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Performance measures for hierarchical organizations: Frontier analysis as a decision support tool

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Abstract: *We extend the standard frontier efficiency models (data envelopment analysis [DEA] and stochastic frontier analysis [SFA]) by allowing the “decision making units” (DMUs) whose performances are assessed to consist of two different levels within hierarchical organizations. Generally, the lower level unit is responsible for “operations;” while higher level units are assumed to make “strategic” decisions. Our primary contribution in this paper is thus to extend the use of frontier efficiency models to assess each level performance with relevant technical and allocative inefficiency measures. We illustrate our approach using DEA applied to data from a sample of 1,585 branches of a major French bank. A second contribution of the paper is to explicitly relate the efficiency to differences in the operating environments and the sizes of the bank branches. We believe that the simple, easy to implement method we introduce can serve as a valuable component of a “balanced score card” approach to benchmarking performance within hierarchical settings such as a banking network.*

Résumé : *Dans cet article, nous évaluons la performance d'organisations en considérant explicitement deux niveaux de décision. Nous étendons ainsi les modèles d'évaluation traditionnels d'enveloppement des données (DEA) ou les frontières stochastiques (SFA). Généralement, ces organisations sont caractérisées par deux niveaux : le niveau inférieur, en charge des activités de production et le niveau supérieur, davantage responsable des décisions stratégiques. Notre principale contribution est donc d'étendre l'utilisation des modèles de frontière de production pour évaluer chaque niveau de décision avec des mesures de performance techniques et allocatives adaptées. Nous appliquons ensuite notre approche à une base de données comprenant 1585 agences d'un même groupe bancaire français. Une seconde contribution de ce travail est la prise en compte explicite de l'environnement commercial et de la taille des agences dans leur processus d'évaluation. Nous pensons que l'approche que nous proposons peut être utile à l'élaboration de tableaux de bord qui différencient les différents niveaux hiérarchiques typiques des activités en réseau comme dans le secteur bancaire.*

JEL Codes: M40, G21, C43.

Performance measures for hierarchical organizations:

A decision support tool

“What you measure is what you get.”

—Kaplan and Norton (1992, p. 71)

1. Introduction

In principle, organizations are optimizers. However, whether they attempt to maximize profit, revenue, or services provided, or to minimize cost or defects, or to achieve some combination of these goals and others, organizations are dependent upon the actions of decision-makers whose goals may not be the same as that of the organization. Management control systems (MCS) are one means to assure that an organization's goals are achieved. Organizational structure or design also plays an important role in influencing organizational performance. For example, Mookherjee and Reichelstein (1997) proposed a model of budgeting in hierarchical organizations and analyzed its optimality in terms of the incentives it creates and the coordination it achieves. They demonstrated that a variety of hierarchical arrangements can be equally effective in creating incentives and coordinating decisions provided the organization uses an appropriate responsibility accounting. Brickley et al. (2004) argued that a key issue in organizational design is assuring that decision makers not only have the relevant information needed to make decisions, but that they must also be provided with the incentive to use the information to achieve organizational objectives. Brickley et al. (2004) further reasoned that organizational architecture is analogous to a three-legged stool for which three legs—the assignment of decision rights, the evaluation of performance, and the rewards system—must be appropriately balanced.

In this paper we focus on one of the legs of the stool, performance evaluation, in a particular setting, hierarchical organizations, through the novel application and interpretation of frontier efficiency analysis.¹ Generally, lower level units within a hierarchical organization are responsible for “operations;” therefore, their performance can be assessed using a measure of technical efficiency—i.e., a measure of whether the *levels* of inputs and/or outputs have been optimized. Higher level units within an organization typically make “strategic” decisions. Higher level, or centralized, decisions may also involve the allocation of resources among lower level units; hence, higher level units can be assessed using a measure of allocative

¹ Two general approaches to frontier efficiency analysis are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). For a detailed introduction to these methods, see Coelli et al. (2005).

efficiency—i.e., a measure of whether the *mixes* of inputs and/or outputs have been optimized. As in the case of standard applications of frontier efficiency models, the overall performance of a hierarchical organization is given by the combination of the technical and allocative performances of the lower and higher levels, respectively, of the hierarchy.

Our primary contribution in this paper is thus to provide a means of assessing the contributions of different levels of a hierarchical organization to its overall performance by extending the use of frontier efficiency models. Identifying and quantifying inefficient performance across different levels of an organization can provide valuable insights into how to improve overall organizational performance.² A second contribution of this paper is to show how to explicitly relate differences in performance to differences in the operating environments and the sizes of the lower level units in the firm. We postulate that lower level units operating in different environments could face different production technologies and that optimal product-mixes could vary with the size of the lower level unit. We believe that the simple, easy to implement method we introduce can serve as a valuable component of a “balanced score card” approach to benchmarking performance within a hierarchical setting.³

The next section of the paper further motivates our analysis. We then present our models in section 3. Section 4 provides an application of our ideas to a French banking organization that operates 1,585 branches in 17 different regions of the country. In section 5 we present a summary and conclusion.

2. Conceptual Framework

Traditionally, accounting and financial reporting have played an important role in evaluating the performance of organizations.⁴ These measures capture the “financial perspective” of performance. Kaplan and Norton (1992) argued that a broader array of measures should be taken into consideration when examining performance. In particular, they advocated the use of a “balanced scorecard”—the evaluation of performance from various perspectives—to better assess and improve performance. The performance measures we use in this paper take

² For example, Demski (1972) argued that performance evaluations help to inform principals about the choice problem, to inform agents about their decisions, and to align the interests of agents with those of principals.

³ See Budde (2007) for a discussion of the incentive effects of the balanced scorecard.

⁴ Demski (1972, p. 243) noted that, “[a]ccounting measurements have many and varied uses; and for any specific use the conceivable array of alternative measurement methods often borders on the bewildering.” Performance evaluation is just one of the “many and varied uses” of accounting data. Rather than contributing to the “bewilderment,” we hope that use of accounting data introduced in this paper provides a simple, complementary tool for performance evaluation.

an “internal perspective,” assessing how well “inputs” are transformed into “outputs.” By incorporating output prices into the analysis, the performance measures have a straightforward revenue interpretation that serves as a valuable supplement to more traditional “financial perspective” performance measures. Both perspectives shed light on “...two seemingly innocuous questions: *what might it cost*, and *did it cost too much?*” (Demski, 2008, p. 1; italics in the original). By viewing performance from these two perspectives (as well as others), a more “balanced” evaluation of performance can be gained (Kaplan and Norton, 1992). In particular, we use frontier analysis, a benchmarking tool based on observed best-practice, to assess the performance of a hierarchical organization. Frontier analysis, available in two major variants—stochastic frontier analysis (SFA) and data envelopment analysis (DEA)—has become increasingly popular both in the academic literature and in practice. We present a novel use of frontier analysis as a means to generate an overall evaluation of an organization’s operational performance and then show how to decompose the overall measure into performance evaluations at two different levels in a decision making hierarchy.

Consider a hierarchical organization with two levels—a centralized level (“top management”) and a decentralized level (e.g., “sales offices”). Each level of the hierarchy uses its specialized knowledge to make its decisions. Centralized decision makers will likely have better knowledge with regards to pricing (a strategic variable), while the decentralized decision makers will likely have better knowledge about local customer characteristics, local competition, etc. Thus, we assume that the top management makes decisions regarding product pricing and the allocation of resources to lower level units. The sales offices (retail bank branches in the application presented below) can be thought of as revenue centers⁵—they make operational decisions regarding the level of service to offer, which customers to target, etc. The objective of the top management in this case is to select a set of product prices that will generate the revenue maximizing mix of product sales; the goal of the sales offices is to sell as much output as possible given the prices set by “headquarters” and the resources made available to them.

We assume that decision rights have been appropriately assigned, with some decision rights being centralized, while others are decentralized. To assure that each level of the hierarchy

⁵ While our focus is revenue efficiency and its decomposition, our approach can easily be extended to the evaluation of profit centers and cost centers by examining profit and cost efficiency, respectively.

makes good decisions, incentives must be provided. To assure that incentives have been properly set, performance needs to be assessed. Once the performance of each level of the hierarchy is evaluated, rewards/incentives and the assignment of decision rights can be altered if performance is found to be deficient. This is consistent with Ittner et al. (2003), who noted that many firms are adopting strategic performance management as a part of their overall planning activities.

