based on the total loan volume of branch j and the maximum loan volume an average loan officer can effectively service, η.[4] The loan officer variable is also an integer variable as fractional loan officers are not considered.

Each branch the model selects to open must have one branch manager, which means

(10) $M = \sum_{j=1}^{J} Y_j.$

Equation (11) determines the number of branch managers by summing the number of branches that are in operation. Support personnel, such as credit analysts and appraisers, are employed to assist the loan officers with their workload. AgChoice management indicated that one support employee is generally hired for every loan officer, which implies

(11) $S_j - O_j = 0 \quad \forall j$

are the appropriate accounting constraints.

In addition to support personnel, administrative assistants are employed at each branch to assist other key personnel in completing their job tasks. The accounting relation

(12) $A_j - kO_j = 0 \quad \forall j$

suggests that k administrative assistants are required for every loan officer per branch.

Each branch has unique characteristics regarding loan volume and number of employees. For this reason, all of the branches cannot be housed in the same size office space. Facility square footage is determined to reflect the size characteristics of each branch. The equation to determine facility size is

(13) $Y_j[d + h + pO_j + q(S_j + A_j)] - F_j = 0 \quad \forall j.$

Each branch must have d square feet for conference room space, and branch managers and loan officers have offices that are h and p square feet, respectively. In addition, support personnel and administrative assistants are assumed to be assigned cubicles that are q square feet. Notice that, in Equation (13), the S_j and A_j decision variables are actually functions of the O_j decision variable through Equations (11) and (12). However, O_j is also a decision variable chosen by the solver, given that it seeks to find a combination of branches that meet the profit maximization objective. Therefore, Equation (13) forms a set of nonlinear constraints attributable to the multiplication of Y_j and O_j decision variables.

Data

Loan volume data used in the present study were computed from information obtained in the 1998 Annual Reports of Northeastern, PennWest, and York Farm Credit ACAs (the

[4] Like most parameters in the model, the maximum loan volume that a loan officer can effectively service is an average. Although it is true that some loan officers are more capable than others, a level of detail to accommodate such a feature adds little to the model relative to the additional complexity and specificity.

last year before the merger), as well as the 1999 *Pennsylvania Agricultural Statistics* (PAS) and the Regional Accounts Data from the Bureau of Economic Analysis. The combined total loan volume from the three ACAs was used as total loan demand of the 56 counties that AgChoice serves. Total farm receipts for the 56 counties were obtained from PAS.

To differentiate between highly agricultural counties and less agricultural counties, a ratio of county farm receipts to total farm receipts was computed for each county. Total loan demand was then apportioned among the 56 counties according to the ratios suggestive of a positive relationship between farm receipts and loan demand. Loan volume received by branch j from county i was then computed as a percentage of county i loan demand, dependent on the distance between branch j and county i.

The distances between the counties were obtained from Mapquest on the World Wide Web. Initially, a town near the approximate geographic center for each county where an ACA was never previously located was determined. For the 18 counties that had an ACA branch prior to the merger, the exact location of that branch was used. Using these locations, a matrix was compiled of the approximate distances, in miles, between all counties. It should be pointed out that using distances determined in this manner ignores existing road conditions and topology that can potentially affect travel time and costs.

As noted above, some of the data were also obtained from AgChoice management and the 1999 AgChoice Annual Report. Information on the maximum distance limit between a given branch and counties assigned to that branch, the maximum loan volume an average loan officer services, the types and ratios of employees, and the interest rates charged on each type of loan were reported by AgChoice management. The average weighted cost of funds and the proportions of loans comprising the AgChoice loan portfolio were determined from the 1999 Annual Report. The balance of the data needed to conduct the analysis (e.g., wages, travel expenses, square footage requirements, and rental rates) was assumed.[5] All data used to generate the results that follow are reported in Table 2.

Empirical Results

Space limitations preclude an exhaustive presentation of results. In what follows, one solution obtained from the model described above is presented to give an idea of the type of information provided by the model. The model consists of 519 constraints that determine values for the model's 1,445 decision variables. Of the 1,445 decision variables that make up the model, 928 are integer variables.

