Improving service performance in banking using Quality adjusted Data envelopment analysis[1]

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Abstract

The goal of this research is to describe application of data envelopment analysis (DEA) to the performance evaluations of bank branches. Special focus is on how to incorporate quality dimension into the branch efficiency. DEA will apply to a set of micro-data of a Czech commercial bank branch network.

In the banking sector providing services quality is one of the key focuses. Therefore quality dimension should be incorporated into DEA model. Goal of the quality adjusted DEA model is to identify best practice branches that work efficiently and the same time provide services with high quality. This model avoids productivity-quality tradeoff, which is present by standard DEA model. The quality of services is measured by customer service, mystery shopping and calls, client information index, retention and client product penetration. Main determinants of efficiency and quality level are branch size and region via purchasing power.

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1. Introduction

The service economy has large proportion of the developing countries' economic activity and its growing development has raised the importance of maximizing organizations' productivity. Organizations are searching for benchmarking technique to identify best practices in supporting their decisions in order to receive effective utilization of resources.

Organizations frequently use simple aggregate ratio analysis as a measure of their productivity. According to Camanho and Dyson (1999), Beamon (1999) and Reynolds (2004) ratio analysis are not sufficient[3] to measure productivity for organizations using multiple resources and provide multiple outcomes. To evaluate such organization's performance it needs more sophisticated, non-parametric benchmarking methods. Further advantage of the non-parametric method is the fact that it does not required specification of the production function form, which is required by parametric methods. Therefore managers are interested in supporting their decisions by the use of academic methodologies, Brazdik and Druska (2005).

The difficulties are further enhanced when the relationship between the inputs and outputs are complex and involve unknown tradeoffs as it is argued by Zhu (2009). Particularly difficult problem is for service industries to improve its productivity and find substantial cost saving without scarifying quality of service. There are many subjective factors that affect productivity and service quality. A good example, where quality of services is an important issue, is the banking sector. In banks such subjective factors influencing productivity includes customers' needs, behavior in receiving the service, service provider's judgment and skills in providing service.

This research contributes to propose a methodology to describe an application of non-parametric benchmarking method, data envelopment analysis (DEA) for performance evaluations of bank branches. The advantage of DEA is ability to measure the relative efficiency of branches by simultaneously analyzing their multiple resources with multiple outcomes. Based on the literature, there is proposes and apply three different methods how to incorporate quality dimension into the branch efficiency. Empirical results are discussed on a set of micro-data of a Czech commercial bank branch network (the bank).

In the banking sector providing services quality is one of the key focuses. Therefore quality dimension should be incorporated into DEA model. Goal of the quality adjusted DEA model is to identify best practice branches that work efficiently and the same time provide services with high quality. This model avoids productivity-quality tradeoff, which is present by standard DEA model. The quality of services is measured by customer service, mystery shopping and calls, client information index, retention and client product penetration.

At the end of last century in the Czech Republic banks were focusing solely only on growth of new business volume and on new customer acquisition. Recently due to also financial crises, however they are encouraged to optimize their resources as well. They identified that with cost optimization is possible to receive further improvements. Moreover it becomes more important to maintain customer retention, to have valuable customers via selling more products to existing customers. Success is only possible by high quality service.

[3] The drawback of ratio analysis is its univariate nature.

The paper is organized as follows. The following section contains brief literature review on DEA research with special attention of studies with quality measurement. Section three discusses the details of bank branch network providing services for clients. Focusing on the input and output specification according to the motivation system and long term strategy. Section four gives the overview of the theoretical DEA framework. It also specifies three different methods how is possible to incorporate the quality dimension. The fifth part summaries the results obtained by non-parametric methods and the last section makes conclusion with policy implications.

2. Literature review

The original CCR model (Charnes, Cooper and Rhodes, 1978) is the first DEA model that evaluates technical efficiency in a multiple input and multiple output framework. After that the DEA technique has become a widely used approach for efficiency analysis in many public and private sectors like universities, non-profit organizations, hospitals and banks. The paper Emrouznejad et al. (2008) presents the most extensive listing of DEA research covering its 30 years of history, theoretical developments and empirical applications.

During the 1990s DEA method has been frequently used to evaluate performance of financial and banking organizations. Efficiency review of financial institutions is described in Berger and Humphrey (1997). Several studies have been analyzed solely efficiency of bank branches. Their comprehensive branch performance review is published by Camanho and Dyson (1999).

Oral and Yolalan (1990) and Oral et al. (1992) investigate in their empirical studies the relationship between branch efficiency and its profits. Further Giokas (1991) in his paper first time evaluates branch efficiency with respect of the size. It was followed by studies Drake and Howcroft (1994), Tulkens (1995), Schaffnit et al. (1997) and Athanassopoulos (1998). Drake and Howcroft (1994) reported that more efficient branches had lower cost-income ratios. They utilize data from a UK bank branch network. Schaffnit et al. (1997) use data from a large Canadian bank to show that branch efficiency has a positive effect on profit. Camanho and Dyson (1999) describe an application of DEA to the performance assessment of Portuguese bank branches and show how DEA can complement the profitability measure.

Later Sevcovic et al. (2001) focus on the problem of a suitable choice of efficiency measures and they show how these measures can influence results. Dataset was provided by one of the leading banks in Slovakia. Most recently Irsova (2009) compares two methods in bank efficiency, stochastic frontier approach and DEA, which are supported by the meta-regression part including several studies on the USA and transitional countries.

Callen (1991) early identifies that most DEA studies do not consider the quality of the services or products. Excluding quality can results in applying methods that increase efficiency by reduction quality. Quality in many areas is critical, but is not included in DEA models. These researches assume that the quality is homogenous among investigated units or quality is independent of efficiency. Only few DEA studies explicitly address quality.

First Sherman and Ladino (1995) used DEA to substantially improve its branch productivity and profits while maintaining service quality. Athanassopoulos (1997) in his DEA study of a Greek bank branch network considers the relationship of the DEA productivity scores with quality. Bank branch operations are demonstrated by the effort made by management to pursue the banks' corporate objectives which consists the tangible part described by the operating efficiency and the intangible part characterized by the quality of the provided services. The effort effectiveness is estimated by embodying three quality dimensions approachability, location and telephone service. These independent quality measures are developed based on customer surveys and the statistical relationship between quality and the outputs in the DEA model. The study however, does not combine operating efficiency and the quality into the effort effectiveness, the DEA scores are calculated without quality adjustment. It requests for research to find ways how to properly combine quality and efficiency Sherman and Zhu (2006).

Further Soteriou and Zenios (1999) gain superior insight by analyzing simultaneously the design of operations together with the quality of the provided services and profitability, rather than by benchmarking these three dimensions separately. Other measures of service quality in banking are discussed in Athanassopoulos and Giokas (2000).

Only few DEA studies explicitly address quality and those that consider it have not fully adjusted for quality. This paper suggests how to enhance and fully adjust the standard DEA method by quality dimension. It also evaluates how the results change due to different quality measurement.