Given that it is unlikely that an absolute level of performance can be established due to uncertainty in the market, relative performance evaluations are often appropriate. For an organization with multiple units performing essentially similar tasks (e.g., sales offices) their performances can be assessed relative to one another. This is exactly what frontier analysis is designed to do—measure relative performance by benchmarking entities against observed “best practice.” Thus, our approach is consistent with the literature on relative performance evaluation (Dopuch and Gupta, 1997, Brickley et al., 2004). While based upon a relative performance measure, our approach is consistent with the contingency approach to management—separate benchmarks can be established for different operating environments. This recognizes that there may not be “one best way” to operate; rather, it accounts for factors beyond decision makers’ control, which helps to obtain “buy in” from those being evaluated.

3. The benchmarking models

Our models are based on an approach for measuring the economic (e.g., profit, revenue, cost), technical, and allocative efficiencies that has become increasingly popular among both academics and practitioners—frontier analysis. However, we offer a novel means of employing the method, one that offers insights not available from standard applications of the techniques.

We assume that the objective of the organization is the maximization of revenue, though other “economic” goals (e.g., profit maximization or cost minimization) could also be assumed and the models could easily be modified to account for these alternative objectives. Thus, in the models presented below the performance of revenue centers is being assessed.

Suppose that an organization uses N different inputs (represented by the vector $x \in \mathbb{R}_+^N$) to produce M different outputs (represented by the output vector $y \in \mathbb{R}_+^M$). The organization

transforms the inputs into outputs using a production process. This production process can be represented by the output correspondence which maps inputs into subsets of outputs called the output set, $P(x)$. The output set designates all technologically-feasible output vectors for a given input vector; i.e., $P(x) = \{y: y \text{ can be produced from } x\}$.⁶

Now suppose that the outputs y are sold at prices p , where $p \in \mathbb{R}_+^M$. The maximum potential revenue is obtained if the firm can solve the following optimization problem:

$$R(x, p) = \max_y \{p' \cdot y: y \in P(x)\} . \quad (1)$$

The revenue function, $R(x, p)$, indicates the maximum feasible revenue given an input quantity vector (x) and an output price vector (p). Revenue is maximized through the choice of the optimal vector of outputs, y^* . The maximization of revenue requires that two conditions are met. First, as much output as is technically feasible must be produced; second, the mix of outputs produced must be optimal given output prices. The former condition implies that revenue is maximized only when technical efficiency (discussed below) is achieved. The latter condition implies that resources must be properly allocated across the production of different outputs so as to obtain the revenue maximizing mix of output; i.e., allocative efficiency (discussed below) must be achieved. Following Farrell (1957), revenue efficiency (RE) is calculated as $RE = R(x, p) / R^o$, where $R(x, p) = p' \cdot y^*$ is maximum potential revenue as given by equation (1) and $R^o = p' \cdot y^o$ is the observed revenue actually generated by the organization. Note that RE has a minimum value of 1—this occurs when potential revenue and observed revenue coincide; i.e., revenue performance cannot be improved and the organization is 100 percent revenue efficient. Revenue efficiency scores greater than 1 indicate the presence of revenue inefficiency; in this case, RE gives that factor by which observed revenue would be enhanced if the organization were to realize “best-practice” performance. For example, $RE = 1.25$ indicates that revenue would be 25 percent greater if the organization operated at the optimal point on the revenue frontier; alternatively, observed revenue falls 20 percent $\left(\text{i.e., } 1 - \frac{1}{RE} \right)$ short of potential revenue.

⁶ We assume that technology satisfies the standard Shephard axioms of production—i.e., the possibility of producing no output, the impossibility of producing outputs without inputs, the free disposability of inputs and outputs, convexity, and variable returns to scale (see Färe and Primont (1995) for details).

As noted above, revenue efficiency (or any measure of economic efficiency) has two constituent pieces—technical efficiency (which involves finding optimal *levels*) and allocative efficiency (which involves finding an optimal *mix*). We first discuss the measurement of technical efficiency; the measurement of allocative efficiency is discussed below. In a revenue context, technical efficiency is measured as the maximum proportionate increase in output that is feasible given the available inputs and technology.⁷ Conceptually, this output-oriented measure of technical efficiency (*TE*) is the maximum radial expansion of the observed output vector that remains a member of the output set; i.e.,

$$TE = \max_{\lambda} \{ \lambda \in R_+ : \lambda \cdot y \in P(x) \}, \quad (2)$$

Note that all outputs are scaled by the same factor λ ; thus, *TE* is a “radial measure.”—the mix of outputs remains constant but the level of outputs is expanded until the output vector y lies on the boundary of the production possibilities set. *TE* takes on a minimum value of 1; the measure gives the amount by which output must be scaled up to lie on the boundary of the output set. For example, $TE = 1.25$ indicates that 25 percent more output would be produced if technical inefficiency were removed; alternatively, output is only 80 percent ($1-1/1.25$) of its potential “best practice” level.

The second component of overall performance that is to be evaluated is the allocative efficiency of an entity. Allocative efficiency involves finding the right mix of outputs in this case—resources must be allocated across the production of the M different outputs in such a way that the revenue maximizing combination of outputs is produced. Because the technical efficiency measure is radial (i.e., mix-preserving), the allocative efficiency (*AE*) measure is simply a “residual” measure that is easily computed once measures of *RE* and *TE* have been obtained (see Farrell, 1957):

$$AE = \frac{RE}{TE}. \quad (3)$$

Allocative efficiency, *AE*, also ranges from 1 and up; it can be interpreted as the proportion by which revenue could be expanded if the observed output mix were adjusted to the optimal mix based on observed “best-practice.”

⁷ Our approach is “output-oriented” in that it involves adjusting outputs while leaving input use unchanged. In a cost efficiency context, technical efficiency involves the maximum feasible proportionate contraction of inputs with a given technology that would preserve the observed level of output. Because of this, the cost efficiency approach is said to be “input-oriented.” Efficiency measures that simultaneously adjust both the outputs and the inputs also exist.

Earlier, we argued that the centralized decision making by top management involved determining the resources to allocate to the sales offices and the optimal output prices—allocative efficiency is thus a measure of top management performance. That is, it evaluates how well resources were allocated and prices were set. The decentralized decision making of the sales offices involved producing the maximum output from available resources—thus, technical efficiency is a measure of lower level decision making in the hierarchy. That is, it measured whether output levels were maximized by the lower level unit. Together, the performances of the centralized and decentralized decision makers (*AE* and *TE*, respectively) determine the overall performance (*RE*) of the organization.

Figure 1 graphically depicts the three performance measures presented above for the simple case of two outputs. We begin by illustrating the notion of overall (revenue) efficiency and then demonstrate how this measure is decomposed into measures of technical and allocative efficiency. Consider the observed output vector y^o in Figure 1. Because y^o is in the interior of $P(x)$ rather than on its boundary, or frontier, the observed output vector is less than the potential level. The revenue associated with y^o is given by $R^o = p' \cdot y^o$. Maximum revenue, the solution to equation (1)—i.e., $R(x, p) = p' \cdot y^*$ —is characterized by a point of tangency between the line representing the output price ratio (p_2 / p_1) and the boundary of $P(x)$ —i.e., by point y^* in Figure 1. Revenue efficiency is the ratio of potential to observed revenue—i.e.,

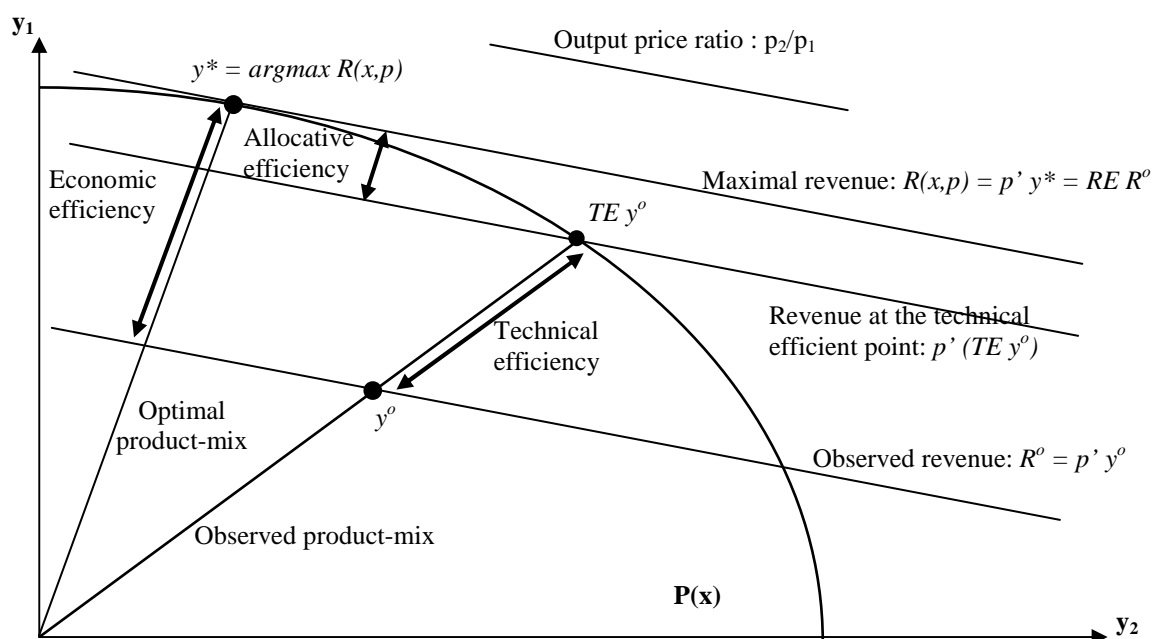
$$RE = \frac{R(x, p)}{R^o} = \frac{p' \cdot y^*}{p' \cdot y^o}.$$

As noted above, observed revenue falls short of potential revenue for two reasons—first, “too little” output is produced; second, the “wrong” mix of outputs is produced.