It should be noted that although the decision variables for the number of loan officers per branch, O_j, is defined as a general integer variable, the solver used was unable to provide a solution in a reasonable amount of time.[6] Probably the simplest way to handle the fractional amounts on what should be integer variables is to round up or round down. This is typically the first method espoused in standard LP textbooks on the subject of integer programming. However, rounding is usually not a good idea, because the true solution can be very far from the rounded solution (Walker). Perhaps the best solution for such a stubborn problem is to interpret the continuous solutions as loan officer full time equivalents. That is, a solution that suggests 5.5 loan officers either entails 5 full-time loan officers working the equivalent of 5.5 loan officers or 5 full-time loan officers and 1 who works part (in this case half) time. Although such a solution is invariably suboptimal relative to the true integer solution, sometimes this is the best we can do with the available software and computer horsepower. Therefore, the results presented are for O_j as a continuous variable under the full-time equivalents assumption.

The optimal branch locations, as well as size characteristics for each branch under the

[5] Assumed in the sense that they are representative of reality after having discussions with FCS personnel and others with knowledge about facilities or costs in the areas of interest.

[6] Model runs >72 hours on a Pentium 1 Ghz computer with 512 Mhz of RAM are noted.

Table 2. Parameter Definitions and Values

Parameter	Definition	Value
η	Maximum loan volume per loan officer ($)	16,000
ω	Number of counties included in model	56
v	Maximum distance allowed between county i and branch j (miles)	100
b	Branch manager annual wage ($/branch manager)	60,000
o	Loan officer annual wage ($/loan officer)	40,000
s	Support employee annual ($/support employee)	25,000
a	Clerical employee annual wage ($/clerical employee)	15,000
t	Loan officer annual expense from travel ($/loan officer)	3,100
r	Annual rental rate per square foot ($)	120
k	Number of administrative assistants required per loan officer	0.5
d	Conference room square footage	300
h	Branch manager office square footage	200
p	Loan officer office square footage	100
q	Support personnel and administrative assistant cubicle square footage	150
f	Average percentage of farm mortgage loans	60%
m	Average percentage of intermediate term loans	30%
c	Average percentage of other loans	10%
e	Average interest rate charged on farm mortgage loans	9.00%
g	Average interest rate charged on intermediate term loans	11.00%
u	Average interest rate charged on other loans	9.00%
z	Average cost of funds rate	6.75%

profit maximization objective are presented in Table 3. The model solution suggests 9 branch offices, as opposed to the 10 offices that are presently in operation. The total profit earned by AgChoice ACA under this operating scheme is $9.8 million. While recognizing that the model is not totally inclusive of all of AgChoice's revenues and costs,[7] this value is somewhat consistent with the actual profit of the $7.6 million that AgChoice reported in 1999. In addition, total loan volume captured by the nine branches is $505.6 million. In 1999, AgChoice had $528.5 million in outstanding loans.

Most of the branches have loan volumes ranging from $35 to $61 million. Two exceptions to this are the Cumberland and Potter County branches. The branch operating from Cumberland County has more than double the loan volume of each of the other branches. This result was not unanticipated, given that this region of Pennsylvania is highly agricultural. In 1999, the largest branch at AgChoice held 17.3% of total loan volume. The Cumberland County branch from the profit maximization solution captures 28.4% of AgChoice loan volume. Accordingly, the number of personnel required for running that branch is considerably more than that of the other branches. On the other hand, the Potter County branch is the smallest in terms of loan volume, with only $19.6 million dollars in loans.

As noted above, the model also assigns counties to branches through the X_{ij} variables. Taken collectively, the model identifies the boundaries of territories for each branch in AgChoice. The current branch configuration of AgChoice is shown in Figure 2, with stars denoting the present location of the branch offices and territories of each branch color-coded. The configuration of the branches under the profit-maximization model solution is shown in Figure 3. In this case, the stars denote the optimal location of the branch offices selected by the solver. A comparison of the two configurations shows the model solution to be very similar to that of the present oper-

[7] Not included are all the costs associated with system headquarters (including the AgChoice CEO's salary) in Harrisburg, PA. These costs were not included because they have no impact on system configuration.

