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Labor-Cost Efficiency with Indivisible Outputs and Inputs: A Study of Indian Bank Branches

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This study uses Data Envelopment Analysis to examine the efficiency of 536 branches of a major Indian public sector bank across four large metropolitan cities. Unlike previous papers on branch banking in India we model branch operations following the production approach and introduce several methodological extensions to account for the product mix of branches in creating the efficient cost frontier. Our results indicate that there is significant labor cost inefficiency in the operations of the branches. Overall Chennai branches are the most efficient both with respect to their metro specific best-practice frontier as well as the grand frontier. While deposit oriented branches in Kolkata are considerably efficient with respect to their metro specific frontier, branches of other orientations perform quite poorly. Across the three types of labor, attaining efficiency in the number of clerks would have the highest impact in terms of cost savings.

Keywords: Data envelopment analysis; Indian banking; Labor-cost efficiency; Indivisible outputs and inputs

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1. Introduction

Since 1969, India has pursued one of the largest state-led bank credit programs ever attempted in a developing country. Starting with the nationalization of major commercial banks in 1969, the effort has been to create an extensive network of public sector banks and their branches in order to expand financial coverage throughout the country. The government has maintained the position that the role of the banking sector is to achieve the larger social and economic goals of the country and meet the financial needs of all the sections of society.[1]

In the early 1990s, India instituted major economic reforms, a central aspect of which was financial sector reforms. The Reserve Bank of India initiated measures to improve the efficiency and profitability of Indian banks. These measures included deregulation on entry of private and foreign banks to increase competition, allowing public sector banks to raise capital from the market, branch delicensing, deregulation on interest rates and other quantitative restrictions on bank portfolios, while at the same time introducing prudential regulations to improve the soundness of banks. Propelled by the economic reforms, the Indian economy grew rapidly, reaching a peak of over 9% annual average GDP growth rate during the years 2005-06 through 2007-08. The reforms created a more level playing field for banks of different ownership types, allowing them to compete within a new set of broad and more relaxed regulations. Currently the competitive landscape for the commercial banking industry comprises the State Bank of India and its affiliates,[2] nationalized banks, private sector banks, and foreign banks. In 2013, there were a total of 88,562 branches of commercial banks throughout the country, of which the State Bank of India alone operated a total of 14,699 branches.

Since the reforms, several studies have focused on estimating the efficiency and productivity of Indian banks using both parametric and non-parametric methods (predominantly data envelopment analysis, (DEA)). These studies offer valuable insights on the relative performance of banks by type of ownership, size, and so on. However, from the perspective of a bank, achieving operational efficiency at the branch level is a prerequisite for the goals of technical and economic efficiency of the bank (Berger et al., 1997). In the U.S. and European banking context, therefore, a sizeable number of studies have examined the various dimensions of branch level efficiency (Paradi and Zhu, 2013). In contrast, to our

[1] The Reserve Bank of India has continued a multi-pronged approach to achieve the goal of universal financial inclusion. Though that goal is still far away, marked progress has been made in recent years. For example, the number of banking outlets (branches and branchless mode) in villages went up from 67,694 in March 2010 to 586,307 in March 2016. Further, the number of basic savings bank deposit accounts have gone up from 73 million in March 2010 to 469 million in March 2016. (Reserve Bank of India Annual Report 2015-16.)

[2] According to a new government policy, the State Bank of India will merge five of its associate banks with itself in April 2017 to become a global-sized bank.

knowledge, so far only two studies (Das et al., 2009 and Ray, 2016) have examined the efficiency of Indian banks at the branch level.

The analytical format for measuring efficiency of banks at the institutional level fits poorly when applied at the level of a branch of the bank. A bank primarily functions as a financial intermediary between borrowers and lenders of funds transforming deposits and other borrowed funds into credit and investments. It is generally accepted in the literature that while, the *intermediation function* applies more appropriately to a bank, such functions are not totally at the discretion of individual branches. By contrast, the primary business of an individual branch is to provide deposit and credit services to the customers of the bank. At the branch level, labor and physical capital (like the premises and machines) serve as inputs. Services are indirectly measured by the number and type of transactions carried out for both deposits and loans, documents processed for taking deposits, extending loans and other direct services and so on. Hence, the *production approach* (introduced by Benston, 1965) is more appropriate for modeling the business of a bank branch wherein it is considered as a producer of services. Branches are responsible for managing their labor and capital efficiently in servicing the deposit and loan accounts of customers and offering other fee based services. Also, branches serve as the main interface between the customers and the bank. How a customer's banking need is serviced is of prime importance. What differentiates a branch from an ATM are the employees providing face to face interaction with the customers. Labor is, in a sense, the soul of a branch. Not surprisingly, labor also accounts for a significant proportion of operating costs of a branch. According to Das et al. (2009), personnel expenses account for 34% - 39% of the total operating costs of banks in Asian countries in comparison to which the same ratio is even higher for Indian banks and stands at around 60%. Other efficiency studies on Indian banking based on disaggregated inputs and outputs have also identified that management of labor is one of the major factors contributing to inefficiency (Fujii et al., 2014). Insights obtained from benchmarking analysis can help branches to continuously improve their operations and realign their businesses with the best practices available (Paradi and Zhu, 2013). However, appropriate models are needed so that top level bank decision makers or branch managers may benefit from these analyses. In a typical bank branch in India, the extent and type of labor used by a branch depends not only on the volume of transactions provided but also on the *product mix* of a branch. It is important to explicitly account for these factors in conducting meaningful efficiency analysis of the branches.

Our paper adds to the sparse literature on operational efficiency of branches in the context of Indian banking. In this study, we examine the efficiency of 536 branches of a major Indian bank with nationwide presence across four large metropolitan cities, Chennai, Delhi, Kolkata, and Mumbai. By including the branches of a single large bank, we are able to control for factors emanating from bank level policy that could affect the relative efficiency of branches. We utilize DEA to analyze data for the year

2007-08, which was a remarkable year for India with respect to banking development, growth, and stability. During this year, both deposits and credit grew at an annual rate of 22 percent. Further, non-performing loans were at a historical low of around 1%.[3] Finally, this is the latest year of data prior to the global financial crisis. Thus the business prospects for branches was favorable in 2007-08 which ensures that any observed inefficiency in resource utilization can be attributed to the performance of the branches rather than to insufficient demand.[4]

Our study makes several important contributions to the literature. This is the first study in the Indian banking context to model the operations of branches using the *production approach*. Second, we focus on labor cost efficiency and account for various complexities of branch level operations in creating the cost frontiers. We create separate technology frontiers for the branches based on their functional orientation in terms of credit-deposit ratio to ensure that we are comparing within homogenous clusters of branches. Further, this is the first study to account for the different *product mix* of branches by explicitly considering large credit accounts and small credit accounts as separate outputs. Third, the current study makes innovative contributions to the traditional DEA methodology for measuring bank branch performance in two ways. To account for the case of indivisibility of some outputs as well as inputs, we explicitly incorporate integer constraints in our DEA models.[5] Additionally, because labor requirement for providing banking services to the deposit and credit account holders depends on both the number of accounts and their value, we require that the benchmark branch for comparison should not have either fewer accounts or lower balances of any type of deposit or credit accounts. We believe that the main contributions of this paper lie in both extending the methodology and at the same time providing an important empirical application in the context of Indian branch banking.[6] Lastly, this study is based on a larger sample size compared to most studies on bank branch efficiency. For instance, only a handful of the reported 80 studies in the survey paper by Paradi and Zhu (2013) use data sets containing more than 200 branches. Our use of a bigger data set makes our empirical findings more reliable.

Our empirical findings indicate that there is significant inefficiency in labor use in the branches and cost could be curtailed substantially by addressing overstaffing. Across the three types of labor, reducing the number of clerks would have the highest impact for cost saving. Efficiency varies across regions, even after controlling for functional orientation of the branches in terms of credit/deposit intensity. In general Chennai branches are more efficient than branches from other regions within the

[3] Source: Reserve Bank of India.
[4] In the Indian banking sector, labor is hired with long term goals. Hence observed data during a weak economic environment can lead to biased measurement of efficiency.
[5] Das et al. (2009) considered indivisibility for the labor inputs only.
[6] Other notable studies that have made methodological contributions in the context of bank branch performance include Athanassopoulos (1997), Camanho and Dyson (1999), Drekker and Post (2001), Wu et al. (2006), and Paradi et al. (2010).

same homogenous group whereas Kolkata branches are the least efficient. The divergence across regions seem to be more pronounced for low and medium credit intensive branches and less so for high credit intensive branches.

The rest of the paper is organized as follows. In Section 2, we provide a brief review of the literature on efficiency in branch banking. In Section 3, we explain the non-parametric methodology and the proposed extensions. Section 4 describes the data construction and modeling issues and presents the mixed integer programs used in our empirical application. Section 5 provides a discussion of the main results and Section 6 concludes.

2. Review of Literature

The operational efficiency of banks has been a matter of immense and growing interest in all countries and has, accordingly, been the subject of a voluminous literature on banking. Three major survey papers on bank performance, Berger and Humphrey (1997), Berger (2007), and Fethi and Pasiouras (2010), all reveal that a substantial body of this literature is devoted to studying performance at the institutional level. A much smaller number of studies address performance at the branch level. A recent survey paper by Paradi and Zhu (2013) also finds that of the 275 studies between 1985-2011 that utilized DEA for examining bank sector performance, only 80 were focused on efficiency at the branch level. The first application of bank branch efficiency analysis was by Sherman and Gold (1985). Since then, the number of branch studies has increased over time, with 53 of the 80 studies being conducted in 2001 and later. Further, of the 80 studies, 65% were focused on the U.S. and major European countries. One reason for the limited number of branch level studies on other countries is the lack of publicly available reliable data at this level of operation.