3. Banking sector providing services for clients

Each DEA model is constructed for special reason, to solve concrete requirement. Therefore formulation of DEA problem requires an understanding of the production process, assumes deep industry knowledge, organization strategies with key motivation elements as well as identification of the appropriate input (resources) and output (outcomes) factors.

Strategy

The bank's long term goal is on grow of business profit through selling deposit and loan products. However it is hard to manage the new volumes. Branches have only limited control over their new volumes that are determined by external factors, mainly by sales potential of the region. In order to receive a long term profit grow in such competitive industry, it is possible only by focusing also on other essential components. Therefore banks' recent strategy has focused also on rationalization of existing branches, cost optimization and redeployment of surplus staff to new ones (step I). In addition special focus is on the quality how the service is provided to the clients in order to meet their needs (step II).

The key activity of the bank is based on the operation of branch network, which represent the main contact point between customers and management of the bank. Officers in branches sell various types of deposit and loan products to generate profits. Therefore branches and their employees are service providers. They have to understand customers' needs, sell appropriate products and provide services in high quality in order to receive their loyalty and make customer more valuable. Branches in order to operate efficiently, they need to solve not only simply cost minimizing strategy, but also attract customers by offering high quality of services.

Branch network

Organization within the branch network and production process is the following. There are large, medium and small branches based on their number of employees[4]. In branches there are four types of client officers. Universal client officers are responsible for teller activities (standard transactions such as deposits, withdrawals, bank checks). Officers deal with general and simply customer queries (opening bank account, travel insurance, payment and credit card administration). Advisers deal with more complex activities according to its specialization[5]. Personal and firm bankers advise for most valuable clients, care about their product portfolio. Finally branch directors manage client officers and take care about the most important issues.

Performance evaluation

The bank uses two different methods to analyze the performances of its branches. The first is based on the volume of new business[6] within a year. Specialists measure savings and loan volumes separately on retail and firm portfolios. Savings contain all major deposit and investment products: current and saving accounts, term deposits, investment funds, pension funds, housing savings, single and regular life insurance. Loans include all products with loan characteristics: consumer loans, credit cards, overdraft, housing loans, mortgages, investment loans, revolving, factoring and leasing. Measured values are compared with the plan determined by top management and then the weighted averages of ranks in each category describe the final branch rank performance.

Second method emphasizes more the branch activities. Activities are defined as number of sold products (investment, housing loans and mortgages, non-specified loans, SME loans) within a year and net increase in number of active clients per number of branch employees. It has two dimensions – actual stage and growth. Branches receive rankings in each category. Some branches are new with high growth in these factors but have poor actual stage. Most of the branches already have very good actual stage but have slow growth in several indicators. The best branches have very good actual stage and very high growth in most of variables and they are a best practice branches for others. On the other hand opposite branches need a special focus, because they have poor actual situation with poor growth. It is necessary to find out what is the reason, external factors or a poor management.

Advantage of the second method is that better reflects officers' effort. While in a city with high purchasing power on one investment deal a branch can receive a new volume of several million CZK but effort from the officers side is the same as in the small village for the investment in a volume of several thousand CZK. The more active officers have a branch, then the better ranking receive by this method.

Results of both methods are entering to the motivation system for client officers, their bonuses are depending on them. The motivation system should reflect company's long term strategy and should fairly reward the employees' effort in this direction. The management of the bank identified that long term strategies should have not based only on financial indicators (first method), but also how it is received, how much effort is needed (second method).

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[4] Small branches have up to 10 employees, medium branches have up to 20 employees and large branches have more than 20 full time employees.

[5] For example, retail investment advisers offer services in investments to the funds, firm loan advisers help firms to find out the most appropriate loan to their business.

[6] New business volume is measured as a difference between a stage at the end of the year *t* and at the end of the year *t-1*

Standard DEA application

Any of above mentioned methods does not take into the consideration employee structure of branches and external factors such as region's purchasing power. They are not able to find out what it is the source of inefficiency and how to deal with them in order to receive efficient environment. Furthermore even the second method does not take into the account the quality of service. Just considering on activity is only a short term issue. To maintain long term excellent results it is necessary to know more about the clients and their needs, increase product penetration, have higher client retention. This is possible to reach only by high quality service. Models excluding quality dimensions assume that quality is homogenous through the branches.

Appropriately defined DEA model is able to solve some of the above mentioned weaknesses of the current performance measurements. Goal of the proposed standard DEA model is to find out the optimal resource allocations and minimize the branch costs. It contains the following input and output factors[7].

The best indicator for branch resources is the branch size. To estimate the branch size, number of branch employees is used, because personal costs take a major part of overall branch costs. In total there are three input (resource) variables: UCO FTE – universal client officers and a branch director, Retail FTE – advisors and personal bankers for retail clients, SME FTE – advisors and firm bankers for non-retail clients. FTE means number of full time employee, i.e. number of employees is adjusted by maternity leave, holidays, part-time workers, illness and training. It explains how much full-time-employees were present in a certain period in the branch.

There are four output measures: retail loans (consumer loans, credit cards, overdraft, housing loans, mortgages), retail savings (current and saving accounts, term deposits, investment funds, pension funds, housing savings, single and regular life insurance), SME loans (overdraft, investment loans, revolving, factoring and leasing) and SME deposits (current and saving accounts, term deposits, investment funds).

There are three different specifications. First, output factors are measured as new volumes within a year. This method favorites branches in large cities, where clients are more likely to invest higher amount, buy mortgages with higher value or where there are located bigger firms who are searching for large investment loans. Second, output factors are measure as above but the volumes are divided by branch's town purchasing power index[8] in order to eliminate the effect of that external factor, to avoid discrimination of otherwise equally good officers employed in the region with low purchasing power. Results expected to be more homogenous.

Third, output factors are measured as number of new sold products, which reflect rather the client officers' activities. The motivation behind this specification is that to measure what client officers are able to influence. They are able to influence with their service that a certain client will buy mortgage in the bank and not at the competitors, but they are not able to influence the volume of the mortgages. We believe that client officers with their services are able to influence mostly the number of sold products. Therefore output in the model is

[7] Full definition of factors are in *Appendix, Table A1*

[8] It is a complex index taking into the consideration several external factors such as unemployment, cost of living etc and therefore it is the most appropriate indicator

measured by number of sold products, which should be a result of high quality service, number of meetings with clients and other officers' valuable efforts.

Quality adjusted DEA application

The standard DEA model however is not quality adjusted and assumes that quality is homogenous among branches. However this is not our case. Therefore the basic DEA model is enhanced by the quality dimension. There are four quality measurements: service quality index, client information index, product penetration index and client retention. The paper demonstrates short term interaction among service quality and operating branch efficiency[9].

Banking market is very competitive and banks cannot longer grow rapidly just through new acquisition. It becomes more important to have valuable customers via selling more products to existing customers and maintain customer retention. Both of them are only possible by high quality service. Therefore bank's actual strategy is focus more on the quality[10]. Service quality is considered very important because of high competition on the market and the value of retaining customers.