Table 3. Optimal AgChoice ACA Branch Locations, Personnel, and Profitability

	Branches				
	Armstrong	Blair	Centre	Crawford	Cumberland
Loan Volume ($)	30,648,230	37,981,770	59,491,230	59,206,630	143,860,100
Revenue ($)	873,475	1,082,480	1,695,500	1,687,389	4,100,013
Cost ($)	333,905	384,481	534,709	532,566	1,122,509
Profit ($)	539,570	697,999	1,160,791	1,154,823	2,977,504
Personnel					
Loan Officers	1.92	2.37	3.72	3.7	8.99
Support Staff	1.92	2.37	3.72	3.7	8.99
Clerical Staff	0.96	1.19	1.86	1.85	4.5
Payroll					
Branch Managers ($)	60,000	60,000	60,000	60,000	60,000
Loan Officers ($)	76,800	94,800	148,800	148,000	359,000
Support Staff ($)	48,000	59,250	93,000	92,500	224,750
Clerical Staff ($)	14,400	17,850	27,900	27,750	67,500
Facility Size (ft^2)	1,122.5	1,271.5	1,708.4	1,702.6	3,422.2
Rental Fee ($)	134,705	152,581	205,009	204,316	410,659
	Branches				
	Montour	Potter	Susquehanna	Westmoreland	Total
Loan Volume ($)	63,429,910	20,196,630	47,208,930	43,937,090	505,960,520
Revenue ($)	1,807,752	575,604	1,345,455	1,252,207	14,419,875
Cost ($)	561,710	260,580	449,022	426,397	4,605,879
Profit ($)	1,246,042	315,024	896,433	825,810	9,813,996
Personnel					
Loan Officers	3.96	1.26	2.95	2.75	31.62
Support Staff	3.96	1.26	2.95	2.75	31.62
Clerical Staff	1.98	0.63	1.48	1.37	15.82
Payroll					
Branch Managers ($)	60,000	60,000	60,000	60,000	60,000
Loan Officers ($)	158,400	50,400	118,000	110,000	1,264,800
Support Staff ($)	99,000	31,500	73,750	68,750	790,500
Clerical Staff ($)	29,700	9,450	22,200	20,550	237,300
Facility Size (ft^2)	1,788.4	910.2	1,458.9	1,392.5	14,777.2
Rental Fee ($)	214,610	109,230	175,072	167,097	1,773,279

ating scheme of AgChoice. Therfore, it appears that the reconfiguration of AgChoice's branch offices, after the ACA merger, is reasonably consistent with the notion of profit maximization.

Service Maximization

Although the model results presented above appear to be consistent with the postmerger configuration of AgChoice, the fact remains that the FCS is organized as a cooperative and therefore has a service obligation that may not be entirely consistent with profit maximization. Although "service ratios" (e.g., customer/loan officer or the volume/loan officer) have likely increased significantly, we assume that a more constant level of service is consistent with the goals of a cooperative. Locating a branch in each of the