The global economic outlook indicates that most of the growth in the world economy in the near future will come from the emerging economies, where the banking sector will play a significant role by facilitating this growth. India is a leading emerging economy and understanding the performance of the banking sector of India can serve as an important case study for banking in the context of emerging economies. Not surprisingly, there is now a sizeable literature examining the efficiency and productivity of banks in the Indian banking sector, especially since the 1990s financial reforms. While Saha and Ravisankar (2000) focuses only on public sector banks, a major aspect of analysis of most studies has been the comparison of performance of banks across different ownership types (Sathye, 2003; Bhaumik and Dimova, 2004; Ram Mohan and Ray, 2004; Sensarma, 2006; Das and Ghosh, 2006; Zhao et al., 2010; and Ray and Das, 2010, among others). Recent studies along these lines include Casu et al. (2013), Fujii et al. (2014), Tzeremes (2015) and Badunenko and Kumbhakar (2017). Casu et al. (2013) utilize both parametric and non-parametric methods to estimate the efficiency frontier and obtain Divisia and

Malmquist indexes of total factor productivity, respectively. They use a metafrontier approach to account for heterogeneity across bank ownership types. Fujii et al (2014) examine the efficiency and productivity growth of the Indian banking sector over the period 2004 to 2011. They utilize DEA and a weighted Russell directional distance model to measure efficiency in the presence of undesirable output (non-performing loans) and compare performance of banks of different ownership types. Tzeremes (2015) analyzes the efficiency dynamics of the Indian banking industry from 2004 to 2012 applying a conditional directional distance function. Badunenko and Kumbhakar (2017) use a heteroscedastic four-component panel data stochastic frontier model to study Indian banks from 2002-2009. They control for bank-heterogeneity and introduce persistent and time-varying inefficiency and incorporate determinants of both inefficiency and production risks. Their model allows them to jointly estimate the different technologies for different ownership types.

The literature on efficiency and productivity of Indian bank branches, however, is very limited. To our knowledge, only two published studies have addressed this aspect of bank performance (Das et al., (2009) and Ray (2016)). Das et al., (2009) use DEA to measure labor-use efficiency of 222 individual branches of a large public sector bank in 2003 across four metropolitan cities. They model the operation of a branch using the *intermediation approach*. Using a variable cost minimization model, they find considerable variation in efficiency of bank branches across regions which indicate that the effects of cultural and regional differences are important in spite of the same organizational culture.

Ray (2016) takes a very different perspective and evaluates the 'overall' cost efficiency of a network of 193 branches of a single large public sector bank within the city of Kolkata using data for the year 2012. The study attempts to determine the optimal number of branches within a postal district that could provide the observed amounts of banking services to customers in that area at the minimum operating cost. The DEA results show that overall there is evidence of 'over-branching'. However, there are also instances where increasing the number of branches within a market area would be optimal.

While the basic research question of the current paper takes off from Das et al. (2009), we extend that research in both methodological and empirical dimensions.

- We model the operations of a branch using the *production approach*, which we argue, is the more appropriate characterization of the functions of a branch.
- We treat the numbers of large and small credit accounts as separate outputs to represent the difference in *product mix* of branches.
- Because labor requirement for providing banking services to the deposit and credit account holders depends on both the number of accounts and their value, we incorporate constraints in our model to ensure that the benchmark branch for comparison do not have either fewer accounts or lower balances of any type of deposit or credit accounts.

- We formulate an improved DEA model that imposes integer constraints to address the indivisibility of not only some of the inputs but also some of the outputs.
- Rather than limit our study to only branches with a balanced portfolio of credit and deposit, we study three types of branches (i) low credit intensive (deposit oriented), (ii) medium credit intensive (balanced portfolio of credit and deposit), and (iii) high credit intensive (credit oriented). This enables us to accommodate the differences in types of task performed by the employees in different categories of branches and their implications for labor requirements.

To summarize, the current study revisits the estimation of labor cost efficiency in Indian bank branches with a uniquely large and detailed data set pertaining to the year 2007-08, the final year of what is often described as India's short lived era of 'golden growth'. This permits us to offer new and valuable insights into the performance of the Indian banking industry at a disaggregated level. To the extent that the branch banking scenario in India, characterized by heterogeneous product mix, can be generalized to other large emerging economies, our modeling structure would be appropriate for other studies as well.

3. The Nonparametric Methodology

For efficiency measurement using econometric techniques, one specifies some explicit form of the production, cost, or profit function to represent the benchmark technology. In the nonparametric alternative, however, one makes a number of fairly general assumptions about the technology and leaves the functional form unspecified. Typically, it is assumed that the production possibility set is convex and both inputs and outputs are freely disposable.

Consider an industry producing m outputs from n inputs. An input-output bundle $(x, y): x \in R_+^n, y \in R_+^m$ is considered feasible when the output bundle y can be produced from the input bundle x. The technology faced by the firms in the industry can be described by the production possibility set

$$T = \{(x, y): y \text{ can be produced from } x\} \qquad (1)$$

In the single output case, one can conceptualize the production function

$$f(x) = \max y: (x, y) \in T \qquad (2)$$

In the multiple output case, the production possibility set may be defined as

$$T = \{(x, y): F(x, y) \le 0\} \qquad (3)$$

where $F(x, y) = k;\ x \in R_+^n, y \in R_+^m$ is the production correspondence.

It is conventional to assume that

(A1) every observed input-output bundle is feasible;

(A2) inputs are freely disposable;

(A3) outputs are freely disposable;

(A4) the production possibility set is convex.

Suppose that the data set $D = \{(x^j, y^j); j = 1, 2, \ldots\ldots, N\}$ consists of observed input-output bundles (x, y) from N firms in the industry,

Then

(1) $(x^j, y^j) \in D \Rightarrow F(x^j, y^j) \leq 0$ by (A1)

(2) $(x^0, y^0) \in T \wedge x^1 \geq x^0 \Rightarrow (x^1, y^0) \in T$ by (A2). Further, if the function $F(x, y) = k$ is differentiable, then $\frac{\partial F}{\partial x_i} \leq 0$ for each input *i*.

(3) $(x^0, y^0) \in T \wedge y^1 \leq y^0 \Rightarrow (x^0, y^1) \in T$ by (A3). If the function $F(x, y) = k$ is differentiable, then $\frac{\partial F}{\partial y_i} \geq 0$ for each output *i*.

(4) By the convexity assumption (A4)

$(x^1, y^1), (x^2, y^2) \in T \wedge 0 \leq \lambda \leq 1 \Rightarrow (\lambda x^1 + (1 - \lambda) x^2;\ \lambda y^1 + (1 - \lambda) y^2) \in T$

In terms of the production correspondence,

$F(x^1, y^1) \leq 0 \wedge F(x^2, y^2) \leq 0 \wedge 0 \leq \lambda \leq 1 \Rightarrow F(\lambda x^1 + (1 - \lambda) x^2;\ \lambda y^1 + (1 - \lambda) y^2) \leq 0$

Under the assumptions (A1)-(A4) an empirical estimate of the production possibility set is the free disposal convex hull of the observed data points

$$S = \{(x, y): x \geq \textstyle\sum_{j=1}^{N} \lambda_j x^j; y \leq \sum_{j=1}^{N} \lambda_j y^j;\ \sum_{j=1}^{N} \lambda_j = 1;\ \lambda_j \geq 0; (j = 1, 2, \ldots\ldots, N)\} \quad (4)$$

3.1 Alternative Measures of Efficiency

The two most popular measures of efficiency in the DEA literature are the radial input and output oriented measures of technical efficiency due to Farrell (1957), Charnes, Cooper, and Rhodes (CCR)(1978), and Banker, Charnes, and Cooper (BCC)(1984). In an empirical analysis, for any unit using input x^0 to produce output y^0 the radial input-oriented efficiency is

$$\tau_x(x^0, y^0) = \min \theta: (\theta x^0, y^0) \in S \quad (5)$$

and the radial output-oriented efficiency is

$$\tau_y(x^0, y^0) = \frac{1}{\varphi^*} \text{where } \varphi^* = \max \varphi: (x^0, \varphi y^0) \in S \quad (6)$$

When output is preassigned as a given task, efficiency lies in delivering the target output using the minimum quantity of inputs. In this respect, however, the radial input-oriented measure in (5) is rather inadequate because it does not capture the potential for reducing individual inputs to their fullest extent. A more complete measure of input-oriented technical efficiency is the non-radial Russell measure:

$$\rho(x^0, y^0) = \min \frac{1}{n} \text{trace}(\Theta): (\Theta x^0, y^0) \in S; 0 \leq \Theta \leq I \quad (7)$$

where Θ is a diagonal matrix.

Although better than the radial measure, the Russell measure is still somewhat unsatisfactory because it treats reduction in all inputs equally without any reference to their market prices. When reliable price information is available, economizing on the use of inputs amounts to minimizing the total cost of the input bundle used even if it might require increasing some individual inputs while reducing others. At this point, it is useful to consider the empirically constructed input requirement set[7] of the observed output bundle y^0

$$V(y^0) = x: (x, y^0) \in S \tag{8}$$

The minimum cost of producing y^0 at input prices w^0 is

$$C(w^0, y^0) = \min w^{0\prime}x: x \in V(y^0) \tag{9}$$

Following Farrell (1957), the cost efficiency of the unit can be measured by the ratio of the minimum cost to its actual cost

$$\gamma(w^0, y^0; C^0) = \frac{C(w^0, y^0)}{C^0} \text{ where } C^0 = w^{0\prime}x^0. \tag{10}$$

We next introduce a cost-aggregated representation of the input-requirement set which we define as a cost set and highlight some of its properties which follow from the convexity and disposability assumptions A1 through A4 above.