If you know more about your customers you can better manage customer relationship and you know better what customers need and what their interests are. Consequently you can sell them more appropriate products. Customers will be more satisfied, will be more loyal and will return. Their churn will be lower and the bank utilizes long term business growth. Therefore it is important to measure and be under the control these indicators. There are several measurements how bank currently controls and tries to increase the service quality[11].

First, the bank creates a Service quality index, which has three parts: customer service, mystery shopping and mystery call. Each of them is focusing on quality of officers' willingness and proficiency. Customer service is a certain type of a meeting between a client officer and an existing customer in order to maintain a customer relationship, to identify customer needs and finally increase probability to sell a new product. Client officer should proactively address clients and thoroughly prepare in advance for the meeting based on available information about clients, their past needs and interests. Correctly done customer service meetings encourage branch sales results. Therefore client officers are motivated to arrange meetings with clients and they have to fulfill certain number of customer service meetings with their customers. Fulfillment of the branch plan is given by a score for customer service.

Mystery shopping is evaluated by a mystery shopper posing as customer from an external consulting firm. Mystery shopper visits a branch in order to receive information about certain type of products, for advice in investment or to receive mortgages and other loan products. During the visit he evaluates several aspect of the service, mainly quality and correctness of provided information as well as way of communication with a customer. In advance mystery shopper is educated how the high service quality is looks like, what is the correct answer and

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[9] In reality, however, service quality has substantial effect on branch efficiency rather on the long term. Due to lack of data for long term, we estimate only the short term interaction.

[10] Recent situation on the financial markets further confirm that quality of services is an important element. Customers require more explanation about the investment products, put their savings where they feel in more safety or searching for more appropriate mortgages that fit to their needs and are flexible enough. If they do not see a high quality service or confidence they quickly change the bank for another one or just leave their savings at home. Customers start to value the quality of services.

[11] Full definition of quality indicators are in *Appendix, Table A2*

what he can do and cannot do. After the visit he fills a certain document, where is indicated which tasks are fulfilled and which are not. Based on this figures a branch receive another quality score. Each time the visit of mystery shopper focuses on the different topic, product needs or client officer's seniority level. Mystery call is very similar to mystery shopping, but in this case mystery customer calls to the branch. Client officers have to give a correct answer on the counterparty question and offer a personal meeting in the branch. Based on the behavior of officer and the correctness of the answers branch receive the third quality score. Finally these three quality scores are put together and create a complete service quality index, which is evaluated on the monthly bases.

Second, it is client information index. Client officers should put into the internal systems information about clients, like phone numbers, emails, ID cards, education, job, incomes and expenses. Client information index expresses how much information is recorded in the internal system about the branch customers. Of course, there is a causality problem between owned products by customer and available customer information at the banks. Selling certain products like mortgages is conditioned to deliver a lot of special information from customers regardless how active are officers. Basic products such as current accounts or savings do not need any additional information from clients to deliver. However, more active officers should receive more information from customers regardless which products their own.

Third, it is a product penetration index[12]. It is very important to have customers with more than one product. Customers with more products are less likely to leave the bank. Therefore the bank's long term objective is a good cross selling. Client officers are motivated to sell mortgages together with life insurances and possibly credit cards as well. For customers who open just a current account is recommended to sell debit card with advantaged travel insurances for the whole family. In this way there is lower probability that customer is going to make a business at the competitors, will be more loyal and generate higher profit.

Forth, it is a client churn or retention. Monitor client churn (and the reasons for leave) is inevitable. Active customers are the most important assets. Dissatisfied clients with quality service are more likely to leave. Therefore client retention is a good estimation of the service quality.

All these aspects contribute to the overall performance of the branches and they are controlled fully by client officers (SQI index) or partially (client information index, product penetration index and client retention). Therefore they should be incorporated to the DEA model. The paper demonstrates interaction among service quality and operating branch efficiency.

4. Methodology

Section three gives the overview of the theoretical DEA framework. It also specifies three different methods how quality is possible to incorporate. The proposed methodology follows Sherman and Zhu (2006) on a real data from a branch network.

4.1 Standard DEA framework

[12] Penetration index is based on Finalta definitions. Each of the following products is counted with equal weight: current account, saving account, term deposit, investment fund (including pension savings), life insurance, consumer finance (including consumer loan, overdraft, and credit card) and mortgage.

DEA is a linear programming technique for measuring relative efficiency of a homogenous set of Decision Making Units (DMUs, in this study they are branches) by analyzing their multiple inputs with multiple outputs. It identifies a subset of efficient best practices branches through a piecewise linear envelopment of observed data. For the rest branches the magnitude of their inefficiency is measured by the distance from the envelope of best practice branches. DEA derives summary measure of efficiency for each branch. It also derives what would be the optimal combination of input and output for inefficient branches. This means that DEA allow us not only to say whether a certain branch is efficient or not, but also which inputs and outputs are the sources of inefficiency.

The original CCR model (Charnes, Cooper and Rhodes, 1978) is the first DEA model that evaluates technical efficiency in a multiple input and multiple output framework. CCB model assumes constant return to scale, i.e. outputs increase by the same proportional as inputs. This assumption is appropriate only when all DMUs operate at an optimal scale. In general however this is not true in many sectors. Banking sector is a good example, where there is a significant difference between small and large branches' activities. This indicates the existence of variable return to scale. Therefore in this paper BCC model (Banker, Charnes and Cooper, 1984) is applied to estimate efficiency, which assumes variable return to scale. During the 1990s DEA technique has become a widely used approach for efficiency analysis in many public and private sectors like universities, non-profit organizations, hospitals and banks. We use input-oriented[13] (cost-minimizing) BCC models, where envelopment model and its dual specifications are demonstrated in *Table 1*.

	Envelopment model	Multiplier model
Input – oriented DEA	$\min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$ $s.t.$ $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{io}, i = 1,2,...,m$ $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}, r = 1,2,...,s$ $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j \geq 0, j = 1,2,...,n$ $s_i^- \geq 0, i = 1,2,...,m$ $s_r^+ \geq 0, r = 1,2,...,s$	$\max \sum_{r=1}^{s} \mu_r y_{ro} + \mu$ $s.t.$ $\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \mu \leq 0, j = 1,2,...,n$ $\sum_{i=1}^{m} v_i x_{io} = 1$ $\mu_r \geq \varepsilon > 0, r = 1,2,...,s$ $v_i \geq \varepsilon > 0, i = 1,2,...,m$
Efficient target	$x_{io}^{/} = \theta^* x_{io} - s_i^{-*}, i = 1,2,...,m$ $y_{ro}^{/} = y_{ro} + s_r^{+*}, r = 1,2,...,s$	

Table 1 – *Input-oriented BBC model with variable return to scale, Envelopment model and its dual problem Multiplier model*

[13] Expansion on the market is limited, and it is more difficult to manage output increase than optimizing resources. We assume that outputs are given exogenous variables and searching for optimal input for each branch. Therefore input oriented strategy is chosen and with this kind of strategy is possible to receive further improvements as earlier discussed.