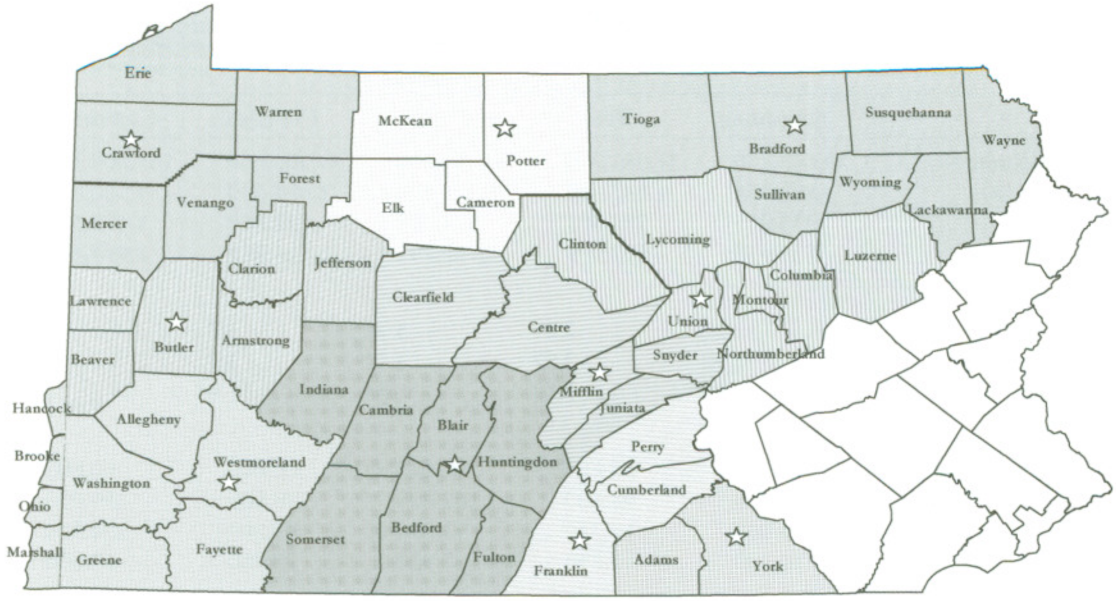

Figure 2. 2001 Branch Configuration of AgChoice Farm Credit ACA

56 counties is one method (albeit somewhat extreme) for satisfying an alternative goal of service maximization.[8] Locating a branch in every county would result in an increase of nearly $12 million in total loan volume and >$300,000 in net interest revenue over the profit maximization solution. However, the cost component would greatly increase as a consequence of opening 56 branches. Forty-seven more branch managers would be required, and the employee salary expense would increase by $2.8 million dollars. In addition, the greater number of branches results in an additional $2.8 million in facility rental fees.

These results are depicted graphically in Figure 4, which shows the relationship between the number of branches and the tradeoffs involving profit and loan volume under a profit-maximization objective. Profits are maximized when nine branches are operating; however, only $505.9 million in loan volume is captured. Each additional branch increases system loan volume until the maximum of $517 million results with 19 branches. The kinks in the loan volume curve are caused by alternative optimal solutions for a given number of branches. Profits steadily decrease with the addition of each branch in this range. Beyond 19 branches, no additional loan volume is acquired. However, because of the variable cost of opening more branches, profits continue to decrease with each added branch and fall to $4.3 million in the 56-branch configuration.

Compromise Programming

Although service maximization is important, likely no reasonable decision maker would put quite the preceding emphasis on it when exploring reconfiguration alternatives for AgChoice. However, some consideration is warranted in the present case, because profit and service maximization are competing objectives. Compromise programming (CP) is a technique introduced by Yu and Zeleny that can be used for problems with multiple competing objectives. Compromise solutions minimize the aggregate distance between a given solution and the unobtainable ideal solution in

[8] Although other measures could have been selected—for example, the minimization of the sum of aggregate distances between counties and their assigned branches—total loan volume for the 56 branches is maximized as a quantitative measure for the service objective.