3.2 A Cost Set Representation of the Technology

For a given vector of input prices w^0, one can evaluate the cost $e = w^{0\prime}x$ of every input bundle $x \in V(y^0)$. Because $C(w^0, y) \leq w^{0^\prime}x \; \forall x \in V(y)$, a dual representation of the overall technology through its *cost set* is

$$E(e, y|w^0) = \{(e, y): e \geq C(w^0, y)\}. \tag{11}$$

It can be easily shown that

(a) $(e_0, y) \in E(e, y|w^0) \wedge e_1 > e_0 \Rightarrow (e_1, y) \in E(e, y|w^0)$.

Clearly, $(e_0, y) \in E(e, y|w^0)$ implies $e_0 \geq C(w^0, y)$. Hence, $e_1 > e_0 \geq C(w^0, y)$. Thus, $e_1 \in E(e, y|w^0)$.

(b) $(e, y^0) \in E(e, y|w^0) \wedge y^1 \leq y^0 \Rightarrow (e, y^1) \in E(e, y|w^0)$. This follows from free disposability of outputs, which implies that if $x \in V(y^0)$, then $x \in V(y^1)$ for any $y^1 \leq y^0$.

(c) $E(e, y|w^0)$ is convex. Consider the output bundles y^0 and y^1. Suppose x^{0*}minimizes the cost of producing y^0 and x^{1*}minimizes the cost of producing y^1at input prices w^0. Now consider the output bundle $\bar{y} = \lambda y^0 + (1 - \lambda)y^1$ $(0 < \lambda < 1)$. By convexity of the technology, the input bundle $\bar{x} = \lambda x^0 + (1 - \lambda)x^1 \in V(\bar{y})$. However $\bar{x}$ may not be cost minimizing for $\bar{y}$. Hence, $\bar{e} = w^{0\prime}\bar{x} \geq C(w^0, \bar{y})$ implying

[7] An input requirement set consists of all the input bundles that can produce the specified output.

that $\bar{e} = w^{0\prime}\bar{x} \in E(e, \bar{y}|w^0)$. Now, $e_0 \in E(e, y^0|w^0) \Rightarrow e_0 \geq C(w^0, y^0) = w^{0\prime}x^{0*}$. Similarly, $e_1 \in E(e, y^1|w^0) \Rightarrow e_1 \geq C(w^0, y^1) = w^{0\prime}x^{1*}$.

Therefore, $\bar{e} = \lambda e_0 + (1-\lambda)e_1 \geq w^{0'}(\lambda x^{0*} + (1-\lambda)x^{1*}) \geq C(w^0, \bar{y})$

$\Rightarrow \bar{e} = \lambda e_0 + (1-\lambda)e_1 \in E(e, \bar{y}|w^0)$.

The dual cost function $e = C(w^0, y)$ is the lower boundary or the frontier of the cost set for a given vector of input prices.

3.3 Group Specific Cost Frontiers and Group Efficiency

In the production possibility set (4) represented by the free disposal convex hull of all of the observed input-output data points in the sample, it was implicitly assumed that every decision making unit has access to all points in the technology set. In many cases there are geographical and/or institutional factors specific to units from different groups that introduce a degree of technological heterogeneity. In that case, one can think of group-specific technology sets subsumed under the overall or industry-wide production possibility set shown in (4). Intuitively, this implies that while input-output bundles are interchangeable across and/or may be combined with units within a group, they may not be so between groups.

Let the set J consist of all units in the data. Partition the entire set into G groups as $J = \{J_1, J_2, \ldots\ldots, J_G\}$. Any unit $j \in J_g$ if and only if it belongs to group g. We may now create group-specific sub technologies for each group $g = (1,2, \ldots, G)$.

$$S_g = \left\{(x,y): x \geq \sum_{j\in J_g} \lambda_j x^j, y \leq \sum_{j\in J_g} \lambda_j y^j, \sum_{j\in J_g} \lambda_j = 1; \lambda_j \geq 0; j \in J_g\right\} \qquad (12)$$

The corresponding input requirement sets are

$$V_g(y^0) = x: (x, y^0) \in S_g \qquad (13)$$

resulting in group-specific minimum cost

$$C_g(w^0, y^0) = \min w^{0\prime}x: x \in V_g(y^0) \qquad (14)$$

and cost efficiency

$$\gamma_g(w^0, y^0; C^0) = \frac{C_g(w^0, y^0)}{C^0} \text{ where } C^0 = w^{0\prime}x^0. \qquad (15)$$

For each unit $j \in J_g$, one can now compute two different measures of cost efficiency. The first, $C_g(w^0, y^j)$ is relative to the group frontier. The other, $C(w^0, y^j)$ is relative to the industry or grand frontier. The first measures how close the unit is to the group frontier. The second, on the other hand, measures, how close the unit is to the grand frontier. The ratio of the two is a measure of the proximity of the group frontier to the grand frontier evaluated at a specific output level.[8]

This is illustrated geometrically in Figure 1. Suppose that the units can be categorized into two groups. Assume, for simplicity, that all firms face the same input prices. The point P_1 through P_4 show the output quantities and the actual costs of the 4 firms from group 1. The cost frontier for this group is shown by the piecewise linear lower envelop $AP_1P_3P_4D$. Similarly, points Q_1 through Q_4 show the outputs and costs of the firms from group 2 and the corresponding cost frontier is $BQ_1Q_2Q_3E$. The overall (grand) frontier is the outer envelope of the two group frontiers and is shown by the broken and piecewise connected line $AP_1P_3Q_2Q_3E$ corresponding to the technology set defined in (4). Note that a segment of this frontier – identified by the broken line P_3Q_2 lies below both of the group frontiers. A point in this interval corresponds to a convex combination of the output bundles of firm 3 in group 1 and firm 2 in group 2 and the cost of the corresponding convex combination of their input bundles. This, it may be noted, is feasible in case of the overall frontier but not for the individual group frontiers.

Consider, now, firm 1 from group 2 producing output OK at the cost Q_1K. The point Q_1 is on the cost frontier for group 2 and it is efficient within the group. However, the minimum cost for the same output as per the overall cost frontier is LK and this unit is not efficient relative to the overall frontier. The ratio $\frac{LK}{Q_1K}$ is a measure of the cost efficiency of group 2 relative to the entire industry evaluated at the output level OK. For firm 4 in group 2 producing the output ON, the actual cost is Q_4N while the relevant points on the group and grand frontier are M and R, respectively. Thus, the group specific cost efficiency of firm 4 in group 2 is $\frac{MN}{Q_4N}$ while the efficiency of group 2 at the output level ON is $\frac{RN}{MN}$. In the case of firm 4 from group 1, point P_4 is located on the group frontier showing a 100% group specific efficiency for this unit. The cost of the same output level OT based on the group 2 frontier would be UT which is lower than P_4T. But the corresponding benchmark point on the grand frontier is S which is even lower being located on the P_3Q_2 segment connecting two points from the different frontiers.

A measure of the average cost efficiency of the units within the group is

$$\bar{\gamma}_g = \frac{\sum_{j\in J_g} C_g(w^0, y^j)}{\sum_{j\in J_g} w^{0\prime}x^j} = \sum_{j\in J_g}\left(\frac{w^{0\prime}x^j}{\sum_{j\in J_g} w^{0\prime}x^j}\right)\left(\frac{C_g(w^0,y^j)}{w^{0\prime}x^j}\right) = \sum_{j\in J_g}\alpha_j\,\gamma_g\big(w^0, y^j\big), \qquad (16)$$

$$\text{where } \alpha_j = \frac{w^{0\prime}x^j}{\sum_{j\in J_g} w^{0\prime}x^j} \qquad (17)$$

is the share of unit j in the total cost of all units in group g. A proportional measure of the cost saving that could be achieved if all units could be made efficient relative to the group cost frontier is $(1-\bar{\gamma}_g)$. Similarly, the average cost efficiency of the units within the group corresponding to the grand frontier is

[8] Battesse et al (2004) characterize this as the 'technology gap' in the context of a production frontier.

$$\bar{\bar{\gamma}}_g = \frac{\sum_{j \in J_g} C(w^0, y^j)}{\sum_{j \in J_g} w^{0'} x^j}, \tag{17a}$$

which is also a cost share weighted average of the efficiencies of units in the group.

Hence, a measure of the overall efficiency of group g relative to the entire industry is

$$\mu_g = \frac{\sum_{j \in J_g} C(w^0, y^j)}{\sum_{j \in J_g} C_g(w^0, y^j)} = \frac{\bar{\bar{\gamma}}_g}{\bar{\gamma}_g} \tag{18}$$

$$\bar{\bar{\gamma}}_g = (\bar{\gamma}_g) \cdot (\mu_g) \tag{18a}$$

A low value of μ_g indicates that the group cost frontier of group g is located much above the grand cost frontier and $(1 - \mu_g)$ is a measure of the proportional decrease in the total cost if all firms from group g could move from the group frontier to the grand frontier. While $\gamma_g = (w^0, y^j)$ measures the performance of the decision maker at unit j, μ_g is an overall measure of the performance of the group relative to the entire industry. When the groups corresponding to geographical areas, the group efficiency can be interpreted as 'area efficiency'.[9] While previous studies such as Das et al (2009) do measure area efficiency, their use of unweighted averages do not accurately reflect the relevant potential reduction in cost.