Next, consider the technical efficiency of the observed output vector y^o in Figure 1. Again, because y^o is in the interior of $P(x)$ it is inefficient. The technical efficiency measure, *TE*, radially expands y^o by the maximum amount consistent with $P(x)$. That is, *TE* projects the inefficient point y^o to an efficient point $TE \cdot y^o$ on the boundary of $P(x)$; the “output gap” between y^o and $TE \cdot y^o$ is technical inefficiency. Note that if an observed output vector is on the boundary of $P(x)$ then there is no output gap and $TE = 1$; however, if an observed output

vector is on the interior of $P(x)$ (such as y^o in Figure 1) then $TE > 1$. Note that the efficiency is measured along the observed product-mix and thus considers a proportionate change in the outputs. With the removal of technical inefficiency, revenue would be enhanced to $p' \cdot (TE \cdot y^o)$. While this is greater than the observed revenue, it still falls short of potential revenue because the mix of outputs is suboptimal—i.e., allocative inefficiency is present.

Figure 1. Measuring Overall (Revenue) Efficiency and its Components, Technical and Allocative Efficiency



In Figure 1, note that the revenue maximizing output mix (i.e., the output mix given by y^*) is different from the observed mix of outputs (i.e., the mix associated with y^o and $TE \cdot y^o$). The optimal output mix takes into account the output prices in choosing the product-mix that maximizes revenue. Any inefficiency associated with the observed product-mix is captured by the measure of allocative efficiency. In Figure 1, if the mix of outputs were changed in a manner consistent with their relative prices—more of output 1 and less of output 2—then revenue could be further enhanced. That is, by moving along the boundary of $P(x)$ from the point $TE \cdot y^o$ to y^* , revenue can be expanded (to the maximum possible level) without an increase in inputs or a change in technology.

To summarize, Figure 1 illustrates a “revenue gap” that results from too little output being produced (technical inefficiency) and from a suboptimal mix of outputs (allocative inefficiency). Correcting the level and mix of outputs closes the revenue gap, allowing the organization to achieve maximum potential revenue.

Now that the notions of overall (revenue), technical and allocative efficiency have been presented, we next turn to the calculation of these three efficiency measures. To compute the efficiency measures, we need to establish the benchmark relative to which performance is assessed. Unfortunately, the true output set $P(x)$ is not observed. Instead, the “best-practice” technology is determined and performance is measured relative to the observed best practice.

As noted earlier, two common approaches for measuring efficiency are the stochastic frontier analysis (SFA) and data envelopment analysis (DEA). We adopt the latter method; for a discussion of SFA, see Kumbhakar and Lovell (2000). Suppose that the organization being evaluated has K lower level units in its hierarchy; thus, we would observe K pairs of input and output vectors— $(x^k, y^k), k = 1, \dots, K$. As observed production plans, these K input-output combinations are clearly feasible though not necessarily efficient. What needs to be determined is the boundary, or envelope, of the K observed production plans—i.e., the “best-practice” technology relative to which the efficiency of each observed decentralized “sales office” is evaluated. An operational definition of the output set that satisfies the basic Shephard axioms noted above is given by:

$$P(x) = \left\{ y : x \in \mathbb{R}_+^N; y \in \mathbb{R}_+^M; \sum_{k=1}^K z_k y_k^m \geq y^m, m = 1, \dots, M; \right. \\ \left. \sum_{k=1}^K z_k x_k^n \leq x^n, n = 1, \dots, N; \sum_{k=1}^K z_k = 1; z_k \geq 0 \forall k = 1, \dots, K \right\}, \quad (4)$$

where the z_k are “intensity variables,” or weights, that form the linear combinations of all observations’ inputs and outputs that determine the boundary of $P(x)$.

From this operational definition of the output set, maximum feasible revenue and technical efficiency can be computed for each of the K observed lower level units by solving the following two linear programs once for each of the $j = 1, \dots, K$ lower level units in the hierarchical organization:

$$\begin{aligned}
 R(x_j, p_j) &= \max_{z, \tilde{y}} \sum_{m=1}^M p_j^m \tilde{y}^m \\
 \text{s.t.} \quad & \sum_{k=1}^K z_k y_k^m \geq \tilde{y}^m \quad \forall m = 1, \dots, M; \\
 & \sum_{k=1}^K z_k x_k^n \leq x_j^n \quad \forall n = 1, \dots, N; \\
 & \sum_{k=1}^K z_k = 1; \\
 & z_k \geq 0 \quad \forall k = 1, \dots, K
 \end{aligned} \tag{P1}$$

$$\begin{aligned}
 TE(x_j, y_j) &= \max_{z, \lambda} \lambda \\
 \text{s.t.} \quad & \sum_{k=1}^K z_k y_k^m \geq \lambda y_j^m \quad \forall m = 1, \dots, M; \\
 & \sum_{k=1}^K z_k x_k^n \leq x_j^n \quad \forall n = 1, \dots, N; \\
 & \sum_{k=1}^K z_k = 1; \\
 & z_k \geq 0 \quad \forall k = 1, \dots, K
 \end{aligned} \tag{P2}$$

The constraints in (P1) and (P2) are simply the output set given by equation (4)—i.e., technology (represented by the output set) constrains the maximum levels of both revenue and the output that can be achieved from a given set of inputs.

As noted above, it may be desirable to evaluate performance contingent upon the environmental factors facing different decision makers. Such “contingent efficiency evaluations” can easily be accommodated by creating different “reference” or “best practice” technologies through the appropriate grouping of observations. This is done based on an analysis of a variety of environmental variables and the opinions of experts in our application presented in the next section.

To summarize, based on the results of the two linear programs (P1) and (P2) presented above, the revenue (overall) efficiency, and its components technical efficiency and allocative efficiency, are calculated as:

$$1) \text{ Revenue efficiency : } RE = \frac{R(x, p)}{p' \cdot y^0} = \frac{p' \cdot y^*}{p' \cdot y^0}$$

$$2) \text{ Technical efficiency: } TE = \lambda^*$$

$$3) \text{ Allocative efficiency: } AE = \frac{RE}{TE} = \frac{R(x, p) / (p' \cdot y^0)}{\lambda^*} = \frac{p' \cdot y^*}{p' \cdot (\lambda^* \cdot y^0)}$$

4. An Application to a Large French Banking Firm

4.1 Motivation for the Application

In this section we apply the approach presented above to a sample of 1,585 French bank branches. These branches all operate under the same brand, but are distributed among seventeen independent regional banks. Within each regional banking group two decision-making levels, each with its own objectives, interact—one at the top bank level and another at the branch level (i.e., the retail banking network). It is vital for any successful organization to clearly identify the responsibility and decision rights of each level in conjunction with the other two legs of the stool—performance evaluation and the incentives system. In our application of the models presented above, we address managerial control and the ability to maintain coherent decision-making between policies made at the top banking group level and the performance measures of the sales offices or branches.