In the model there are n branches, where every branch$_j$, $j = 1,2,\dots,n$ produces s outputs in different amounts y_{rj} ($r=1,2,\dots s$) using m inputs in different amounts x_{ij} ($i=1,2,\dots,m$). In addition $\varepsilon > 0$ is a non-Archimedean element defined to be smaller than any positive real number. The presence of ε in the objective function effectively allows the minimization over θ to preempt the optimization involving the slacks $s_i^-, s_r^+ \geq 0$ (Cooper, Seiford and Zhu, 2004).

Branch$_o$ is efficient if and only if $\theta^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$ for all i and r. Branch$_o$ is weakly efficient if and only if $\theta^* = 1$ and $s_i^{-*} \neq 0, s_r^{+*} \neq 0$ for some i and r.

The complete theoretical background of the applied DEA methods is described more in details in studies such as Cooper et al. (2004) or Zhu (2009). The efficiency measurement used in this study was created by Tone (1993) with respect of proportional and non-proportional slacks. It was followed by Sevcovic et al. (2001) that also analyze several choices of efficiency measures. The next sections describe how to enhance and fully adjust the standard DEA method by quality dimension.

4.2 Method I — Quality indicator as an Output in DEA model

This is the first method, which reflects quality dimension in branch performance. In this specification basic DEA model is enhanced with one more output, with quality indicator. It is true that the DEA efficiency will not be decreased if additional output is included. Therefore some branches, which were inefficient in a standard DEA model, are getting to be efficient. In addition there could be several branches, which are efficient but have low quality measured by a certain indicator. In these cases high productivity compensates for low quality. Quality – productivity tradeoff is present. However in many applications this kind of tradeoff is not acceptable[14]. Benchmark branches should have high productivity with high quality. In the following Model II and III, there are suggestions how to avoid quality – productivity tradeoff.

4.3 Method II — Quality indicator as an independent factor

In Method II, quality indicator is not included to the basic DEA model, but it is treated independently. In this way it is possible to avoid quality – productivity tradeoff. All branches have two independent dimensions productivity (from DEA model) and quality. Each branch has its own place in the two-dimension chart. It is necessary to set a cut-off for high productivity and a cut-off for high quality in a way that meets its operation objectives. Cut-off for high productivity should be 1 and for high quality should be the top 20 or 50 percentile through all branches. The two-dimension chart is split up into four quadrants: high productivity and high quality (HP-HQ), high productivity but low quality (HP-LQ), low productivity but high quality (LP-HQ) and finally low productivity and low quality (LP-LQ). Branches in the quadrant HP-HQ are the best practice benchmark branches. In this two-dimension chart it is possible to depict relationship between efficiency and quality. However, efficiency measurement with respect of quality is not possible to quantify with this model.

Similar approach was done by Camanho and Dyson (1999), where authors situated bank branches in efficiency – profitability matrix and analyzed relation between the DEA

[14] Or should be within a certain limit

efficiency measure and profitability measure used by a bank. Soteriou and Zenios (1999) published similar method enhanced by quality of the services in banks. In addition Brazdik and Druska (2005) applied the DEA efficiency score – revenue performance chart for a mobile telecommunication network.

4.4 Method III — Quality adjusted DEA model

Another way how to eliminate quality – productivity tradeoff and simultaneously quantify efficiency measurement with respect of quality is to apply quality-adjusted DEA model. Quality-adjusted DEA model is a multi-level DEA model where non-efficient branches are compared only with best practice branches that are efficient (first level) with high quality (multi level).

More precisely, at the end of each level the efficiency score is calculated for all branches according to the DEA model that includes quality dimension too. Those branches which are efficient but with low quality are eliminated and do not enter to the next level. This iteration is finishing at that level, where all efficient branches have high quality as well. Therefore they are benchmark branches. Inefficiency score of all other branches are calculated relative to these best practice branches according to variable benchmark methods applied on e-commerce banking activities Cook et al. (2004) and later in Zhu (2009)

5. Results

5.1 Standard DEA framework

In this section there is a summary of results obtained by non-parametric DEA models. The empirical results are received from the analysis of 185 bank branches based on their figures for the year 2007. These branches deal with individuals and small business enterprise accounts as well. Their activities are considered as reasonable homogenous. The input and output specification[15] of standard DEA model with their descriptive statistics are in *Table 2*.

Variables	Obs.	Median	Mean	St. dev.	Min	Max
Inputs (in # persons)						
SME FTE	185	0.0	2.1	3.6	0.0	15.8
Retail FTE	185	1.3	2.5	3.3	0.0	19.4
UCO FTE	185	7.0	8.8	5.5	2.8	32.1
FTE	185	8.9	13.4	11.7	3.0	64.0
Outputs (in million CZK)		M – Volume *				
Retail Savings	185	58	94	135	0	1269
Retail Loans	185	74	110	124	2	898
SME Deposits	185	52	90	121	0	836
SME Loans	185	252	322	204	0	1257
Outputs (in million CZK)		M – Volume				
Retail Savings	185	56	86	124	0	1276
Retail Loans	185	72	100	99	2	677
SME Deposits	185	51	83	107	0	841
SME Loans	185	244	309	209	0	1264
Outputs (in # contracts)		M – Count				
Retail Savings	185	1257	1682	1269	206	6642
Retail Loans	185	363	444	287	61	1657
SME Deposits	185	106	150	145	4	925
SME Loans	185	48	71	63	0	310

[15] Defined earlier and are in *Appendix, Table A1*

Table 2 – *Description statistics of inputs and outputs of the standard DEA model*[16]*, data are related to the year 2007*

There are three specification of the standard DEA model. First, output factors are measured as new volumes within a year (M–Volume*). Second, in order to eliminate the effect of purchasing power as an external factor outputs are measured as new volumes within a year adjusted by region purchasing power (M–Volume). Third, output factors are measured as number of new sold products (M–Count). Models based on new volumes identify 33-34 branches as fully efficient and 151-152 branches as inefficient, i.e. 18% of branches are efficient, see *Table 3*. The average efficiency of all branches in the network is 74%. Model developed on number of sold products, however, identify 54 branches as efficient and the average efficiency is 84%. These results indicate that branches are more homogenous with respect of number of new sold products and their variations are lower. However the average efficiency 74-84% implies that there are reserves for improvement through optimal resource allocations.

Model	Number of efficient branches	Median	Mean	St. dev.	Min	Max
M–Volume*	33	74%	74%	19%	27%	100%
M–Volume	34	72%	74%	19%	28%	100%
M–Count	54	89%	84%	15%	49%	100%

Table 3 – *Average efficiency of the branch network, M–Volume* is based on new volumes, M–Volume is based on new volumes adjusted by region purchasing power, M–Count is based on number of new sold products*

According to the characteristics of efficient branches it is possible to recommend the optimal branch size. Efficient branches are mainly (54-59%) small branches with 4-6 universal client officers as it is shown in *Table 4*. However among efficient branches there are 6-12 medium sized and 7-13 large branches as well. Advisors, personal and firm bankers are efficient only for medium and large branches. Most of the efficient branches are located in Region A and Region G[17]. In Region A there is the highest purchasing power, which has positive external effect on the branch efficiency in the model M–Volume*. On the other hand Region G has the lowest purchasing power, where excellent management of branches over performs the negative external factor.