3.4 Indivisibility of Inputs and Outputs

We have so far assumed that all of the inputs and outputs are non-negative, real-valued, continuous variables. Suppose, however, that some of these inputs and outputs can only be positive integers. This would immediately invalidate both the convexity and disposability assumptions in (A2)-(A4). Even when x_1 and x_2 are integer valued, every convex combination $\bar{x} = \lambda x_1 + (1 - \lambda) x_2; (0 \leq \lambda \leq 1)$ need not also be integer valued. In the same vein, even when (x_1, y_1) is feasible, $\delta > 0$ does not imply $(x_1 + \delta, y_1)$ is also feasible, unless δ is also an integer. Similar reasoning applies about the output when y also has to be an integer.

Kuosmanen and Matin (2009) and Matin and Kuosmanen (2009) introduced the concepts of *Integrality, Natural Disposability, and Natural Convexity* in the context of DEA in order to accommodate integer outputs and inputs.[10] Consider the most general case where some inputs and outputs are integer valued while the others can take any non-negative real value.

[9] In our empirical application, there are four groups ($g = 1, \ldots, 4$), pertaining to each metro Chennai, Delhi, Kolkata, and Mumbai. Accordingly, the group efficiency (μ_g) of a metro with respect to the grand frontier is the 'area efficiency' of that specific metro.

[10] Integrality implies the relevant input or output can only be integer valued. Natural Disposability means that if any input-output bundle is feasible, reducing any output or increasing any input by an integer amount does not affect the feasibility of the new bundle. Similarly, Natural Divisibility means that one can scale down any feasible input-

Accordingly, partition the input vector as $x = (x^I \mid x^{II})$ where $x^I \in R_+^{n_1}$ is restricted only to be real valued whereas $x^{II} \in Z_+^{n_2}$ must also be integer valued.[11] Similarly, partition $y = (y^I \mid y^{II})$ where $y^I \in R_+^{m_1}$ and $y^{II} \in Z_+^{m_2}$. Of course, when $n_2 = 0$ all inputs can take any non-negative real value and for $n_2 = m_2 = 0$ we get back to the usual DEA models.

When the technology includes strictly integer-valued inputs and outputs the empirically constructed production possibility set shown in (4) above has to be redefined as

$$S = \{(x^I, x^{II}, y^I, y^{II}): x^I \geq \sum_{j=1}^{N} \lambda_j x_j^I \,;\; x^{II} \geq \sum_{j=1}^{N} \lambda_j x_j^{II} \,; y^I \leq \sum_{j=1}^{N} \lambda_j y_j^I \,;\; y^{II} \leq \sum_{j=1}^{N} \lambda_j y_j^{II} \,;$$
$$\sum_{j=1}^{N} \lambda_j = 1;\; x^I \in R_+^{n_1};\; y^I \in R_+^{m_1}; x^{II} \in Z_+^{n_2};\; y^{II} \in Z_+^{m_2} \} \tag{19}$$

4. The Empirical Application

4.1 Data Construction and Modeling Issues

Our study focuses on the labor cost efficiency of branches of a large public sector bank in India with nationwide presence. Data relates to the year April 2007 to March 2008 (financial year 2007-08). This is the latest year of data prior to the global financial crisis and allows us to draw policy conclusions that apply to normal economic conditions.[12] Our sample comprises 536 branches, with 89 branches in Chennai, 164 branches in Delhi, 169 branches in Kolkata, and 114 branches in Mumbai. Branches of Indian banks are engaged in one or more of the following functions: (i) banking business (i.e., accepting deposit and /or offering credit to their customers), (ii) administration, and (iii) foreign exchange business. In this analysis we exclude purely administrative branches. As in other countries, operations of a typical bank branch in India involve collection of deposits, making loans and providing other financial services. However, due to location (dis)advantage, other socio-economic characteristics of customers as well as strategic decisions, the primary function of a large number of bank branches in India is deposit mobilization. Similarly, there are branches whose major focus is offering credit - sometimes only to a particular segment of industry. As a result, it is quite common to observe very high or low credit-deposit ratio of a branch in the same city. As documented in Ray (2016) branch level operations of public sector banks in India are very labor intensive. However, while the process of depositing and withdrawing money

output bundle to a smaller bundle where the reduced input-output quantities are integers. Finally, a set is Natural Convex when convex combinations of its elements belong to the set only if they also are integers.

[11] In manufacturing, for example, production labor measured in hours can take fractional values but the number of managers must be an integer.

[12] Indian banks had very little exposure to it at the beginning. The actual crisis as unfolded worldwide got reflected in Indian policy scenario only after September 2008 when RBI started reducing policy rate drastically over a period of time.

requires many steps of customer interactions with clerical and subordinate workers, the process of loan origination involves interaction with and decision making by officers. To account for the difference in the nature of labor service required and ensure that branches with the same orientation are being benchmarked against one another, we classify our sample of branches into three classes based on their credit-deposit (C/D) ratio: (i) Class 1 – low credit intensive branches (C/D ratio less than 15%), (ii) Class 2 – medium credit intensive branches (C/D ratio between 15% and 40%), and (iii) Class 3 – high credit intensive branches (C/D ratio more than 40%). In terms of the product mix, we can say that Class 1 and Class 3 branches are more specialized, whereas Class 2 branches have a more balanced portfolio of loans and deposits. We follow the earlier literature (Das et al., 2009, Ray, 2016) and assume that branches within a C/D ratio class operate under the same technology.

Following the *production approach* we include four inputs in our analysis: three types of labor - (i) number of officers, (ii) number of clerks, and (iii) number of subordinates, as well as a measure of capital - (iv) overhead expenses. The wage rates for the different kinds of labor were constructed from the individual salaries data for a large number of employees of the bank.[13] For our outputs, we choose (i) number of large loan accounts (with more than ₹200,000 balance), (ii) number of small loan accounts (with less than ₹200,000), (iii) number of deposit accounts, and (iv) non-interest income (as a proxy for other fee based services offered by a branch).[14] Given that the fee structure of this bank is the same across the branches, the monetary value of this service is an acceptable measure. Ideally, the number of loan and deposit transactions should be used as the outputs of a branch since resource use is determined by the number of transactions serviced (Sherman and Gold, 1985). However, such detailed data is not available and the number of accounts was the best possible way to measure the outputs. By separating loans into two categories, we account for the fact that origination and monitoring of larger loans are more important from risk and stability point of view, and requires a branch to devote more resources in terms of screening and credit check of the borrower and may also involve more frequent transactions.

[Table 1 about here]

Table 1 presents the summary data for our sample of 536 branches. We observe that there is a significant variation in the intensity of credit versus deposit function carried out by a branch. The C/D ratio ranged from a low of 0.0062 for a Delhi branch (with aggregate deposit balance of ₹7.4 billion and

[13] To construct the wage rate for the individual labor categories for the 2007-08 year, we first analyzed over 100,000 salary details for the year 2015 to obtain the share of total salary going to the three types of labor. These shares were then utilized to apportion the total salary bill into the three parts for each branch for our sample year. Finally we divided by the number of employees of each type to obtain the wages for each type of labor.

[14] ₹ is the currency symbol for the Indian Rupee (INR). The conversion rate was 1 USD = 39.43 INR as of December 31, 2007. Thus, the value of a small loan is less than approximately $5,000.

aggregate loan balance of about ₹46 million) to a high of 10.83 for a Kolkata branch (with aggregate deposit and loan balance of ₹0.24 billion and ₹2.6 billion). Our sample branches also exhibit a wide range in terms of the size of total business (measured by aggregate deposits plus aggregate advances plus total non-interest income), from ₹42 million for the smallest branch (located in Kolkata) to ₹102 billion for the largest branch (located in Delhi). Accordingly, the branches also differed widely in terms of the number of loan and credit accounts, with the average branch managing 12,965 deposit and 652 loan accounts. With such heterogeneous size and composition of business, the labor requirement also varies across these branches. Hence, for the efficiency analysis to be meaningful we must control for several aspects to ensure that in creating a benchmark input-output bundle for a branch, we use convex combinations of the input-output bundles of only those branches that exhibit similar product mix. We next consider the alternative optimization problems for measuring labor efficiency.

4.2 The Proposed DEA Models

4.2.1 Non-radial Labor Efficiency

A common approach for measuring efficiency is the input- oriented model. First we consider a non-radial DEA model that captures all potential reduction in the different categories of labor. We incorporate natural divisibility of the labor inputs through appropriate constraints in the following problem:

$$
\begin{aligned}
& Min. \overline{\theta} = \tfrac{1}{3}(\theta_1 + \theta_2 + \theta_3), \text{subject to} \\
& \textstyle\sum_j \lambda_j L_{1j} \leq \ L_1;\ L_1 \leq \theta_1 L_1^0 \ \text{(No. of officers)}; \\
& \textstyle\sum_j \lambda_j L_{2j} \leq \ L_2;\ L_2 \leq \theta_2 L_2^0 \ \text{(No. of clerks)}; \\
& \textstyle\sum_j \lambda_j L_{3j} \leq \ L_3;\ L_3 \leq \theta_3 L_3^0 \ \text{(No. of subordinates)}; \\
& \textstyle\sum_j K_j \leq \ K^0 \ \text{(overhead expenses)}; \\
& \textstyle\sum_j \lambda_j y_{1j} = \ y_1;\ y_1 \geq y_1^0 \ \text{(No. of large loan accounts)}; \\
& \textstyle\sum_j \lambda_j y_{2j} = \ y_2;\ y_2 \geq y_2^0 \ \text{(No. of small loan accounts)}; \qquad (20) \\
& \textstyle\sum_j \lambda_j y_{3j} = \ y_3;\ y_3 \geq y_3^0 \ \text{(No. of deposit accounts)}; \\
& \textstyle\sum_j \lambda_j y_{4j} \geq \ y_4^0 \ (\text{non} - \text{interest income}); \\
& \textstyle\sum_j \lambda_j z_{1j} \geq \ z_1^0 \ \text{(large loan account balance)} \\
& \textstyle\sum_j \lambda_j z_{2j} \geq \ z_2^0 \ \text{(small loan account balance)}; \\
& \textstyle\sum_j \lambda_j z_{3j} \geq \ z_3^0 \ \text{(deposits account balance)}; \\
& \textstyle\sum_j \lambda_j = 1;\ \theta_1, \theta_2, \theta_3 \ \leq 1\ ;\ y_1, y_2, y_3, L_1, L_2, L_3 \ \in Z_+;\ \lambda_j \geq 0\ (j = 1,2, \dots \dots, N)
\end{aligned}
$$

Note that, in this problem, the optimal labor quantities (which are potentially fractions of the original quantities) are constrained to be integer valued. Further, the numbers of deposit and credit accounts at the optimal solution of the problem have to be integers.[15]

The optimization problem above identifies the extent of potential downsizing in employment of different kinds of labor input. The overall efficiency $\bar{\theta}$ indicates the average reduction factor across types of employees. However, this unweighted average is of limited practical use because in any branch there are far fewer officers or managers compared to clerical staff. In this model reducing the number of officers from 2 to 1 has the same effect as reducing the number of clerks from 30 to 15. Moreover, different categories of employees earn different wages which needs to be taken into account to ensure that allocative efficiency is also achieved.