We assume that a manager (at either the branch or bank level) acts to maximize his own utility: first the top bank managers aim at maximizing the Net Banking Product (denoted NBP)⁸ by making decisions about the locations, resource allocations, and “product-mix” strategies of the branches; second, the branch managers make decisions to optimize their commissions which are directly related to the branch performance. Conventionally, partial productivity indices, such as deposits per employee, or financial savings per employee, are used to evaluate branch performance. These indices evaluate the performance of branches, and the top bank management provides incentives (such as commissions) that depend on their performance levels. Moreover, the top bank management uses these incentives to communicate their product strategy. However, integrating both objectives in a common decision support tool is not an easy task because the top bank managers’ performance language is financial (profitability objectives) and the branches managers’ performance

⁸ Net Banking Product (NBP) is the sum of net income interest income, net commissions, and net profit from financial transactions.

language is operational (i.e., sales objectives to maximize the commissions). Moreover, one has to clearly identify the specific responsibilities in order to define appropriate measures of performance. Although the objectives at the two levels of the hierarchy are different in nature, our performance evaluation model allows us to link these two objectives. The model aims at evaluating the performance of a branching network with two decision levels (branches and top bank management) to answer the following three questions:

(Q1) What is the source of organizational inefficiency: top management, branch management, or both?

After that, we analyze the implications of the empirical results on strategic control practices:

(Q2) Are the inefficiencies of top bank management and the branches correlated?

(Q3) How does top management need to adapt the incentives plan to achieve maximal NBP?

Within our framework, we estimate the branch management inefficiency as the inability to maximize the level of output given an assigned allocation of resources while operating in a particular market environment. For the bank top management, inefficiency is defined as the inability of the banking group to maximize the NBP given their margin rates on activities. We explicitly relate the latter inefficiency to the market environment and to the size of branches. We postulate that branches in different environments could face different production technologies and that optimal product-mixes could vary with the size of the branches.

Our application contributes to the literature on the performance evaluation of branch banking. While there are literally hundreds of studies of bank performance at the organizational level, there are, as noted by McEachern and Paradi (2007) few studies of bank performance at the branch level. One main reason for this fact is the difficulty to obtain specific data. The first paper was published by Sherman and Gold (1985), comparing 14 branches of a US bank, followed by Parkan (1987), Oral and Yolalan (1990), Vassiloglou and Giokas (1990), Giokas (1991), Tulkens (1993), Al-Faraj et al. (1993), and Sherman and Ladino (1995). These studies are focused on the operational efficiency of the branches. More recently, the global performance of the branches was the main interest in evaluating its productivity, its profitability, or its service quality (Schaffnit et al. 1997, Athanassopoulos 1997, Soteriou and Zenios 1999, Hartman et al. 2001, Camanho and Dyson 2008, Conceição et al. 2007). However, all of these papers only addressed performance at the branch level efficiency; none

of them linked branch performance to the performance of top bank management. Under our approach, measures of both branch efficiency and overall bank network efficiency are developed.

Two of the above papers are most closely related to our application. First, Athanassopoulos (1998) notes that while operationally similar, bank branches face different market environments. Failure to account for factors beyond branch managers' control will reduce their "buy in" of a performance evaluation scheme. Athanassopoulos accounted for factors that differentiated branches and clustered similar branches in order to achieve a homogenous set to which to apply performance measures. Following his lead, we account for market environment in our study and we explicitly specify a different production technology for each environment. Second, McEachern and Paradi (2007) study the performance of a multinational bank's branches within (intra-) a given country and then compare their findings across (inter-) countries. We adopt their managerial objective of intra- and inter-market performance analysis by analyzing the relative performance of seventeen networks. Finally, we note that our approach supports the claim of Berger et al. (1997, p. 141) that, "[a]n understanding of bank branch efficiency may help resolve a number of conceptual, measurement, and policy questions about efficiency at the bank level."

4.2 Modifying the model to account for outputs measured in value terms

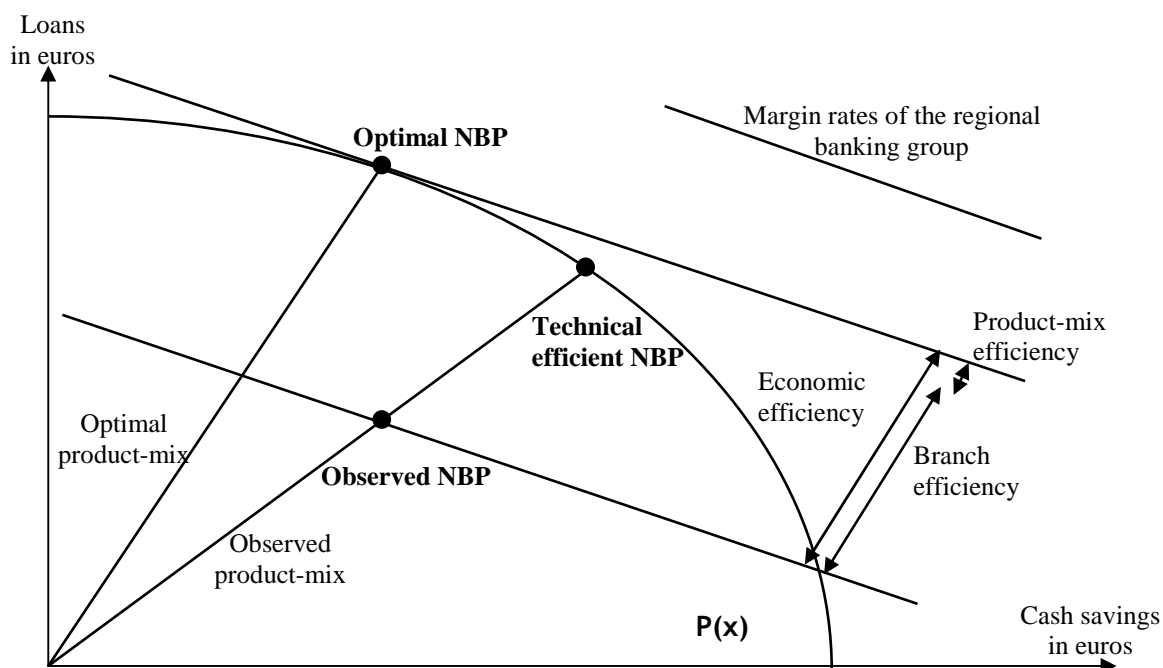
In the models developed above, inputs and outputs were assumed to be traditional "physical" units measured as "quantities." In many cases, however, data may be available in terms of monetary values rather than physical quantities. For example, in banking studies outputs are typically measured in terms of monetary units—e.g., the Euro value of the loan portfolio. This consideration leads to two modifications of the general framework presented above. First, because outputs are measured in value terms, it would make little sense to include prices in the revenue function. Instead, we use margin rates to reveal the economic objectives of the regional banking group. The revenue is thus interpreted as the net banking product (the sum of each margin rate multiplied by its corresponding output measured in value terms). As a result, efficiency will be measured in value terms (Euros, in our case). A benefit of this is that we can use the monetary values to directly compare and aggregate the efficiency measures of

different branches.⁹ Second, while the revenue, technical, and allocative efficiency measures presented above have a multiplicative relationship, in our application the three efficiency measures satisfy an additive decomposition due to the way in which the variables are measured:

$$\begin{aligned} \text{Revenue efficiency (maximum NBP - observed NBP)} = \\ \text{Technical efficiency (technically efficient NBP - observed NBP)} + \quad (6) \\ \text{Allocative efficiency (maximum NBP - technically efficient NBP)}. \end{aligned}$$

Since technical efficiency is clearly related to the branch manager effort, we call it the branch efficiency. As we have seen, the allocative inefficiency can be easily interpreted as a product-mix efficiency that is attributed to the top bank manager. The adapted model is illustrated in the Figure 2, which is a direct analog of Figure 1.