Model	Number of efficient branches	Branch size	Branch category	Region
M–Volume*	33	5-6 FTEs (4)	Small (20)	Region A (10)
M–Volume	34	5 FTEs (5)	Small (20)	Region G (10)
M–Count	54	4 FTEs (7)	Small (29)	Region G (13)

Table 4 – *Characteristics of efficient branches, in brackets are number of branches with the most frequent characteristic*

Findings indicate that optimal branch network should contains high number small sized branches with only universal client officers and some medium and large branches focusing on personal and firm bankers' and advisors' activities. Most frequent branch size of 4-6 FTEs indicates that the optimal branch size should be within this interval. Moreover, in the future it will be optimal to open rather small branches or redeploy client officers from larger branches to several small ones.

Efficiency score was used to find out performance rankings of branches. The sensitivity of results with respect to input-output model specifications was evaluated by calculating Spearman rank correlation[18] coefficients and by testing statistics for significance of rank

[16] Volume of new business is defined as difference between end-year and start-year stage. Therefore branches could have negative grow of AUM or loans. These figures are entering to the model as zero outputs.
[17] Regions are characterized by its purchasing power. Region A has the highest purchasing power, while Region G has the lowest purchasing power
[18] Defined in the paper Spearman (1994), which is commonly used to compare rankings

correlation coefficients. Results in *Table 5* shows that all estimated correlation coefficients are significant, but there is only moderate positive relationship between average efficiency by models M–Volume and M–Count, i.e. branches which are operate efficiently with respect of sold products are not necessary operate efficiently with respect of new volumes on those products. These results suggest not a high sensitivity of input-output model specification.

	Obs.	M–Volume*	M–Volume	M–Count
M–Volume*	185	1.000		
M–Volume	185	0.902 (0.000)	1.000	
M–Count	185	0.316 (0.000)	0.423 (0.000)	1.000

Table 5 – Spearman rank c*orrelation coefficients among three standard DEA models M–Volume*, M–Volume, M–Count*

In order to identify determinants of efficiency correlation analysis was done[19]. Interestingly, there is negative relationship among M–Volume, M–Count and purchasing power, *Table 6*. This indicates that branches with higher purchasing power are less efficient because they are not able to fully utilize the regions good purchasing power, they do not sell enough number of products or they do not have enough high volumes on new products. They have comparable new volumes on deposit and loan products with branches in lower purchasing power regions[20] but after eliminating positive effect of purchasing power the relative value of new volumes on products are tend to be lower. It is true especially for Region A, where the purchasing power is the highest one.

	Obs.	M–Volume*	M–Volume	M–Count
PP	185	0.077 (0.299)	-0.179 (0.015)	-0.432 (0.000)
FTE	185	-0.254 (0.000)	-0.246 (0.001)	0.037 (0.621)

Table 6 – *Correlation coefficients among average efficiencies of three standard DEA models (M–Volume*, M–Volume, M–Count), external factors like purchasing power (PP) and branch size (FTE), Obs. – number of observation, p-values are in the brackets*

Another inside gives a negative relationship between M–Volume efficiency and the branch size, i.e. larger branches are less efficient in terms of new product volume. However branch size has no influence on efficiency by number of sold products.

In *Table 7* there are reported average efficiency results with respect of region and branch size. There are significant variations among regions and branch sizes. Region A is only a region where average efficiency is lower in the model M–Volume than M–Volume* (p-value at t-test of means is 0.000). It is due to the highest purchasing power in the region that branches are not able to fully utilize. Branches in Region A are the less efficient ones according to number of new sold products. There is a place for improvement. Most efficient branches are in Region D.

[19] Regression analysis gives similar results, therefore we present only the correlation coefficients with p-values
[20] There is no correlation between M–Volume* efficiency and purchasing power, i.e. the correlation is 0.077.

	Large branches							Medium branches						
Region	M – Volume*	St. dev.	M – Volume	St. dev.	M – Count	St. dev.	Obs.	M – Volume*	St. dev.	M – Volume	St. dev.	M – Count	St. dev.	Obs.
Region A	89%	18%	83%	20%	84%	17%	10	77%	19%	63%	17%	60%	15%	7
Region B	56%	8%	57%	11%	83%	6%	3	59%	14%	65%	22%	72%	18%	5
Region C	44%	12%	48%	16%	89%	12%	6	61%	n/a	69%	n/a	94%	n/a	1
Region D	57%	11%	60%	12%	91%	16%	3	74%	17%	77%	17%	98%	3%	6
Region E	46%	11%	49%	12%	74%	9%	5	62%	8%	64%	9%	70%	15%	3
Region F	74%	20%	77%	19%	92%	10%	4	75%	22%	81%	22%	91%	13%	7
Region G	66%	27%	70%	24%	89%	18%	6	57%	18%	66%	20%	94%	7%	9
All	65%	24%	66%	22%	85%	14%	37	67%	19%	70%	19%	83%	18%	38
	Small branches							All branches						
Region	M – Volume*	St. dev.	M – Volume	St. dev.	M – Count	St. dev.	Obs.	M – Volume*	St. dev.	M – Volume	St. dev.	M – Count	St. dev.	Obs.
Region A	77%	15%	69%	14%	73%	14%	21	80%	17%	72%	18%	73%	17%	38
Region B	78%	15%	78%	14%	84%	15%	16	71%	17%	73%	17%	81%	15%	24
Region C	74%	16%	75%	18%	83%	15%	15	65%	20%	67%	21%	85%	14%	22
Region D	88%	11%	89%	10%	94%	8%	12	79%	17%	82%	16%	95%	8%	21
Region E	80%	14%	80%	14%	85%	12%	20	72%	18%	73%	18%	81%	13%	28
Region F	81%	19%	81%	18%	87%	13%	12	78%	20%	81%	19%	89%	12%	23
Region G	79%	20%	84%	20%	93%	9%	14	70%	23%	75%	22%	92%	11%	29
All	79%	16%	79%	16%	84%	14%	110	74%	19%	74%	19%	84%	15%	185

Table 7 – *Average branch efficiency according to regions, branch size and DEA models*

In general it is true that larger branches are less efficient with respect to the new volume. The explanation should be in the branch organization[21] and in fact that larger branches have larger customer portfolio which includes higher proportion of less valuable clients. The exception is in Region A, where large branches are the most efficient. Behind of this interesting result is the fact that in Region A small branches are not standalone branches but are connected to one of the large branches.

5.2 Quality indicators

Four main types of quality indicators – penetration index, service quality index, client information index and retention – are investigated in more details.