4.2.2 Labor Cost Minimization

Given that the main objective of eliminating labor use inefficiency is to reduce the personnel costs, a proper optimization problem is one that minimizes the total wage payment. Accordingly, the DEA model can be reformulated as:

$$
\begin{aligned}
&Min.W = w_1 L_1 + w_2 L_2 + w_3 L_3, \text{ subject to}\\
&\textstyle\sum_j \lambda_j L_{1j} \le L_1 \quad (\text{No. of officers});\\
&\textstyle\sum_j \lambda_j L_{2j} \le L_2 \quad (\text{No. of clerks});\\
&\textstyle\sum_j \lambda_j L_{3j} \le L_3 \quad (\text{No. of subordinates});\\
&\textstyle\sum_j K_j \le K^0 \ (\text{overhead expenses});\\
&\textstyle\sum_j \lambda_j y_{1j} = y_1;\ y_1 \ge y_1^0 \ (\text{No. of large loan accounts});\\
&\textstyle\sum_j \lambda_j y_{2j} = y_2;\ y_2 \ge y_2^0 \ (\text{No. of small loan accounts});\\
&\textstyle\sum_j \lambda_j y_{3j} = y_3;\ y_3 \ge y_3^0 \ (\text{No. of deposit accounts});\\
&\textstyle\sum_j \lambda_j y_{4j} \ge y_4^0 \ (\text{non}-\text{interest income});\\
&\textstyle\sum_j \lambda_j z_{1j} \ge z_1^0 \ (\text{large loan account balance})\\
&\textstyle\sum_j \lambda_j z_{2j} \ge z_2^0 \ (\text{small loan account balance});\\
&\textstyle\sum_j \lambda_j z_{3j} \ge z_3^0 \ (\text{deposits account balance});\\
&\textstyle\sum_j \lambda_j = 1;\ y_1, y_2, y_3, L_1, L_2, L_3 \in Z_+;\ \lambda_j \ge 0\ (j = 1,2,\ldots\ldots,N)
\end{aligned}
\tag{21}
$$

As in model (20), the optimal values of different kinds of labor and the numbers of different types of accounts are required to be integer valued. However, the optimal number of any specific type of labor is not constrained to be less than or equal to the corresponding actual number of employees. Another

[15] As is often the practice, at the branch level we assume variable returns to scale.

aspect of our models is that both the number of accounts as well as the average balance per account are incorporated as constraints, since both have implications for the labor requirement of a branch.

Using this conceptual framework of cost minimization and the DEA model (21) above, we estimate the labor cost efficiency of the sample branches. The feasibility of these targets will be assessed by the branch management in light of any other constraints applicable to a specific branch.

It is worthwhile to argue here that cost minimization is the most appropriate economic objective of an Indian bank branch. While profitability is a meaningful objective at the bank level, it is not the appropriate model for a branch, especially in the Indian banking context. In a standard profitability model of branch banking (as proposed by McEachern and Paradi, 2007), the inputs considered are basically expenses towards interest outgo, remuneration and other operating cost. Outputs are revenues in the form of interest and non-interest earnings.

Using the profitability model would imply that the deposit taking branches are loss making as interest expenses are much higher than interest earning. In the Indian context, branch profitability in practice, however, is not assessed by its interest income from loans or interest expenses towards deposits. Rather, as a corporate strategy, commercial banks operating in various market conditions use an internal fund transfer mechanism based on the opportunity cost of funds. Over a common pool, funds are assigned to specific assets and liabilities to various functional units like deposit taking, lending or investments. Within the bank, a deposit taking unit can sell liabilities, buy funds for lending based on a market determined price. This mechanism also helps mitigate risks arising from asset-liability and maturity mismatch. In this framework, in order to maximize profit, it is of minor consequence if a branch is collecting deposits or extending loans or both. This also makes the standard notions of profitability or intermediation models for a bank branch less convincing.

5. Results

[Table 2 about here]

We next examine the distribution of our sample branches in the four metros. Chennai, Delhi, Kolkata and Mumbai are the largest metropolitan cities in the country and represent considerable divergence in terms of their cultural and economic environment. Mumbai is the capital of the state of Maharashtra in the western part of India. It is also the financial capital of the country and offers a thriving business environment. Not surprisingly, we observe that our average branch in Mumbai has the highest balance of deposits (₹1.5 billion) and loans (nearly ₹1 billion). Delhi, on the other hand is the capital of India and hence the most prominent city in terms of political and administrative power. While the average branch in Delhi has almost the same size of deposit balance as their counterpart in Mumbai (₹1.4 billion) it has a much smaller loan portfolio (₹0.65 billion). Chennai is the capital city of the state of Tamil Nadu in southern India which prides itself for its high skilled workers and superior work ethics and Kolkata is the capital of the eastern state of West Bengal known for its inclination to art and culture. The top panel of Table 2 reports the distribution of branches by C/D ratio. We find that Chennai and Mumbai have a more or less even distribution of branches across the three classes. Delhi has predominantly low credit intensive (i.e., deposit oriented) branches with a relatively small percentage of high credit intensive branches. On the other hand, the majority of Kolkata branches are medium credit intensive, with an equal number of branches in the other two classes. Across the four metros, the average branch in Kolkata has the smallest balance of deposits (₹0.6 billion) and loans (₹0.2 billion).

In addition to the above classification, in order to capture a commonly used dimension, we also categorize our branches based on the size of total business. Based on size, we again create three classes: (i) Class 1 – small branches with size of total business less than ₹600 million, (ii) Class 2 – medium branches with size of total business between ₹600 million and ₹1.2 billion, and (iii) Class 3 – large branches with size of total business greater than ₹1.2 billion. Table 2 (bottom panel) shows that based on this classification, 57% of Kolkata branches are small in size whereas 57% of Mumbai branches are large. Chennai and Delhi have a relatively even distribution of branches with a slightly heavier proportion of small branches and medium branches, respectively.

[Table 3 about here]

Table 3 summarizes the labor cost efficiency of our sample of branches based on model (21). Branches of homogenous functional orientation (i.e., in the same C/D ratio class) are assumed to operate with the same technology. We, therefore, measure the labor cost efficiency of each branch of a particular orientation first with respect to the metro-specific frontier.[16] These results are reported in Table 3. Based on metro-specific frontiers the average efficiency was 84.93% for our entire sample of branches. This implies that overall the branches of this bank could reduce labor cost by about 15% if they operated according to the best practices of branches of similar orientation in their respective metro. Comparison of the actual total cost (over all branches in a metro) with the sum of the minimum cost of each branch provides a measure of the average cost efficiency of branches in the metro. As shown in equations (16) and (17), the average metro-specific efficiency is equal to the cost-share weighted average efficiency of the branches within the metro. This is a more accurate measure than the simple mean of the efficiency of branches within a region as is often reported.[17] The average efficiency of all branches in Chennai was

[16] This is referred to as γ_g in equation (15).

[17] The simple average efficiency of branches for any class in a specific metro differed from the cost share weighted average measures reported in Table 3. For instance, in case of Kolkata Class 1 branches, the simple average efficiency was 92.5%. However, the cost share weighted average efficiency was 94.03%. This is because the five

92.65% and was above 90% for all three classes of branches. Mumbai branches had an average efficiency of 85.69% with low credit intensive branches in this metro having an average efficiency of 88.93% but Class 2 and Class 3 branches having a lower average efficiency of about 84.5%. Delhi and Kolkata branches had the lowest efficiency of 82.23% and 82.99% respectively. The Delhi branches across the three orientations had similar efficiencies – 81.46% for class 1, 80.68% for Class 2 and 86.54% for Class 3. However, in case of Kolkata, there was a wide variation in efficiency across the branches of different orientation – the efficiency was 94.03% for Class 1 branches, 84.50% for Class 3 branches and as low as 79.08% for Class 2 branches. Thus, there is evidence that in Kolkata as well as Mumbai, branches specialized at deposit mobilization are better at following the local best practices than other branches. The average efficiency across all metros ranged from 82.69% for medium credit intensive branches to a little over 86% for low credit intensive and high credit intensive branches providing general evidence that specialized branches perform better in terms of relative efficiency .