Figure 2. Optimal Net Banking Product and measurement of branch and product-mix inefficiencies

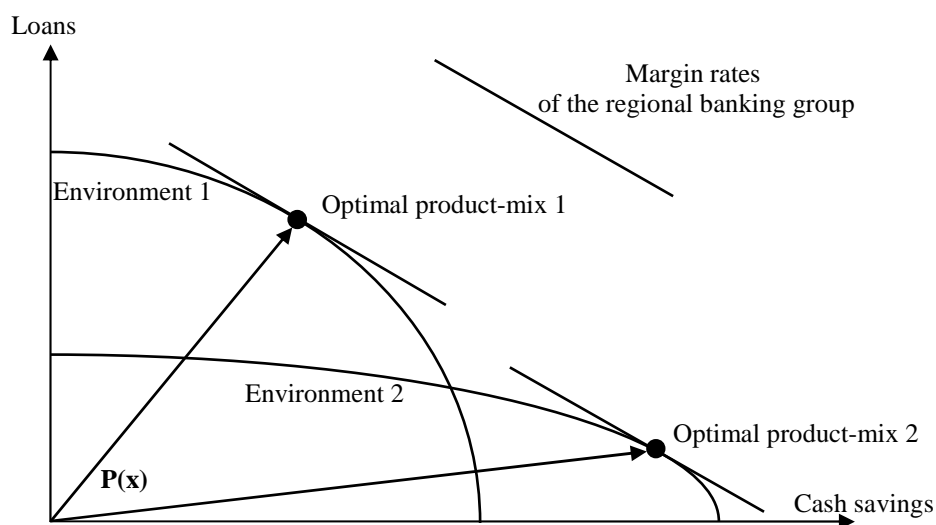


Different environments likely manifest themselves as different output sets. Figure 3 illustrates the case of two different environments, suggesting the importance of contingent

⁹ When data are available as quantities, the aggregation of efficiency measures is still possible if one uses directional distance functions rather than the standard distance functions that underlie the Farrell measures of efficiency.

performance evaluations. As the technologies can be different for different environments, it is clear that, even under the same margin rates, the optimal product-mix likely will be different. Though not shown in the Figure 3, it is also possible that margin rates will differ across environments. Thus, a different environment leads to a different optimal product-mix; as a consequence, even with the same margin rates, top bank managers should apply different product strategies and different incentives to branches in different environments. Consistent with the contingency approach to management control, relative performance is measured separately for each of the different environments in which the lower level units operate.¹⁰ Banker et al. (1998) and others have noted the importance of basing evaluations of “controllable” factors; “uncontrollable” factors can be accounted for by applying the relative performance evaluation to a group of lower level units facing the same set of external constraints.¹¹

Figure 3. Optimal product-mix and the effect of the environment



Finally, we will consider the effect of branch size on performance. First, it is possible that branch size affects the output sets (i.e., technology). Under an assumption of constant returns to scale would yield homothetic boundaries for $P(x)$ and thus a uniform optimal product-mix

¹⁰ As Fisher (1995) noted, the contingency approach to control systems is an intermediate form between the situation-specific and universalistic views. What distinguishes the contingency approach and the situation-specific approach is that the former applies to classes of business settings (“environments” in our case) while the latter is specific to each entity.

¹¹ This is consistent with the notion of “responsibility accounting.”

for all scales of operations. Instead, we allow for variable returns to scale, which allows for different optimal product-mix at different production scales as illustrated in Figure 4. In Figure 4, we model the same technology but at two different levels of input utilization—input vectors x_1 and x_2 , with $x_2 \geq x_1$. Under an assumption of variable returns to scale, the boundaries of the output sets $P(x_1)$ and $P(x_2)$ potentially have different shapes. As was the case for different environments, size differences also lead to different optimal product-mixes, and, as a direct consequence, top bank managers should again apply different product strategies and different incentives to branches of different size.

Figure 4. Optimal product-mix and the effect of size (Note: $x_2 \geq x_1$)

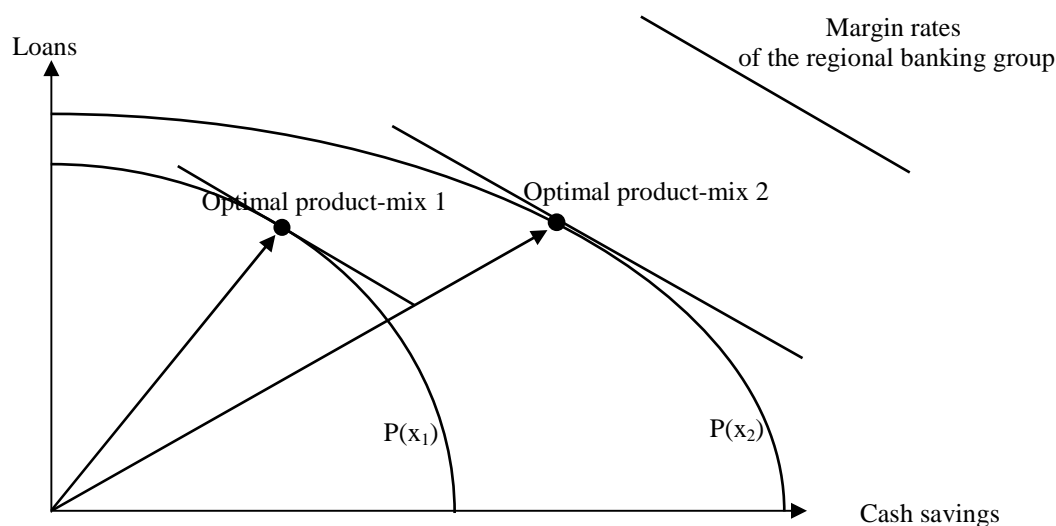


Figure 5 illustrates the distribution of the decision making among the central management and the branch managers. The central bank management is solely responsible for making the decisions for the branch network (branch location, branch equipment, and output mix) as well as for its policies and strategies. Bank branches are the points of sale for the bank. The responsibilities of the branches obviously include sales, but the branches also play a crucial role in the support of the information bank system by maintaining direct relationships with local customers. The branches sell different types of products: deposits, personal loans and mortgages, commercial loans and mortgages, special services (issuing of credit cards and ATM cards), insurance and securities, life insurance, and financial capital (equity); and they use three types of resources: human resources, operating capital, and the local customer sales base. The customer base is a specific banking resource considered as the necessary funds to allow the bank branch to be a retailer for credit and liquidity services.

Here, we assume that the central bank management has the decision rights with regards to the margin rates of the products and chooses the product-mix strategy that maximizes its financial situation. These factors depend on financial markets, interest rates, legislation, regional, national, and international competition. Based on these elements, central bank managers have to formulate an incentive plan. Conventionally, bank branches are evaluated based on productivity indices (and partial productivity indices in particular) and the objectives to be reached are declined in sale volume by product. If the objectives are achieved, the branch's management and the front office sellers receive bonuses/commissions. This is the instrument used by the central management to communicate the product-mix strategy. Nevertheless, branch profitability is evaluated too, but it is not used to communicate product-mix strategy; instead, profitability is evaluated to check the selling prices. To increase the selling volume the branches could not sell under any price.¹²

¹² Within this model bank branches are evaluated with relative performance measures and they are equivalent to Banker and Datar (1989), Baiman and Demski (1980), and Holmstrom (1982): the output of the branches is used in the performance evaluation of the bank and the output of the bank is correlated with the output of the branches.