Correlation among quality indicators

Interestingly there is a relevant positive relationship between penetration index and retention, *Table 8*. Branches where clients have in average more different products tend to have more loyal customers as well. There is naturally negative correlation between all factors and product 1, which is defined as percentage of customers with exactly one product. The most important part of SQI index is mystery shopping (SQI II) and mystery call (SQI III), which are highly correlated. However there is low correlation between customer service (SQI I) and other parts of service quality index. It is because number of customer service meeting is rather quantitative indicator and other parts of service quality index measure real quality service. Those branches that have high quality service have on other hand less number of customer service meetings, which indicate a certain level of tradeoff.

[21] They employ more special client officers like personal and firm bankers or advisers who are not able to bring sufficiently valuable clients to the branch portfolio.

	Penetration	Product 1	Product 2+	Product 3+	SQI	SQI I	SQI II	SQI III	Retention	Information
Penetration	1.000									
Product 1	-0.959 (0.000)	1.000								
Product 2+	0.962 (0.000)	-0.999 (0.000)	1.000							
Product 3+	0.948 (0.000)	-0.827 (0.000)	0.832 (0.000)	1.000						
SQI	0.261 (0.000)	-0.324 (0.000)	0.324 (0.000)	0.170 (0.021)	1.000					
SQI I	0.228 (0.002)	-0.250 (0.001)	0.255 (0.000)	0.175 (0.017)	0.634 (0.000)	1.000				
SQI II	0.211 (0.004)	-0.282 (0.000)	0.278 (0.000)	0.121 (0.102)	0.798 (0.000)	0.186 (0.011)	1.000			
SQI III	0.147 (0.046)	-0.209 (0.004)	0.207 (0.005)	0.082 (0.265)	0.714 (0.000)	0.270 (0.000)	0.612 (0.000)	1.000		
Retention	0.491 (0.000)	-0.473 (0.000)	0.475 (0.000)	0.472 (0.000)	0.151 (0.040)	0.053 (0.471)	0.144 (0.051)	0.098 (0.186)	1.000	
Information	0.016 (0.825)	0.048 (0.518)	-0.043 (0.564)	0.078 (0.289)	0.196 (0.007)	0.044 (0.553)	0.200 (0.006)	0.164 (0.025)	0.135 (0.066)	1.000

Table 8 – *Correlation coefficients among quality indicators. Penetration – penetration index, Product 1- portion of customers with exactly one product, Product 2+ - portion of customers with more than 1 products, Product 3+ - portion of customers with more than 2 products, SQI – service quality index, SQI I – customer service, SQI II – mystery shopping, SQI III – mystery call, Retention – percentage of customers who were active in the whole year, Information – client information index, p-values are in the brackets*

Correlation between quality indicators and external factors

There are significant relationship among branch characteristics, efficiency results and quality indicators. Branch size measured as FTE has negative correlation with SQI specially SQI II and III, but positive relationship with SQI I. This indicates that at larger branches there are lower quality services, they are rather focus on quantity as number of customer service meeting. Hence there should be large tradeoff between quality and quantity. At these branches the organization is not effective. There is a big hierarchy at the expense of the quality. On the other hand, in small branches client officers know each other. They can easily cooperate and help to each other which finally indicate higher service quality appreciated by customers measured by mystery shopping or mystery call. In addition *Table 9* shows weak positive correlation between branch size and penetration index. The biggest the branch the more products their clients tend to have. However there is no significant relationship with retention.

Quality indicator	***Obs.***	***FTE***	***PP***	***M–Volume***	***M–Count***
Penetration index	185	0.196 (0.007)	-0.303 (0.000)	0.179 (0.015)	0.327 (0.000)
Product 1	185	-0.113 (0.126)	0.432 (0.000)	-0.202 (0.006)	-0.394 (0.000)
Product 2+	185	0.114 (0.121)	-0.430 (0.000)	0.205 (0.005)	0.393 (0.000)
Product 3+	185	0.245 (0.001)	-0.149 (0.043)	0.138 (0.062)	0.224 (0.002)
SQI Total	185	-0.240 (0.001)	-0.515 (0.000)	0.210 (0.004)	0.317 (0.000)
SQI I	185	0.213 (0.004)	-0.307 (0.000)	0.051 (0.494)	0.186 (0.011)
SQI II	185	-0.387 (0.000)	-0.475 (0.000)	0.196 (0.008)	0.266 (0.000)
SQI III	185	-0.467 (0.000)	-0.390 (0.000)	0.194 (0.008)	0.200 (0.006)
Retention	185	0.051 (0.495)	-0.039 (0.599)	0.013 (0.864)	-0.021 (0.781)
Information	185	-0.160 (0.029)	0.242 (0.001)	0.094 (0.203)	0.017 (0.814)

Table 9 – *Correlation coefficients among branch size (FTE), purchasing power (PP), average efficiency (M–Volume, M–Count models) and quality indicators, Obs. – number of observation, p-values are in the brackets*

Purchasing power has negative correlation with penetration index and SQI. As the highest purchasing power is in region A, there is lowest service quality and also lowest product penetration on customers. The latter is due to larger proportion of foreigners in region A who have particularly just one product – current account. Further purchasing power has slightly positive relationship with client information index and no relationship with retention. Results demonstrate that client officers know better their customers in region with higher purchasing power.

Average efficiency of M–volume and M–count models has positive relationship with penetration index and SQI. These are the most important quality indicators, which influence the branch efficiency[22]. On the other hand, there is no connection among retention, client information index and efficiency.

5.3 Method I — Quality indicator as an Output in DEA model

This is the first specification of standard DEA model, where quality is included as an additional output factor. In order to test sensitivity of results by adding one additional quality output factor Spearman rank correlation coefficient was calculated. All estimated correlation coefficients are significant and their value range between 0.870-0.991, which suggests a low sensitivity of model specification. This is in line with the arguments in section 4.2.

However, here it is demonstrated that this DEA model does not solve the tradeoff problem between quality and productivity[23]. The tradeoff is present and its magnitude differs with respect of a quality indicator, branch size and region as it is shown in *Table 10-11* below[24].

		M–Count model				M–Volume model			
Quality indicator	**Obs.**	**Efficiency**	**St. dev.**	**Effective**	**Trade off**	**Efficiency**	**St. dev.**	**Effective**	**Trade off**
Penetration	185	85%	15%	60	28%	75%	19%	42	29%
Product 1[25]	185	88%	14%	73	53%	79%	19%	45	44%
Product 2+	185	85%	15%	58	26%	75%	19%	39	36%
Product 3+	185	85%	15%	62	32%	75%	19%	40	30%
SQI	185	86%	15%	67	31%	75%	19%	41	34%
SQI I	185	87%	15%	77	36%	77%	19%	50	32%
SQI II	185	86%	15%	63	37%	76%	19%	45	31%
SQI III	185	87%	15%	73	41%	76%	19%	44	36%
Retention	185	85%	15%	61	44%	75%	19%	37	51%
Information	185	86%	15%	66	55%	75%	19%	38	47%

Table 10 – *Tradeoff by quality indicator and model type, Efficiency – average efficiency by the DEA model, St. dev. – standard deviation of efficiency, Effective – number of effective branches, Tradeoff – percentage of effective branches with low quality, Obs. – number of observation*