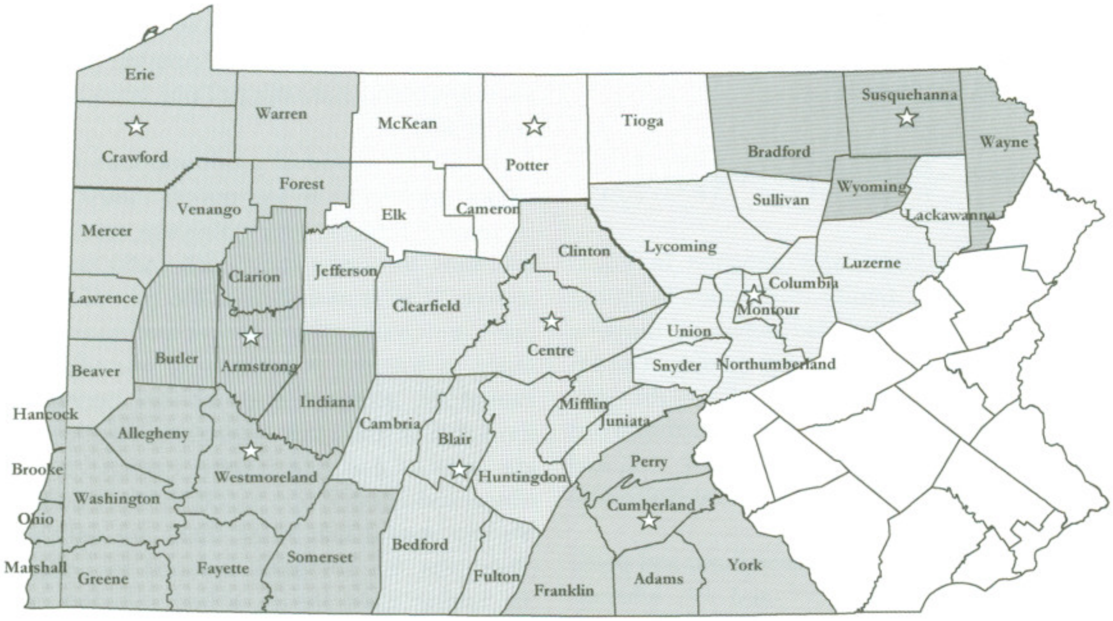

Figure 3. Branch Configuration of the Profit Maximization Solution

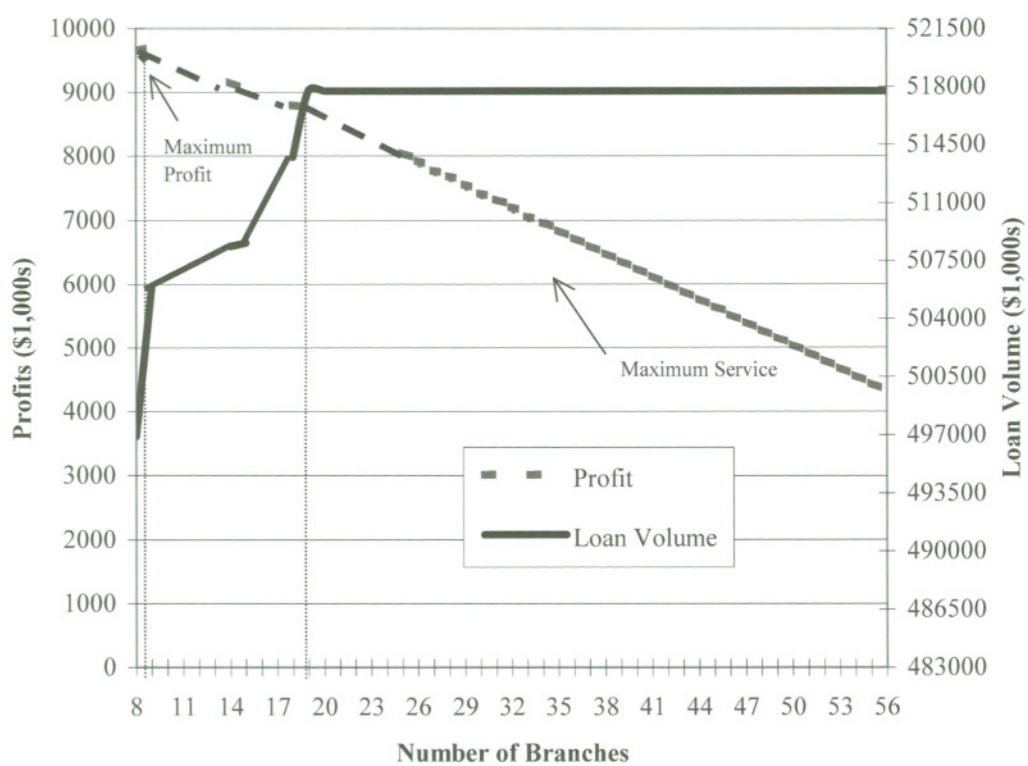

Figure 4. Trade-Offs Between Number of Branches and Profitability and Loan Volume Under Profit Maximization Objective

objective space.[9] The objective function for a compromise programming formulation of AgChoice's problem is

$$\text{(14)} \quad \min Z_h = \left[w_V^h \left(\frac{V^* - V}{V^* - \tilde{V}} \right)^h + w_P^h \left(\frac{P^* - P}{P^* - \tilde{P}} \right)^h \right]^{1/h},$$

subject to the constraints depicted in Equations (2)–(13). A family of distance functions denoted by Z_h defines the objective function for compromise programming models. The parameter h generates a range of possible distance functions, such as a linear function when $h = 1$, a quadratic function when $h = 2$, and a MINIMAX model as $h \rightarrow \infty$ (see Ballestero and Romero).