Figure 5. The decision making process inside the banking group

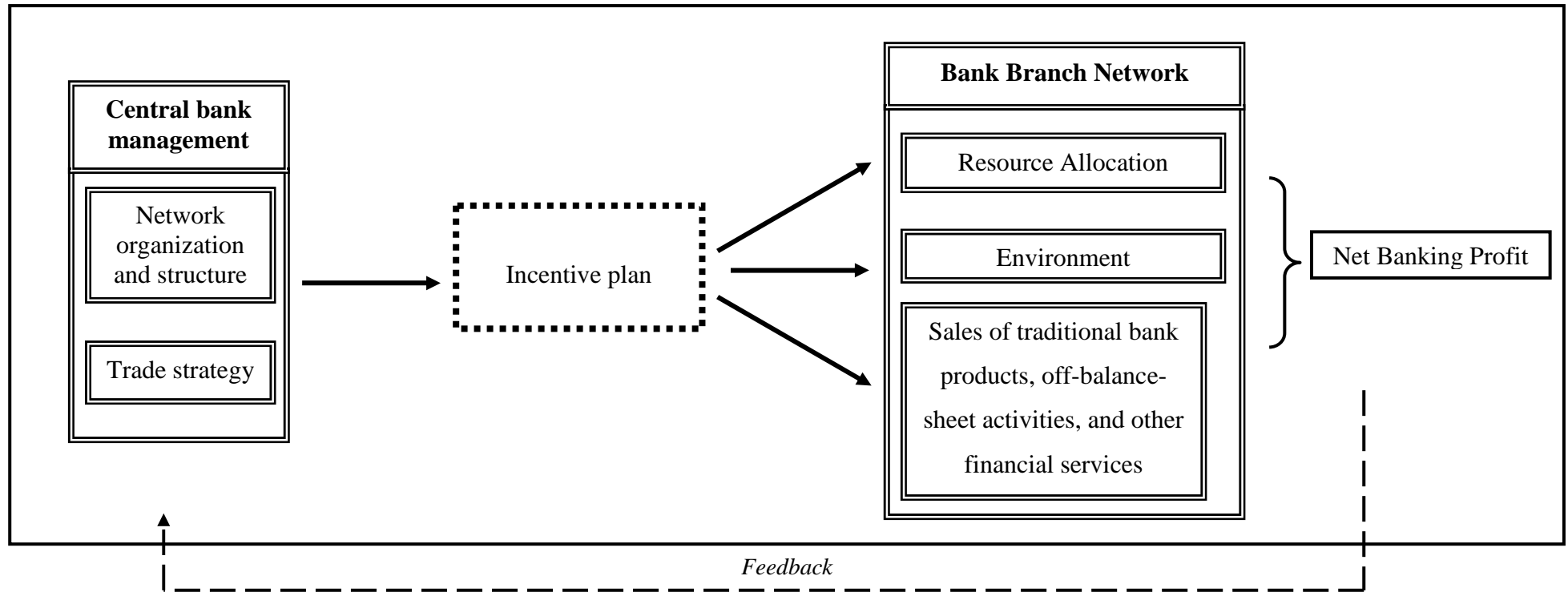


Figure 6 shows the relationships between the decisions made by the central management (manifested by the incentives plan) and the actions taken by the branches (manifested by the sales volume). We need at least two performance measures to evaluate the branches' actions. One, to evaluate the ability of the branches to avoid waste of the allocated resources (by the central management); and another to evaluate the ability of the branches to apply the incentives plan (as communicated by the central management). Thus, as described above, we compute three performance evaluation measures:

1. The technical efficiency, which evaluates possible increases in the NBP of branches without changing its product mix but in improving its global productivity;
2. The allocative efficiency, which evaluates whether a branch can increase its NBP just by changing its product mix and following correctly the incentive plan of the central bank;
3. The overall (revenue) efficiency, which evaluates possible increases in the NBP of branches by improving its global productivity and changing its product mix.

The activities of bank branches is presented in Figure 7 and can be summarized as follows.

- Bank branches offer several products to their customers; these can be grouped by four types: cash savings products also known as interest-bearing deposits and simple deposits with services related to the management of demand accounts, personal and business loans, damage insurance products and financial savings products. Some result from intermediation, others do not, although the production of each is the responsibility of the branch bank's general manager.
- To sell the products to local customers, the bank branches use three types of resources: human resources, operating resources, and customer capital. Customer capital is a specific characteristic of the banking activity. The bank branch contributes directly to the role of financial intermediary of the bank: it collects the deposits that comprise the liabilities on the bank's income statement and it grants loans that comprise the assets on the bank's income statement. The branch's customer capital can be considered as business funds.

Figure 8 presents the proxies chosen to measure the conceptual inputs and outputs discussed above. On the output side, proxies are value of loans portfolio, value of interest-bearing deposits portfolio, amount of damage insurance premiums, and amount of financial savings portfolio; on the input side, the proxies are the number of full-time equivalent employees, operating expenses, and the number of active current accounts.

Figure 6. Relationships between the incentive plan and performance measures

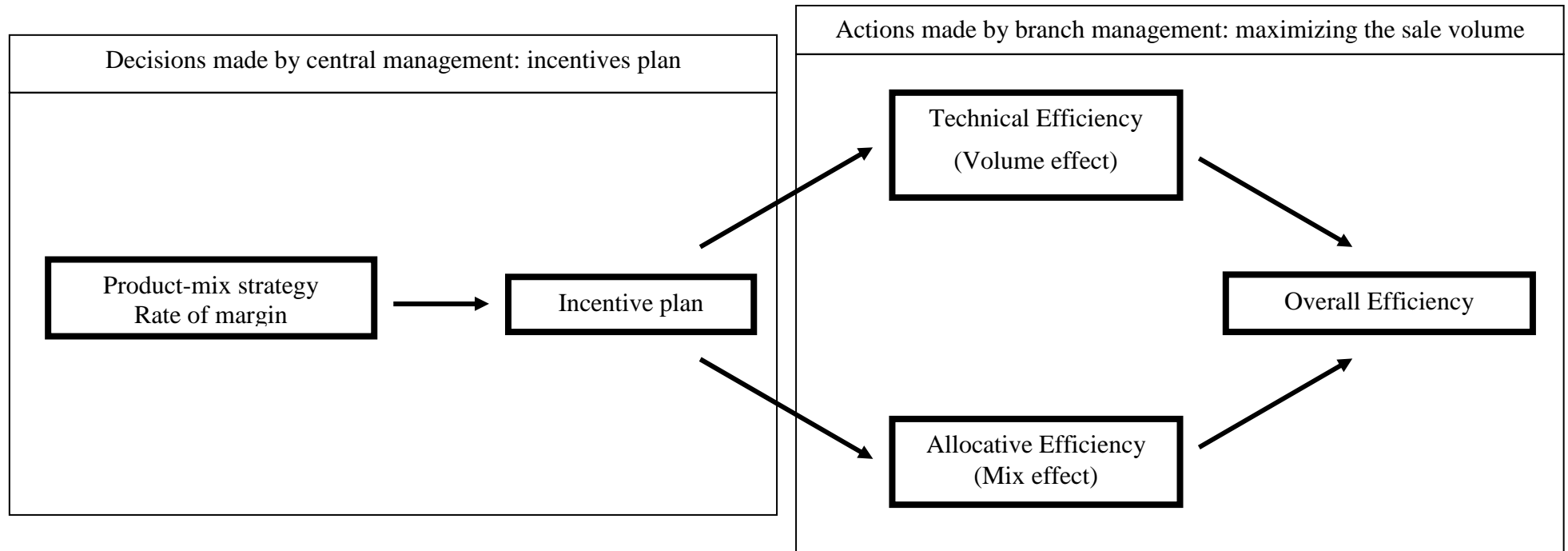


Figure 7. The set of relevant inputs and desirable outputs of the branches retailing process

Inputs	Outputs
<ul style="list-style-type: none"> • Number of personnel • Amount of operating expenses • Number of current accounts 	<ul style="list-style-type: none"> • Cash savings • Loans (personal loans, mortgages, and commercial loans) • Damage insurance • Financial savings (Mutual funds and life insurance)

Figure 8. Proxies selected to estimate the inputs and the outputs of the bank branches

	<u>Inputs and Outputs</u>	<u>Proxies</u>
Output 1	Cash savings	Value of interest-bearing deposits portfolio
Output 2	Loans	Value of loans portfolio
Output 3	Damage insurance products	Amount of damage insurance premiums
Output 4	Financial savings products	Amount of financial savings portfolio
Input 1	Human resources	Number of full-time equivalent employees
Input 2	Operating resources	Operating expenses
Input 3	Customer capital	Number of active current accounts

4.3 The data

Table 1 presents summary statistics for the variables used in the definition of the retailing process of the 1,585 branches on evaluation. For all of the variables, the median value is lower than the mean value meaning that some large values are present in the data. By looking at the range, we also see a large variation in size between the small and the large branches. This observed variation will be taken into account by our model since we explicitly compute the optimal product-mix at each scale of operation.

Table 1. Descriptive statistics for the 1,585 branches

Variable	Minimum	Median	Maximum	Mean	St. dev.
Number of employees	1	10	47	11	6
Operating expenses	74	645	3 894	772	460
Number of accounts	595	5 591	23 767	6 409	3 619
Cash savings	4 060	42 759	279 083	51 284	35 151
Loans	2 302	39 469	310 050	48 935	35 369
Damage insurance products	8	695	5 638	896	664
Financial savings products	606	24 366	224 983	31 589	25 798

The 1,585 branches are also characterized by different local environments. As discussed above, we will model a production technology specific to each environment. Branches are classified into eight distinct environments (cf. Figure 9). The classification has been established both from experts' opinion and on data analysis on a set of twelve criteria: rate of employee assets working in the agricultural field, rate of employees, rate of operative manufacturer, rate of businesses, rate of executives, rate of retirees, proportion of more than fifteen years-old studying, rate of unemployment, income per family, proportion of secondary residences, proportion of homeowners, and rate of population growth. The variability in market environment probably leads to a specialization in the products sold by the branches. In terms of management control, an important question that arises is the determination of the right incentive plan for each type of environment.