The productivity-quality tradeoff ranges between 28-55% with std. deviation 9% in case of M–Count model and it ranges between 29-51% with std. deviation 8% in case of M–Volume model. There is high tradeoff in M–Count and M–Volume models with quality indicator mystery shopping (SQI II) and that is valid mainly at large branches *Table 11*. Similar results are for mystery call (SQI III). Here high productivity compensate for low quality. Large branches have lower quality measured by mystery shopping and mystery call but they are

[22] Again similar result is obtained by regression analysis.
[23] Cut-off for high productivity is set at 1 and cut-off for high quality is set at the level of 50% percentile through all branches.
[24] Tradeoff by quality indicator and region is shown in *Appendix, Table A3.*
[25] Quality indicator Product 1 is an "opposite" indicator, the highest is the worst quality and consequently if you want to compare the tradeoff results with others then you should calculate 100% - actual tradeoff.

more focus on the quantity. As a consequence there is a large productivity-quality tradeoff. Interestingly, large tradeoff at retention indicator is driven by smaller branches. On the other hand, lowest tradeoff is assigned to DEA model with penetration index. Penetration index itself is a good predictor for efficiency and therefore there is a lowest tradeoff.

	M–Count model				M–Volume model			
Quality indicator	LB	MB	SB	All	LB	MB	SB	All
Penetration	20% (3)	23% (3)	34% (11)	28% (17)	11% (1)	38% (3)	32% (8)	29% (12)
Product 1	56% (9)	53% (9)	53% (21)	53% (39)	44% (4)	40% (4)	46% (12)	44% (20)
Product 2+	29% (4)	23% (3)	26% (8)	26% (15)	38% (3)	38% (3)	35% (8)	36% (14)
Product 3+	12% (2)	31% (4)	44% (14)	32% (20)	0% (0)	43% (3)	38% (9)	30% (12)
SQI	57% (8)	24% (4)	25% (9)	31% (21)	75% (6)	38% (3)	20% (5)	34% (14)
SQI I	32% (6)	39% (7)	38% (15)	36% (28)	25% (3)	50% (5)	29% (8)	32% (16)
SQI II	64% (9)	23% (9)	31% (11)	37% (23)	63% (5)	38% (3)	21% (6)	31% (14)
SQI III	73% (11)	53% (8)	26% (11)	41% (30)	100% (7)	63% (5)	14% (4)	36% (16)
Retention	25% (4)	29% (4)	61% (19)	44% (27)	38% (3)	71% (5)	50% (11)	51% (19)
Information	69% (6)	63% (5)	44% (12)	55% (23)	57% (4)	63% (3)	39% (10)	47% (17)

Table 11 – *Tradeoff (percentage of effective branches with low quality) by quality indicator and branch size, LB – large branch, MB – medium sized branch, SB – small branch, in brackets are number of observations*

Volume of tradeoff by region is present in *Appendix, Table A3*. There is large tradeoff in DEA models with quality indicator service quality index (83%-100%) in region A, which clearly indicates that in region A client officers are motivated by the quantity of the sold products and the quality is just on the second place. However, lowest tradeoff is in region F.

5.4 Method II — Quality indicator as an independent factor

In the second specification of standard DEA model quality is treated independently to avoid quality-productivity tradeoff. Each branch is characterized with its DEA and quality score. Based on these scores they are in one of the four quadrants defined in the previous section. Average efficiency and average value of quality indicators within these quadrants are present in *Table 12* and in *Appendix, Table A4*.

Best practice branches are in quadrant 1. Their average efficiency score is 100% and average value of quality indicator is above the cut-off value. Branches in quadrant 2 are those, where efficiency is 1 but the value of quality indicator is low, it is below the cut-off.

M – Count	Average efficiency					Average value of quality indicator					
Quality indicator	1	2	3	4	All	1	2	3	4	All	Cut-off
Penetration	100% (37)	100% (17)	80% (56)	76% (75)	84%	1.61	1.48	1.60	1.46	1.54	1.54
Product 1	100% (15)	100% (39)	76% (74)	81% (57)	84%	0.62	0.54	0.63	0.55	0.59	0.58
Product 2+	100% (39)	100% (15)	81% (56)	75% (75)	84%	0.46	0.37	0.45	0.37	0.41	0.42
Product 3+	100%(34)	100% (20)	79% (61)	77% (70)	84%	0.12	0.08	0.12	0.07	0.10	0.10
SQI	100% (34)	100% (20)	81% (59)	75% (72)	84%	0.89	0.81	0.90	0.82	0.85	0.86
SQI I	100% (28)	100% (26)	80% (61)	76% (70)	84%	0.92	0.78	0.94	0.77	0.85	0.87
SQI II	100% (32)	100% (22)	83% (63)	74% (68)	84%	0.74	0.57	0.76	0.57	0.66	0.67
SQI III	100% (25)	100% (29)	83% (67)	73% (64)	84%	0.93	0.85	0.94	0.85	0.89	0.90
Retention	100% (27)	100% (27)	77% (59)	79% (72)	84%	0.94	0.91	0.94	0.91	0.92	0.92
Information	100% (20)	100% (34)	79% (71)	76% (60)	84%	2.01	1.69	2.02	1.64	1.84	1.81

Table 12 – *Average efficiency and average value of quality indicators according to the quadrants, 1 – high productivity and high quality (HP-HQ), 2 – high productivity but low quality (HP-LQ), 3 – low productivity but high quality (LP-HQ), 4 – low productivity and low quality (LP-LQ), Cut-off – is a cut-off value for high quality, defined as a 50% percentile value of quality indicator, in brackets are number of observations*

In order to make more visible which branches are the best practice ones and which are able to make improvements by increasing quality or productivity, branches are depicted in the two-dimension graphs, see *Figure 1*. In general, the correlation among efficiency and quality indicators is low as it is reported in *Table 9*, which is also clear on *Figure 1*.

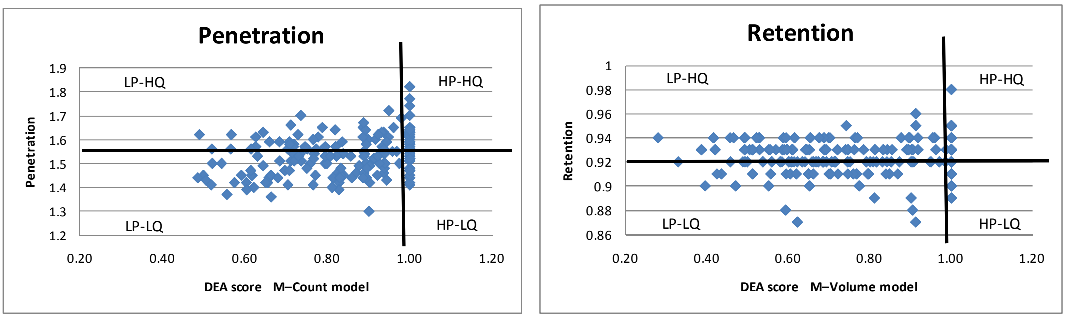

Figure 1 – *Scatter plots, branches are depicted in the 2-dimensions graph DEA score and quality indicators (Penetration and Retention)*

This model specification allows identifying benchmark branches that will move the bank to higher productivity and quality. However model is not possible to quantify efficiency with respect of quality.