Ideal values for the loan volume and profit objectives are denoted V^* and P^*, whereas anti-ideal values are represented as $\tilde{V}$ and $\tilde{P}$. Ideal and anti-ideal values are simply parameters that represent the "best" and "worst" levels for the two objectives. The actual loan volume and profit induced by the solutions are given by V and P in Equation (14). The accounting of loan volume and profit is accomplished by adding two constraints to the compromise programming specification that tally a given AgChoice configuration's loan volume and profit into the associated V and P functions. Weights are assigned to each objective, w_V^h and w_P^h, and denote the relative importance of the objectives to the decision maker.

The ideal and anti-ideal values can be determined in a number of ways. For example, the values can be obtained by asking an expert in the relative field of study or by some other heuristic. The ideal and anti-ideal values can also be determined through alternative model specifications. Both approaches are taken in the present research with the previously specified profit maximization model used to determine ideal profit and a heuristic used to determine ideal service (i.e., maximum loan volume). The ideal loan volume value is set at the maximum possible, whereas the anti-ideal loan volume value is that induced by the profit-maximizing solution. The anti-ideal profit value is determined by calculating profit for a configuration consisting of one branch in every county.

Ideal and anti-ideal profit and loan volume values are shown in the payoff matrix at the bottom of Table 4, which also summarizes the solutions for optimizing each individual objective. It is apparent from the payoff matrix that the two objectives are competing over the range of interest as optimizing one objective cannot be accomplished without decreasing the value of the other objective. Two metrics are used to generate results, namely, $h = 1$ (linear model) and $h = \infty$ (MINIMAX model). Yu has shown that when there are only two objectives, all solutions induced by varying the metric must lie on a line segment connecting the two solutions (in objective space) induced by the $h = 1$ and $h = \infty$ metrics. That is, the $h = 1$ and $h = \infty$ metrics form the bounds of what is referred to as the compromise set.

Although the weights indicating the relative importance of each objective can be varied, for simplicity the equally weighted compromise programming branch configuration is shown in Figure 5. This solution is independent of the metric and is also the solution obtained when loan volume maximization is preferred to profit maximization. The model elects to open 14 branches, whereas several differences exist between the CP configuration and the actual AgChoice configuration. As with the profit maximization solution, the branch serving central Pennsylvania has a much larger territory (in terms of number of counties) in the CP solution than the actual branch's territory. The territory of the AgChoice branch that currently operates from Westmoreland County is split into two territories with the two branches in Fayette and Brooke Counties. In addition, the CP solution has five branches serving northwestern Pennsylvania, as opposed to three branches that actually operate there. Likewise, two AgChoice branches currently serve northeastern Pennsylvania, whereas the CP solution has four branches in that region.

[9] The ideal solution is unobtainable because it is represented by the profit maximization solution and the service maximization solution.

Table 4. Optimal Profit Maximization and Service Maximization Solutions[a]

	Objective	
	Profit Maximization	Service Maximization
Number of Branches	9	56
Loan Volume ($)	505,961	517,725
Profit ($)	9,716	4,327
Net Interest Revenue ($)	14,420	14,755
Costs	4,704	10,428
Salary Expense ($)	2,833	5,706
Employee Travel Expense ($)	98	100
Facility Rental Expense ($)	1,773	4,622
Total Employees		
Branch Managers	9	56
Loan Officers	31.62	32.36
Support Staff	31.62	32.36
Clerical Staff	15.81	16.18
Payoff Matrix		
Profit ($)	9,716	4,327
Loan Volume ($)	505,961	517,725

[a] Dollar values are in thousands.