Figure 9. Descriptions of the eight environments

ENV1	Rural areas with a high rate of employee assets working in the agricultural field and a high rate of retirees
ENV2	Rural areas with a high rate of operative worker and of employee assets working in the agricultural field and a high rate of retirees
ENV3	Residential areas with a high rate of businesses, retirees and secondary residences
ENV4	Peripheral areas with a high rate of population growth, a significant portion of large dwellings and homeowners
ENV5	Urban areas with a high rate of students and of population growth
ENV6	Urban areas with a high rate of unemployment and low incomes
ENV7	Urban areas with quite high unemployment and income
ENV8	Urban areas with a high rate of executives and high incomes

Table 2 presents the distribution of the branches among the seventeen Regional Banking Groups (denoted RBG) and among the eight environments. We note that the banking groups are different, especially with regard to their size—the smallest comprises a network of 28 branches and the largest of 376. The number of branches per environment is also quite variable. Each banking group operates in at least three different environments. To face the competitive pressure, the trade strategy of all the regional banking groups is to be present in all the types of environment of their territory. Inside each regional banking group, we use a Herfindahl-Hirschman Index (HHI) score to evaluate the concentration of the branches among the different environments. The least concentrated regional banking group is RBG5 (HHI = 0.146) and the most concentrated one is RBG14 (HHI = 0.465). We can also note that none of the regional banking groups are highly concentrated in solely one environment.

The objective of the regional banking group is to maximize the NBP. Table 3 presents the rate of margins for the four outputs specified in this analysis. Margin rates vary across banking groups since the margins depend on financial markets conditions, interest rates, legislation and local competition. There is variability of at least 20% among the rates of margins, even for products such as cash savings (minimum is 2.93% and the maximum 3.38%) and loans (the minimum is 4.86% and the maximum 6.00%), which are highly regulated products.

Table 2. Distribution of the 1,585 branches among the seventeen regional banking groups and the eight different environments

	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7	ENV8	TOTAL	HHI Score
RBG1	15	9		5	6		2		37	<i>0.251</i>
RBG2		1	11	12		2	2		28	<i>0.325</i>
RBG3	11	5	2	5	7	11	17	3	61	<i>0.159</i>
RBG4	66	52	16	38	13	7	30	2	224	<i>0.193</i>
RBG5	5	10	2	5	8	11	10	1	52	<i>0.146</i>
RBG6					3	4	9	1	17	<i>0.331</i>
RBG7	15	14	11	6	1	1	5		53	<i>0.200</i>
RBG8	24	14	2	8		5	9	2	64	<i>0.220</i>
RBG9	11	7	4	20	11	68	34	5	160	<i>0.250</i>
RBG10	5	5	1	17	6	9	24	20	87	<i>0.180</i>
RBG11	2		4	2	4	14	24	1	51	<i>0.299</i>
RBG12	31	11	9	45	20	10	19		145	<i>0.187</i>
RBG13	7	32		18	6	3	11	5	82	<i>0.227</i>
RBG14				2	4		15	36	57	<i>0.465</i>
RBG15	17	39	1	149	29	77	58	6	376	<i>0.240</i>
RBG16		4	3	6	8	8	24	1	54	<i>0.249</i>
RBG17	3	6		3	4	6	13	2	37	<i>0.182</i>
TOTAL	212	209	66	341	130	236	306	85	1,585	<i>0.241</i>

Table 3. Margin rates for regional banking groups

	Rate of cash savings margin	Rate of loans margin	Rate of damage insurance products margin	Rate of financial savings products margin
RBG1	3.19%	5.70%	9.93%	0.59%
RBG2	2.95%	5.15%	11.36%	0.53%
RBG3	2.93%	5.74%	12.93%	0.37%
RBG4	3.12%	5.69%	11.39%	0.45%
RBG5	3.21%	6.00%	11.64%	0.60%
RBG6	3.03%	5.55%	16.73%	0.41%
RBG7	3.34%	5.40%	12.06%	0.66%
RBG8	3.23%	5.61%	10.81%	0.57%
RBG9	3.09%	5.94%	8.41%	0.70%
RBG10	3.13%	5.07%	10.03%	0.93%
RBG11	2.97%	5.73%	10.25%	0.56%
RBG12	3.03%	5.42%	12.82%	0.57%
RBG13	3.38%	5.61%	10.77%	0.58%
RBG14	3.11%	4.86%	10.60%	0.69%
RBG15	3.13%	5.27%	10.34%	0.80%
RBG16	2.98%	5.75%	11.64%	0.55%
RBG17	3.14%	5.83%	10.02%	0.61%

Table 4 presents results on the levels of inefficiency. While we compute the three inefficiency measures at the branch level, we present here aggregate results at the regional bank level. To obtain aggregate measures, we have added the branches' inefficiencies. In contrast to the traditional framework for which multiplicative and relative efficiency measures are used, the addition of scores is meaningful in our context because we have an additive decomposition of the economic inefficiency and we use Euros as the single and common unit of measurement for all the types of inefficiencies. Nevertheless for the sake of comparisons among the different regional networks, we have reported the inefficiencies as percentages of the regional bank NBP.

Table 4. Managerial objectives expressed by technical efforts and product-mix efforts

	Branch inefficiency	Product-mix inefficiency	Economic inefficiency
RBG1	27%	5%	32%
RBG2	16%	12%	28%
RBG3	28%	22%	51%
RBG4	13%	30%	42%
RBG5	12%	13%	24%
RBG6	15%	40%	55%
RBG7	12%	4%	16%
RBG8	18%	11%	29%
RBG9	24%	13%	37%
RBG10	9%	8%	18%
RBG11	17%	11%	29%
RBG12	22%	9%	32%
RBG13	15%	8%	23%
RBG14	13%	9%	22%
RBG15	8%	7%	16%
RBG16	19%	11%	30%
RBG17	21%	15%	36%
TOTAL	15%	13%	28%

As an example of interpretation of figures in Table 4, the regional bank RBG1 shows an inefficiency score of 27% on the branch inefficiency. This means that if all the branches among this group were technically efficient, RBG1 could improve its NBP by 27%. Moreover, the choice of the optimal product-mix would raise the NBP by 5%. Together, improving both technical and allocative efficiency could raise the NBP by almost a third (32%). It is clear that for RBG1, the main source of improvement is at the branch level and that the top management seems quite efficient in the incentives it gives to define the branches' product-mix depending on their size and their environment. However, this is not the case for all the banking groups. For example, for RBG6 the main source of improvement is at the regional level (40% of inefficiency) while the branch inefficiency is around the

sample average. On the other hand, for RGB15 the total inefficiency is equally split among the branches and the top management. These results are very relevant from a management control point of view in the sense that they analyze the causes of the economic inefficiency. The mean levels of the technical and allocative inefficiencies are quite similar (respectively, 15% and 13%), but much more variability is present at the individual level as shown by the results. A simple OLS regression of technical inefficiency on product-mix inefficiency shows that there is no correlation among the two types of inefficiencies and we can therefore conclude that there is no association between branch management performance and top bank management performance. (In)efficiency of branches neither implies nor precludes (in)efficiency of the top bank manager. We also note a large variation in the level of inefficiency between the seventeen bank networks. Economic inefficiency ranges from 16% to 55%. The same variability is observed for the allocative inefficiency (5% - 40%) while the range for branch inefficiency is smaller (8% - 28%).

The results presented in Table 4 are derived from a model that explicitly takes into account the effects of size and the environment at the branch level. We now want to test whether these effects remain at the regional level. Indeed, if a regional group has a great concentration of its branches in some specific environments, it may be easier to give the right incentives in terms of product-mix and thus the allocative inefficiency could be related to the concentration of the branches. Second, following the same argument, if the size of the branches is relatively homogenous among a regional group, it could be easier to manage the incentives plan on product-mix and thus the allocative inefficiency could be positively related to the heterogeneity in size. We therefore test for these two hypotheses with OLS regressions where the dependent variables are a Herfindahl-Hirschman Index of concentration and a heterogeneity index of size computed as the variance of branches' size. The result is that there is no relationship between either the concentration of the branches among the different environments or the heterogeneity in size and the regional group allocative inefficiency.