How do the branches in a specific metro perform with respect to the grand frontier constructed from branches of the same orientation across all the metros? Using equation (17a), we measure the grand efficiency of each branch and the summary results are reported in Table 3. We find that Chennai branches have the highest efficiency of 81.42% followed distantly by Delhi at 68.57%, Mumbai at 64.17% and Kolkata at 60.12%. Thus on average, Chennai branches could reduce cost by about 19% if they followed the nationwide best practice of branches of their orientation. In contrast branches in Kolkata could reduce their labor cost by a whopping 40% if they followed the national best practices of branches of the same orientation. Similarly, branches in Delhi and Mumbai could also reduce their labor cost by significant margins if they could adopt national best practices of branches of this bank of the same orientation.

The average efficiency of branches measured against the metro specific frontier clearly reveals how efficiently the unit is managed. This information is particularly valuable to the branch managers. On the other hand, the average efficiency of branches in a metro measured against a common grand frontier reflects both the operational efficiency of the branches as well as differences in economic, institutional, and cultural conditions across the metros. As shown in equation (18), the ratio of the grand efficiency and metro specific efficiency offers a measure of the area efficiency of the metro. The area efficiency is an important measure in providing guidance to the regional and corporate level managers of the bank. The last column of Table 3 shows that for low credit intensive branches, Chennai has a high area efficiency while Kolkata and Mumbai have considerably low area efficiency. For medium credit intensive branches both Chennai and Delhi have a high area efficiency (around 90%) whereas Kolkata and Mumbai both lag behind. For high credit intensive branches the area efficiency is below 85% for each of the four metros.

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largest branches in terms of cost share, together accounting for more than 35% of the total cost of that class/metro, were all efficient, thus pulling up the average efficiency.

The low area-efficiency of Kolkata branches is of particular concern. Even for the low credit intensive orientation, in which case Kolkata branches are performing well in following the best practices of their metro (average metro-specific efficiency of 94%), they are far behind in following the national best practices. Low performance of Kolkata branches is also evident if we consider business per employee, a commonly used measure of performance in the banking industry. We find that the average branch in Kolkata generates roughly ₹35.5 million of business per employee which is significantly behind the ₹65 million for the average branch in our overall sample across the four metros.

Since our sample pertains to branches of the same bank, it is important to note that branches across the four metros have access to the same wage structure, employee training programs, as well as information technology systems to support the employees. They are also guided by the same corporate values and goals. However, these very same corporate level guidelines and incentives become more or less effective based on the overall environment of an individual metro. The major aspects of the environment include the (a) regulatory environment (b) cultural environment (c) local economic conditions (d) infrastructure and (e) industrial relations. Das et al. (2009) expounds on the cultural differences and value systems that have prevailed in the four metros. While the banking regulations are uniform across the states in India, heavy presence of state regulations in other aspects often influence the efficiency of branch performance across regions. Infrastructure differences can also play an important role. For example, wide power outages in a metro can lead to branches operating at less than their potential even with the same availability of computers and technology. Further, labor unions and strikes can also undermine the productive capability of branches.

The process of industrial decline in the state of West Bengal in general and in and around Kolkata in particular over the post partition decades has been analyzed in details in various studies.[18] The year 2007-08 in particular belongs to an era when the Marxist government in the state controlled virtually all spheres of the state economy and the militancy of the party sponsored labor unions was at its height. This is evident from the fact that the state of West Bengal accounted for 87% of the total man-days lost through strikes and lockouts in the entire country in 2007. That percentage was somewhat lower than but remained as high as 57.74% in 2008.[19] This poor state of industrial relations in West Bengal permeated all sectors of the economy including services like banking and transportation. Using somewhat earlier data (1960-1995), Lahiri and Yi (2009) also finds that the productivity growth in both manufacturing and services sectors in West Bengal were considerably lower than in Maharashtra. They attribute the poor relative performance of West Bengal to inadequate development of infrastructure in West Bengal as compared to Maharashtra.

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[18] See for example Ray (2011).
[19] Indian Labor Bureau. http://labourbureau.nic.in/ID%202k7%20Chap%202%20Tab%202(II)(a).htm

[Table 4 about here]

Next we examine the distribution of branches on the cost frontier. From Table 4 we see that for low credit intensive branches, the percentage of branches on the metro specific cost frontier ranged from a low of 39% for Delhi to a high of 66.7% for Chennai. For medium credit intensive branches, the high was 65.5% for Chennai and the low was 29.4% for Kolkata. Lastly, for high credit intensive branches, the percentages of efficient branches varied from 48.6% for Mumbai to 63% for Delhi. Both in terms of average efficiencies as well as the percentage of branches on the frontier, the dispersion is less across metros for the high credit intensive branches. Not surprisingly, a much smaller percentage of branches across metros (around 20%) were on the grand frontier constructed for each of the three classes of branches. Chennai emerges as the metro with the largest percentage of branches on the grand frontier. Hence, Chennai branches play an important role in determining the best practice operations for this bank. Again, Kolkata presents an interesting case. As discussed earlier, low credit intensive Kolkata branches performed well with respect to their metro specific frontier. However, of the 22 Kolkata branches on their own metro specific frontier, only 5 remained on the grand frontier. Thus, even in this case, the best practices within Kolkata are far behind that prevalent nation-wide.

In the Indian banking sector, labor costs in the form of salaries and perks constitute 70% of operating costs and about 25% of total costs (Das et al., 2009). Managing labor costs efficiently at the branch level would have a significant impact on the overall operating efficiency of the bank. Our analysis reveals that if all 536 branches were able to eliminate their labor cost inefficiency and performed based on the best practices of branches of their orientation within the metro in which they are located, then the bank in our study would be able to cut its labor costs by ₹807 million from ₹5.353 billion to ₹4.546 billion (a labor cost saving of 15%). The maximum savings potential at its Delhi branches stands at ₹265 million, Kolkata branches at ₹264 million and Mumbai branches at ₹222, while the possible savings from Chennai branches is at ₹55.5 million. If the bank was able to incentivize all its branches to follow the best practices of their national role models, then the bank would be able to cut its labor costs by ₹1.785 billion from ₹5.353 billion to ₹3.568 billion.[20]

[Table 5 about here]

The overall numbers, however, mask the difference in potential labor cost savings across the three types of labor. Table 5 sheds light into this aspect of our analysis based on metro specific frontiers. We find that across the four metros, the branches in our sample could reduce the number of officers by 9.29%, the number of clerks by 17.73% and the number of subordinates by 19.46% and still produce the

[20] The savings potential with respect to each metro of course depends on the measured inefficiency at the branches as well as the size and number of branches.

same level of output (or more) if they followed the best practices of the branches of the same orientation within their respective metros. In case of Chennai, across the three classes of branches, it is possible to reduce the number of officers by 4.77%, the number of clerks by 7.89% and the number of subordinates by 10.23%. At the other extreme, in case of Kolkata, it is possible to reduce the number of officers by 11.16%, the number of clerks by 19.02% and the number of subordinates by 20.94% and still achieve their output goals. These results suggest that most of the potential labor savings can be realized from reducing the number of clerks and subordinates. To assess the impact on cost savings, however, we must take into account the salaries of these three categories of labor. For the entire sample, savings from the reduction in the numbers of officers, clerks, and subordinate staff would respectively amount to 3.36%, 8.13%, and 3.5% of the actual total labor cost. These results are hardly surprising in light of the extremely cumbersome process currently in practice at a majority of branches for even simple interactions such as deposit withdrawal which requires too many clerks and subordinates (Ray 2016).

[Table 6, 7, and 8 about here]

Our analysis thus far is based on the fundamental hypothesis that banks of different functional orientations (as captured by the C/D ratio) operate under different technologies. We next follow up our analysis to check the robustness of our findings for the branch level efficiencies of this bank. In the banking literature, it is widely accepted that at the institutional level, banks of different sizes operate with respect to different technologies.[21] In measuring efficiency of individual banks it is, therefore, accepted practice to benchmark against peer groups of banks of similar size. Following a similar logic, we categorized our branches in each metro into three classes based on the size of total business. The distribution of this bank's branches based on size classes were presented in Table 2. We carried out our efficiency analysis of branches based on the alternative assumption that branches of a similar size class operate under the same technology. As seen from the results in Tables 6 through 8, the conclusions from this approach are in line with our main findings reported in Tables 3 through 5. Thus there is broad consistency between the results from the two approaches and lends confidence in our results. However, it is important to note that since our focus is on labor cost efficiency, and the size and composition of the labor force depends on the functional orientation (product mix) of the branches, it is more meaningful to characterize the technology in terms of C/D ratios rather than simply branch size.

A general observation across our models and different construction of frontiers is that bank branches in India exhibit significant inefficiencies in labor use. This result is in agreement with the findings of Das et al. (2009) and Ray (2016) on Indian bank branch efficiency. It is interesting to compare

[21] In one of the earlier studies, McAllister and McManus (1993) emphasized that small and large banks produce different output mix.

these results for Indian bank branches with that of branches of other countries surveyed by Paradi and Zhu (2013). They report that most branch level studies reveal high efficiency level of branches. One reason for the measured high efficiency levels in many of the other studies (especially in the context of other developing countries) could be the very small data sets used, which reduces the discretionary power of the analysis. Another reason could be that the branch management in western countries enjoy much greater flexibility in scheduling the number and hours of mostly part time employees. In contrast, bank employees in India are full time and permanent. Hence, adjusting the work force to business conditions is far more difficult.