Conclusions

In response to the recent trend of mergers in the banking industry, the consolidation of three Farm Credit ACAs was examined to learn more about the process of consolidation from a managerial perspective. To accomplish this, a mixed-integer programming model was

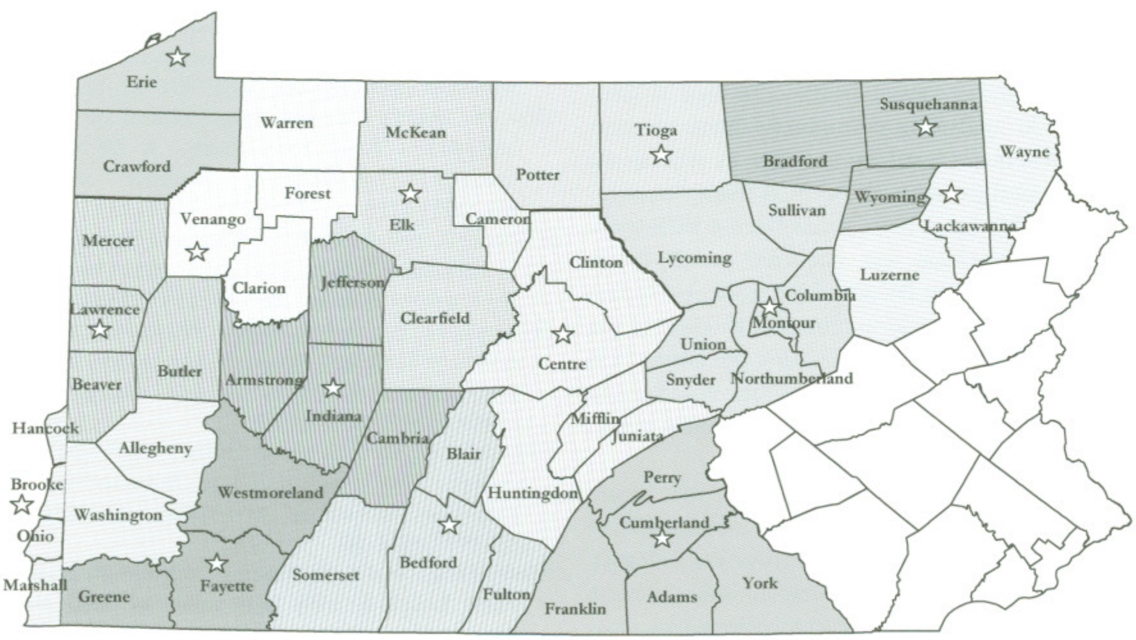

Figure 5. Branch Configuration of the Equally Weighted Compromise Programming Model Solution

developed that determined the optimal number, location, and size of the branch offices for the new AgChoice ACA serving the majority of Pennsylvania and part of West Virginia.

One conclusion drawn from this research is that it appears that AgChoice reconfigured its branch offices in a manner most consistent with profit maximization. This result is supported by the similarities between the model solution configuration and the current configuration. The model selected to open one less branch than is currently in operation. Furthermore, the locations of the branches the model selected to operate are in comparable regions of the present branches. In addition, profit and loan volume values from the model solution are very comparable to the actual AgChoice values from 1999.

It also appears that, consistent with the model, there has been limited negative downside associated with the merger in practice. Although it is probably too early to quantify the exact extent of any efficiency gains that resulted from the merger, it does not appear that much loan demand has been lost as a result. This is interesting in that the model suggests a reconfiguration under profit maximization that also results in fairly constant loan demand.

Another important contribution of this research is that the application, although specific to FCS ACAs, has a framework that is conducive to analyzing commercial bank mergers and subsequent territory redesign as well as the future configuration of the FCS itself. With respect to this latter case, it has been a FCS trend that consolidation has occurred at all levels (e.g., Farm Credit Banks). The model presented herein, appropriately augmented to capture the administration costs of operating the entire FCS system, could be used as a policy mechanism to continually evaluate conditions under which further consolidation is warranted.

Another important aspect of the study worth noting is that the type of normative modeling exhibited herein allows for a degree of interaction between modeler and decision maker that is not often available when conducting economic analyses. The real value of this type of modeling approach is likely not in the final solution the model suggests but, rather, in the model building process itself, where the critical questions are put to those who must make the critical decisions.

Limitations to the model prevent solutions from being exact. One drawback is the inaccessibility to some data. Ideally, branch offices should be opened in least costly locations. However, data on average county rental rates were not readily available. The same situation applies for wages because one wage per employee type was used in the model. In addition, the model does not permit the solver to choose the actual location of the branch within each county because branch locations were assumed to be at the center of each county.

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