Besides the diagnostic results given above, our model can be used as a tool to analyze more deeply the nature of inefficiencies and to suggest corrective actions. We illustrate here how a top bank manager could measure the necessary changes in product-mix which lead to the maximal NBP. From the four outputs we consider, we chose the cash savings as a standard and we compute the ratios of other outputs over cash savings. All the results presented are

therefore relative to cash savings. The first ratio is loans / cash savings for which the results are presented in Table 5.¹³

Table 5. Changes in product-mix needed
to achieve allocative efficiency (loans / cash savings)

ratio loans / cash savings	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7	ENV8	TOTAL
RGB1	-17%	2%		41%	30%		-1%		4%
RGB2		-7%	-6%	28%		42%	144%		23%
RGB3	-20%	-40%	-45%	13%	45%	50%	41%	17%	19%
RGB4	-42%	-29%	-29%	-4%	8%	-24%	-23%	-26%	-25%
RGB5	-42%	-18%	-4%	72%	68%	30%	91%	0%	34%
RGB6					29%	-2%	0%	52%	8%
RGB7	-6%	-9%	2%	36%	7%	-2%	-3%		0%
RGB8	0%	-7%	4%	33%		3%	27%	60%	9%
RGB9	-10%	-12%	18%	87%	120%	44%	93%	46%	58%
RGB10	-54%	-50%	-41%	-24%	-16%	-21%	17%	-4%	-11%
RGB11	-43%		-3%	141%	49%	32%	45%	55%	39%
RGB12	-31%	-8%	9%	31%	20%	19%	8%		8%
RGB13	-4%	-23%		38%	16%	23%	53%	35%	11%
RGB14				-12%	-33%		21%	40%	28%
RGB15	-21%	-17%	0%	24%	4%	-6%	31%	0%	11%
RGB16		-23%	-4%	12%	31%	18%	93%	21%	49%
RGB17	-4%	44%		98%	117%	71%	77%	86%	70%
TOTAL	-25%	-18%	-8%	26%	30%	18%	40%	26%	14%

Table 5 gives the increase or decrease of the ratio loans/cash savings for the entire sample and by environment. We interpret here the first line. For the group RGB1 the ratio loans/cash savings has to be increased globally by 4% to get the product-mix efficiency. Therefore little inefficiency arises at the aggregate level. Nevertheless, if we analyze the results environment by environment we find much more disparities. For example, the branches located in ENV1 have to make a reduction of 17% of the ratio (by decreasing the

¹³ Results for the other ratios (damage insurance/cash savings and financial savings/ cash savings) are presented in Tables A1 and A2 in the Appendix.

volume of loans or increasing the volume of cash savings) while the branches located in ENV4 have to increase the ratio by 41%. For other banking groups, we see that some groups have to change this ratio substantially. For example, the group RGB5 has to increase this ratio by 34% while the group RGB10 has to reduce it by 11%. We also notice that the ratio has to decrease in rural environments (ENV1-ENV3) while it has to increase in the urban environments (ENV4-ENV8). Without going in further interpretations, we are convinced that these results constitute a relevant tool for the regional managers in defining the incentives for each branch according to their environment.

5. Concluding remarks

5.1. Links with a selected literature

Benchmarking is a promising managerial tool for an organizational structure such as a banking network. Central management frequently benchmarks branches. In the construction of our model, we use as our point of departure the three-legged stool metaphor of Brickley et al. (2004). The efficiency score is calculated with respect to the differences in the environments and in the decision empowerment, and with consideration of the architecture as a system of complements.

Our paper also encompasses to the financial literature on positive agency theory and more precisely on organizational architecture theory. Our model is constructed within a normative approach of agency theory, but our empirical results show that the choice of performance measures is essential since it determines the performance of the entire banking group. In this aspect, we can recognize the three components of the organizational architecture: decision rights, incentives plan, and performance measures. In the construction of our model, we consider these three components as the “*three legs of a stool*” (following Brickley et al. 2004). As a second empirical result, we show that the choice of performance measures is crucial: performance evaluation is one of the three legs of organizational architecture. In other words, if the chosen performance measures were not incorporated in a banking group perspective, all the individual profitability gains which would be obtained at a branch managerial level could be lost at central managerial bank level in an increase of the allocative inefficiency. Moreover, in developing a normative agency model and in proposing a positive agency interpretation of the empirical results, we follow Jensen’s recommendations (1983) which suggested bringing the two agency literatures become closer. Finally, we show that to

optimize the financial results of an organization such as a banking group, it is not enough to optimize the individual situation of its entities (bank branches).

5.2. Discussion of the empirical results

The efficiency scores calculated have the objective of assisting managerial decision making and in particular the central regional bank managerial decision making. They are performance measures and present quite a few interesting managerial requirements: simple, robust, easy to control, adaptive, as complete as possible, and easy to communicate (Little, 1970). The efficiency scores are simple because they are easy to understand and robust because there are no absurd answers. They are easy to control because we have explicitly included the decisional power of the branches managers and of the central regional bank managers in the model. Moreover, they are adaptive because in the future we could integrate new information such as market share for example and as complete as possible because the model used is constructed according to a global vision of the banking group. Finally, they are easy to communicate because they are performance measures that are easy to interpret and they are quite familiar ground for banking managers.

We develop two managerial aspects of our empirical results: (i) implications of the results on benchmarking practices and (ii) implications of the results on managerial practices.

(i) The efficiency scores are useful to practice internal benchmarking, they are particularly congruent because they respect the controllability principle at the branch level (branches are only compared to other branches constrained within same trade area). But there is another interesting managerial aspect, it is to benchmark the regional banking group –in other words at the upper aggregate managerial level.

(ii) Our findings confirm that the product mix strategy (through the rate of margins) has to take into account the size and the localization of the branches. The results of our analysis could help the top bank management to adapt the incentives to each branch. The model developed here could also be used as a prospective management tool. It is based on four key variables (margins, size, localization and inputs). By fixing any three of them, this allows us to simulate the last one. For example, bank top management could anticipate the effect of changes in the rate of margins on optimal output mixes to adapt their incentives plan. On this aspect our model catches the Banker and Datar (1989) paper up: “It states that optimal compensation contract design was split into two stages: developing a measure of evaluation for managerial performance, and using that measure to choose a compensation contract”.

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Appendix

Table A1. Changes in product-mix needed to achieve allocative efficiency (damage insurance/cash savings)

Damage insurance/ cash savings	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7	ENV8	TOTAL
RGB1	-5%	-25%		92%	-9%		-1%		3%
RGB2		-34%	-30%	-11%		-23%	-17%		-21%
RGB3	3%	-23%	-17%	87%	32%	47%	54%	-13%	32%
RGB4	23%	-23%	-26%	35%	7%	-9%	11%	-33%	7%
RGB5	-46%	-44%	-7%	6%	-21%	-12%	3%	0%	-18%
RGB6					-7%	-22%	-23%	-30%	-21%
RGB7	7%	-3%	-9%	173%	-17%	43%	54%		25%
RGB8	-27%	-41%	-14%	22%		-22%	-13%	-55%	-22%
RGB9	-16%	-9%	23%	76%	22%	9%	45%	-44%	22%
RGB10	-48%	-47%	-17%	-14%	-8%	-19%	8%	-26%	-14%
RGB11	-19%		-19%	57%	22%	12%	20%	-30%	14%
RGB12	-10%	-8%	-20%	10%	-15%	-5%	-3%		-4%
RGB13	-29%	-24%		66%	-25%	7%	22%	-26%	3%
RGB14				24%	-11%		20%	-18%	-6%
RGB15	-38%	-28%	0%	-8%	-13%	-14%	-11%	-48%	-14%
RGB16		-31%	-10%	-19%	-16%	-6%	14%	-62%	-3%
RGB17	-3%	78%		178%	134%	117%	161%	62%	120%
TOTAL	-4%	-21%	-17%	17%	-1%	1%	19%	-24%	2%

Table A2. Changes in product-mix needed to achieve allocative efficiency (financial savings/cash savings)

Financial savings / cash savings	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7	ENV8	TOTAL
RGB1	19%	34%		34%	-4%		23%		21%
RGB2		-39%	20%	49%		28%	17%		31%
RGB3	-53%	-45%	-47%	-31%	-54%	-41%	-42%	-29%	-44%
RGB4	-65%	-59%	-57%	-56%	-48%	-54%	-53%	-61%	-59%
RGB5	81%	109%	14%	53%	33%	40%	92%	0%	66%
RGB6					-44%	-53%	-55%	-72%	-54%
RGB7	30%	17%	7%	38%	38%	9%	12%		21%
RGB8	6%	-15%	9%	4%		5%	5%	-14%	0%
RGB9	-12%	-28%	-3%	-15%	-35%	-4%	-7%	-13%	-10%
RGB10	33%	78%	-14%	57%	38%	37%	25%	16%	34%
RGB11	-19%		20%	124%	12%	27%	57%	18%	41%
RGB12	-19%	-8%	-6%	-1%	11%	0%	28%		0%
RGB13	-2%	12%		12%	3%	45%	63%	6%	18%
RGB14				16%	103%		44%	-5%	16%
RGB15	7%	1%	0%	11%	18%	22%	14%	-9%	13%
RGB16		31%	38%	34%	9%	19%	14%	44%	19%
RGB17	-28%	22%		-13%	17%	-12%	18%	-7%	6%
TOTAL	-20%	-5%	-9%	6%	3%	8%	11%	-3%	1%