The predominance of inefficiencies in Indian bank branches has been a concern to bank regulators as well.[22] A line of research that focuses on 'rational inefficiencies' could help to throw light on this problem and point to solutions. For instance, Bogetoft and Hougaard (2003) explains that measured inefficiency could actually be part of the non-monetary (fringe) compensations paid to employees and it may sometimes be the cheapest way to provide such compensation. Das et al. (2009) and Ray (2016) provide elaborate evidence of cultural practices in Indian bank branches. Within a culture of slacking, the 'flexibility' in expected duties and responsibility that comes with overstaffing could potentially be regarded by employees as a desirable aspect of the job. Another stream in the managerial economics literature (Williamson, 1964) posits that managers prefer larger staff. Based on both of these lines of argument, if the widespread labor-use inefficiency in Indian bank branches is to be mitigated, incentive-compatible monetary compensation mechanisms should be designed.

As competitive pressures in the Indian banking sector intensify, corporate level management must focus on adopting best practices from external sources (other banks and outside experts) as well as best practice transfer within units (branches) of its own organization. Our study reveals that for this public sector bank, efficient branches within the same metro should be identified to share local best practices and efficient branches in Chennai could serve as 'sources' of best practice transfer of national best practices. Kolkata branches would indeed benefit as 'recipients' of such knowledge transfer. Of course this process should take into account local idiosyncrasies. As recognized in the management literature, the ability to successfully transfer best practices internally may be difficult due to motivational factors or due to other sources of stickiness such as the recipients' lack of absorptive capacity, causal ambiguity in identifying why the 'source' is efficient, or arduous relationship between the 'source' and the 'recipient' (Szulanski, 1996) . An important contribution of this study is to identify the branches that are performing poorly compared to their peers in the same metro area as prime candidates for review. The interregional

[22] This issue has been raised in many addresses by past governors of the Reserve Bank of India.

differences, while beyond the control of the local managers, may be relevant for corporate planners as they chart out the growth strategy and domestic location decisions in an increasingly globalized economy.

6. Conclusion

In this study, we address the issue of operational efficiency of Indian bank branches and examine the efficiency of 536 branches of a major Indian public sector bank across four major metropolitan cities, Chennai, Delhi, Kolkata, and Mumbai.

Examining the branches of a single bank makes it possible to control for factors arising from differential bank level policies across banks that could affect the relative efficiency of branches and enables us to focus on regional differences. We utilize DEA to analyze labor cost efficiency of branches using data for the year 2007-08. We model the branch operations following the production approach and introduce several methodological innovations to account for the product mix of branches in creating the efficient cost frontier. Our results indicate that there is significant labor cost inefficiency in the operations of the branches. Overall Chennai branches are much closer to their metro specific best-practice frontier compared to branches of other metros from their respective metro-specific frontier. The low area-efficiency of Kolkata branches is of particular concern; even branches that perform at the frontier of their metro specific technology are generally far behind in terms of the national best practices. Additional measures need to be taken by the bank at the corporate and regional levels in offsetting the negative effects of poor area efficiency in Kolkata and Mumbai branches. Across the three types of labor, attaining efficiency in the number of clerks would have the highest impact in terms of cost savings of this bank. This would require streamlining the operational processes within the typical branch. Further, the bank would benefit from adopting mechanisms for best practice transfer across its branches and creating incentives for achieving improvements in efficiency.

A word of caution is in order here. In spite of strong resistance from the powerful labor unions, computerization in the Indian banking industry had already been launched in the early 2000s, although there was considerable variation in the availability of digital banking like ATMs across regions and also across branches within regions. It is quite possible that the benchmark for some of the inefficient units was formed by using branches with access to ATMs as the reference group. To the extent this is the case, the measured level of inefficiency may be overestimated. Unfortunately, we do not have specific branch level information on the availability of ATMs to pursue this aspect of analysis.

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Table 1: Summary Statistics for the Data

Variable	Mean	Median	SD	Min	Max
N=536					
No. of Officers	5.32	4	4.17	1	47
No. of Clerks	13.2	10	9.72	1	77
No. of Subordinates	6.69	5	4.64	1	37
Overhead Expenses (₹'000)	4,528.73	3,588.5	3,680.25	422	46,988
No. of Large Loan Accounts	231.63	170	203.5	14	1,419
No. of Small Loan Accounts	420.23	283	559.53	4	9,708
No. of Deposit Accounts	12,964.98	11,261	8,921.89	30	65,896
Non-interest Income (₹'000)	10,281.52	2,941.5	31,649.62	99	52,8074
Total Business (₹'000)	1,632,755.62	796,468	4,828,133.2	42,298	101,890,974
C/D Ratio	0.58	0.23	1.32	0.0062	10.83

Table 2: Distribution of Branches based on C/D Ratio and Size of Total Business

Distribution of Branches Based on C/D Ratio					
	Chennai	**Delhi**	**Kolkata**	**Mumbai**	**Total**
< 15% (Low)	21 (23.6%)	82 (50.0%)	35 (20.7%)	32 (28.1%)	**170**
15% to 40% (Medium)	29 (32.6%)	55 (33.54%)	102 (60.4%)	47 (41.2%)	**233**
> 40% (High)	39 (43.8%)	27 (16.46%)	32 (18.9%)	35 (30.7%)	**133**
Total Branches	**89**	**164**	**169**	**114**	**536**
Distribution of Branches Based on Size of Total Business					
	Chennai	**Delhi**	**Kolkata**	**Mumbai**	**Total**
< ₹600 million (Small)	37 (41.6%)	43 (26.2%)	97 (57.4%)	12 (10.5%)	**189**
₹600 million to < ₹1.2 billion (Medium)	28 (31.5%)	67 (40.9%)	48 (28.4%)	37 (32.5%)	**180**
₹1.2 billion and above (Large)	24 (26.9%)	54 (32.9%)	24 (14.2%)	65 (57.0%)	**167**
Total Branches	**89**	**164**	**169**	**114**	**536**

Table 3: Labor Cost Efficiency of Branches across Metros (by C/D Ratio Classes)

	No. Branches	C^0	C*	C**	Metro-Specific Efficiency	Grand Efficiency	Area Efficiency
Class 1-Low							
Chennai	21	133953.9	121640.2	116418.7	0.9080	0.8691	0.9571
Delhi	82	771841.8	628775.7	521140.2	0.8146	0.6752	0.8288
Kolkata	35	303797.7	285662.3	191572.4	0.9403	0.6306	0.6706
Mumbai	32	406336.3	361383.4	228729.2	0.8894	0.5629	0.6329
All	**170**	**1615930**	**1397462**	**1057861**	**0.8648**	**0.7570**	**0.8753**
Class 2-Medium							
Chennai	29	283250.4	267204.4	239661.2	0.9434	0.8461	0.8969
Delhi	55	427223.9	344683.5	310512.4	0.8068	0.7268	0.9009
Kolkata	102	967275.1	764936.1	575953.1	0.7908	0.5954	0.7529
Mumbai	47	582857.6	492626.4	386070.9	0.8452	0.6624	0.7837
All	**233**	**2260607**	**1869450**	**1512198**	**0.8269**	**0.6689**	**0.8089**
Class 3-High							
Chennai	39	337883.5	310759.6	258732.4	0.9197	0.7657	0.8326
Delhi	27	293816.6	254269	191971.4	0.8654	0.6534	0.7550
Kolkata	32	282057.6	238351.2	166198.9	0.8450	0.5892	0.6973
Mumbai	35	562961.6	475976.7	381204.9	0.8455	0.6771	0.8009
All	**133**	**1476719**	**1279357**	**998107.6**	**0.8664**	**0.6759**	**0.7802**
All Classes							
Chennai	89	755087.8	699604.2	614812.3	0.9265	0.8142	0.8788
Delhi	164	1492882	1227728	1023624	0.8224	0.6857	0.8338
Kolkata	169	1553130	1288950	933724.4	0.8299	0.6012	0.7244
Mumbai	114	1552156	1329987	996005	0.8569	0.6417	0.7489
All	**536**	**5353256**	**4546269**	**3568166**	**0.8493**	**0.6665**	**0.7849**

Notes: Class 1 = Low credit intensive; Class 2 = Medium credit intensive; Class 3 = High credit intensive.
C^0 = Actual cost; C* = Minimum cost based on the metro specific frontier; C** = Minimum cost based on the grand frontier.

Table 4: Frequency Distribution of Efficient Branches across Metros (by C/D Ratio Classes)

	Total No. Branches	Metro Specific Frontier No. of Efficient Branches (%)	Grand Frontier No. of Efficient Branches (%)
Class 1 - Low			
Chennai	21	14 (66.7%)	11 (52.38%)
Delhi	82	32 (39.0%)	16 (19.51%)
Kolkata	35	22 (62.9%)	5 (14.29%)
Mumbai	32	15 (46.9%)	2 (6.25%)
All	**170**	**83 (48.8%)**	**34 (20%)**
Class 2- Medium			
Chennai	29	19 (65.5%)	7 (24.14%)
Delhi	55	19 (34.5%)	12 (21.82%)
Kolkata	102	30 (29.4%)	14 (13.73%)
Mumbai	47	16 (34.0%)	8 (17.02%)
All	**233**	**84 (36.1%)**	**41 (17.6%)**
Class 3- High			
Chennai	39	23 (59.0%)	12 (30.77%)
Delhi	27	17 (63.0%)	3 (11.11%)
Kolkata	32	18 (56.3%)	6 (18.75%)
Mumbai	35	17 (48.6%)	9 (25.71%)
All	**133**	**75 (56.4%)**	**30 (22.56%)**

Note: Class 1 = Low credit intensive; Class 2 = Medium credit intensive; Class 3 = High credit intensive.

Table 5: Optimal and Actual Labor Use of Branches across Metros (by C/D Ratio Classes)

	No. Branches	**$L_1^*(L_1^0)$**	**$L_2^*(L_2^0)$**	**$L_3^*(L_3^0)$**
Class 1 - Low				
Chennai	21	66(71)	158(169)	82(101)
Delhi	82	423(456)	693(940)	377(507)
Kolkata	35	132(135)	428(449)	181(210)
Mumbai	32	188(209)	495(544)	231(282)
All	**170**			
Class 2 - Medium				
Chennai	29	134(140)	371(397)	177(188)
Delhi	55	221(249)	383(529)	230(278)
Kolkata	102	379(447)	1049(1374)	541(697)
Mumbai	47	230(258)	706(837)	341(437)
All	**233**			
Class 3 - High				
Chennai	39	179(187)	382(423)	215(239)
Delhi	27	205(228)	240(290)	120(143)
Kolkata	32	150(162)	290(359)	135(177)
Mumbai	35	280(310)	625(763)	258(327)
All	**133**			

Notes: Class 1 = Low credit intensive; Class 2 = Medium credit intensive; Class 3 = High credit intensive.
L_1^* = Optimal number of officers for the metro based on metro specific frontier; L_2^* = Optimal number of clerks for the metro based on metro specific frontier; L_3^* = Optimal number of subordinates for the metro based on metro specific frontier.
L_1^0 = Actual number of officers in the metro; L_2^0 = Actual number of clerks in the metro; L_3^0 = Actual number of subordinates in the metro.

Table 6: Labor Cost Efficiency of Branches across Metros (by Size of Total Business Classes)

	No. Branches	C^0	C*	C**	Metro-Specific Efficiency	Grand Efficiency	Area Efficiency
Class 1-Small							
Chennai	37	179230	152789	146392.1	0.8525	0.8168	0.9581
Delhi	43	222423.2	190381.8	146121.1	0.8559	0.6570	0.7675
Kolkata	97	567096	470075	351346.6	0.8289	0.6196	0.7474
Mumbai	12	81643	77036	49464.1	0.9436	0.6059	0.6421
All	**189**	**1050392**	**890282**	**693324**	**0.8476**	**0.6601**	**0.7788**
Class 2 - Medium							
Chennai	28	214766.7	199037.8	163213.5	0.9268	0.7600	0.8200
Delhi	67	494697.4	360130.5	330802.3	0.7280	0.6687	0.9186
Kolkata	48	522187.2	426466	304855.5	0.8167	0.5838	0.7148
Mumbai	37	350246.9	295348.5	210903.2	0.8433	0.6022	0.7141
All	**180**	**1581898**	**1280983**	**1009775**	**0.8098**	**0.6383**	**0.7883**
Class 3 - Large							
Chennai	24	361091.3	330908.7	271225.2	0.9164	0.7511	0.8196
Delhi	54	775761.7	654112.7	534599	0.8432	0.6891	0.8173
Kolkata	24	463847.1	418163.3	276058.3	0.9015	0.5951	0.6602
Mumbai	65	1120266	887810.1	737883.9	0.7925	0.6587	0.8311
All	**167**	**2720966**	**2290995**	**1819766**	**0.8420**	**0.6688**	**0.7943**
All Classes							
Chennai	89	755088	682736	580831	0.9042	0.7692	0.8507
Delhi	164	1492882	1204625	1011522	0.8069	0.6776	0.8397
Kolkata	169	1553130	1314704	932260	0.8465	0.6002	0.7091
Mumbai	114	1552156	1260194	998251	0.8119	0.6431	0.7921
All	**536**	**5353256**	**4462259**	**3522865**	**0.8336**	**0.6581**	**0.7895**

Notes: C^0 = Actual cost; C* = Minimum cost based on the metro specific frontier; C** = Minimum cost based on the grand frontier.

Class 1 = Total business less than ₹600 million; Class 2 = Total business between ₹600 million and ₹1.2 billion; Class 3 = Total business greater than ₹1.2 billion.

Table 7: Frequency Distribution of Efficient Branches across Metros (by Size of Total Business Classes)

	Total No. Branches	Metro Specific Frontier No. of Efficient Branches	Grand Frontier No. of Efficient Branches
Class 1 - Small			
Chennai	37	16 (43.2%)	15 (40.54%)
Delhi	43	24 (55.8%)	7 (16.28%)
Kolkata	97	33 (34.0%)	13 (13.40%)
Mumbai	12	10 (83.3%)	4 (33.33%)
All	**189**	**83 (43.9%)**	**39 (20.63%)**
Class 2 - Medium			
Chennai	28	18 (64.3%)	5 (17.86%)
Delhi	67	20 (29.9%)	15 (22.39%)
Kolkata	48	19 (39.6%)	6 (12.5%)
Mumbai	37	17 (45.9%)	6 (16.22%)
All	**180**	**74 (41.1%)**	**32 (17.78%)**
Class 3 - Large			
Chennai	24	15 (62.5%)	8 (33.33%)
Delhi	54	23 (42.6%)	7 (12.96%)
Kolkata	24	17 (70.8%)	8 (33.33%)
Mumbai	65	14 (21.5%)	9 (13.85%)
All	**167**	**69 (41.3%)**	**32 (19.16%)**

Note: Class 1 = Total business less than ₹600 million; Class 2 = Total business between ₹600 million and ₹1.2 billion; Class 3 = Total business greater than ₹1.2 billion.

Table 8: Optimal and Actual Labor Use of Branches across Regions (by Size of Total Business Classes)

	No. Branches	$L_1*(L_1^0)$	$L_2*(L_2^0)$	$L_3*(L_3^0)$
Class 1 - Small				
Chennai	37	86(92)	193(229)	104(139)
Delhi	43	126(130)	200(259)	132(165)
Kolkata	97	240(257)	650(809)	307(417)
Mumbai	12	44(43)	89(97)	60(70)
All	**189**			
Class 2 - Medium				
Chennai	28	100(107)	271(299)	139(143)
Delhi	67	239(290)	383(603)	242(330)
Kolkata	48	192(240)	609(743)	316(378)
Mumbai	37	139(167)	423(480)	202(262)
All	**180**			
Class 3 - Large				
Chennai	24	181(199)	434(461)	214(246)
Delhi	54	453(513)	728(897)	350(433)
Kolkata	24	241(247)	541(630)	249(289)
Mumbai	65	485(567)	1230(1567)	491(714)
All	**167**			

Notes: L_1^* = Optimal number of officers for the metro based on metro specific frontier; L_2^* = Optimal number of clerks for the metro based on metro specific frontier; L_3^* = Optimal number of subordinates for the metro based on metro specific frontier.
L_1^0 = Actual number of officers in the metro; L_2^0 = Actual number of clerks in the metro; L_3^0 = Actual number of subordinates in the metro.
Class 1 = Total business less than ₹600 million; Class 2 = Total business between ₹600 million and ₹1.2 billion; Class 3 = Total business greater than ₹1.2 billion.

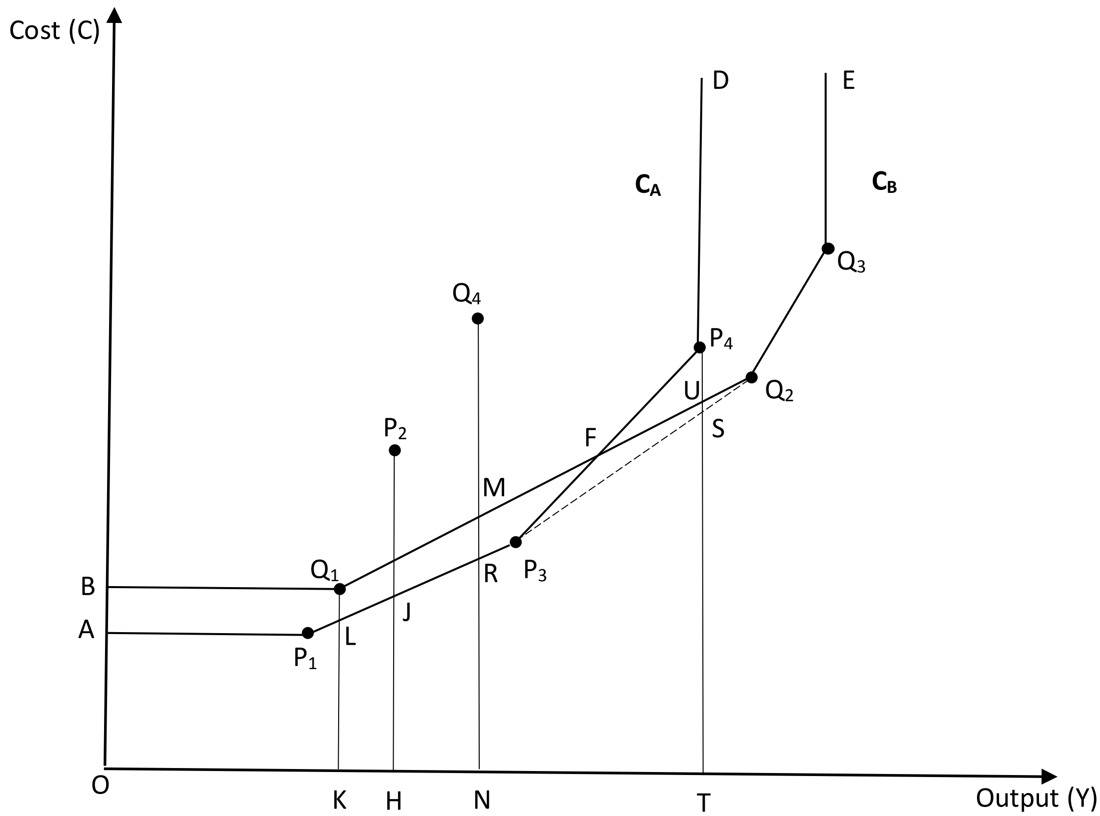

Figure 1: Metro-Specific and Grand Cost Frontiers