5.5 Method III — Quality adjusted DEA model

In the final specification of standard DEA model, productivity-quality tradeoff is completely eliminated by multi-stage quality adjusted DEA model.[26] Here all inefficient branches are compared to the best practice branches, which are efficient with high quality. The average efficiency is the highest at this specification due to quality adjustment as it is demonstrated in *Table 13*[27].

		No quality Standard DEA		Quality as output Method I		Quality adjusted Method III	
M–Count	Obs.	Efficiency	St. dev.	Efficiency	St. dev.	Efficiency	St. dev.
Penetration	185	84%	15%	85%	15%	89%	13%
Product 1	185	84%	15%	88%	14%	91%	13%
Product 2+	185	84%	15%	85%	15%	89%	13%
Product 3+	185	84%	15%	85%	15%	88%	14%
SQI Total	185	84%	15%	86%	15%	88%	15%
SQI I	185	84%	15%	87%	15%	90%	14%
SQI II	185	84%	15%	86%	15%	89%	13%
SQI III	185	84%	15%	87%	15%	91%	12%
Retention	185	84%	15%	85%	15%	91%	11%
Information	185	84%	15%	86%	15%	92%	11%

Table 13 – *Comparison of average efficiency, No quality – standard DEA model, Quality as output – Method I where quality indicator is an additional output factor, Quality adjusted – Method III quality adjusted DEA , Efficiency – average efficiency, St. dev. – standard deviation of efficiency*

When efficiency is increasing, the potential cost reductions are decreasing. Within the standard DEA model the suggested cost saving is 16%. On other hand, the total potential cost reduction by Quality adjusted DEA model is about 10%, which is significantly lower than the amount suggested with standard DEA model not adjusted by quality. It was also tested whether the average efficiency is the same by all methods and the results of t-tests demonstrate that there are significant differences in average efficiency on the significance level 5%.[28] This result clearly indicates that service quality has significant impact on efficiency of branch network and it should be incorporated to DEA models and operational processes.

[26] All estimated Spearman rank correlation coefficients are significant and their value range between 0.753-0.961, which suggests a low sensitivity of model specification.
[27] Results for M–Volume models are in *Appendix, Table A5-A7*
[28] Due to limited space detailed results are not reported in the paper

Distribution of branches according to their efficiency score is shown in *Table 14*. There are 41-54 best practice branches and another 27-60 branches that are efficient but with low quality services. There are 11-31 branches with efficiency score below 70%, which means that costs (number of FTEs) at these branches is possible to reduce at least by 30% in order to operate efficiently.

M – Count			Average efficiency is below				
Quality indicator	**Best practice**	**HP-LQ**	**90%**	**80%**	**70%**	**60%**	**50%**
Penetration	48	27	26	30	13	5	0
Product 1	42	60	21	19	13	6	0
Product 2+	48	25	31	27	15	5	0
Product 3+	48	32	25	26	16	9	0
SQI	49	30	20	24	19	12	0
SQI I	54	35	19	24	12	9	1
SQI II	45	28	23	28	14	7	0
SQI III	54	44	21	21	14	4	0
Retention	41	44	22	23	14	1	0
Information	49	48	19	24	10	1	0

Table 14 – *Distribution of branches based on efficiency score by Quality adjusted DEA model, Best practice – number of best practice branches, HP-LQ – number of branches which have high productivity but low quality, Average efficiency is below X% – number of branches which have efficiency score below X%*

Characteristics of best practice branches are monitored in *Table 15*. It indicates that best practice branches are mainly in region G with lowest purchasing power and they are small branches with 4-6FTEs. Proportion of small branches within the best practice branches is 39-67% depending on a quality indicator used.

M – Count		Best practice								
		Region			FTE			Branch category		
Quality indicator	**All**	**Region**	**#**	**%**	**FTE**	**#**	**%**	**Branch category**	**#**	**%**
Penetration	48	Region G	12	25%	4	6	13%	SB	22	46%
Product 1	42	Region A	9	21%	4	5	12%	SB	26	62%
Product 2+	48	Region G	13	27%	4	7	15%	SB	25	52%
Product 3+	48	Region G and D	11	23%	4	7	15%	SB	21	44%
SQI	49	Region G	12	24%	4,6	5	10%	SB	29	59%
SQI I	54	Region G and D	12	22%	4	7	13%	SB	26	48%
SQI II	45	Region G	12	27%	4,6	5	11%	SB	27	60%
SQI III	54	Region F	12	22%	4	8	15%	SB	36	67%
Retention	41	Region G	12	29%	4	4	10%	SB	16	39%
Information	49	Region A	13	27%	4	6	12%	SB	27	55%

Table 15 – *Description of best practice branches with respect of region and branch size, SB – small branch, # – number of branches within benchmarks, % – percentage of best practice branches with a certain characteristic*

This is a surprising result. Managers based on ratio analysis assumed that small branches are rather not efficient and large branches are considered the best performers. Also it is documented that the best practice branches are mainly in Region G and not in Region A as it was assumed by the bank. These results however are in line with other DEA studies, such as Sherman and Zhu (2006).

6. Conclusion

In this paper there were three methods applied to incorporate quality dimension into performance of bank branches. Quality of service is measured through service quality, product penetration, client information and retention index. We identified that productivity – quality tradeoff exists and it is possible to avoid by multi-level quality adjusted DEA model, where benchmark branches have not only high productivity but high service quality as well. Results show that service quality has significant impact on branch efficiency and it should be incorporated to DEA models and operational processes. The paper demonstrates the short term interaction among service quality and operating branch efficiency.

From a policy perspective, the paper provides evidence that there are real reserves for improvement, average efficiency is 74-84%, which is possible to realize by optimal resource allocations and increasing service quality. We find out that the main factors of efficiency, quality and productivity-quality tradeoffs are branch size and region characterized by complex indicator purchasing power. There is documented that larger branches are less efficient than small ones. Results also show that branches in the region with highest purchasing power are not able to fully utilize their opportunities, which implies lower efficiency. Branches which are operate efficiently with respect of number of sold products are not necessary operate efficiently with respect of new volumes on those products. In addition, branches are less homogenous with respect to new volume than by number of new sold products.

Benchmark branches are mainly small ones and are in the region with lowest purchasing power despite of the managerial expectation. However, the results are in line with other studies conducted to DEA research. The most frequent optimal branch size is of 4-6 FTEs indicates that optimal branch size should be within this interval. In the future it will be optimal to open rather small branches or redeploy client officers from large inefficient branches to several small efficient ones. Moreover findings indicate that branch network should contains high number small sized branches with only universal client officers and some medium and large branches focusing on personal and firm bankers' and advisors' activities.

Most important quality indicator to explain efficiency is product penetration. Further the quality level and magnitude of productivity-quality tradeoff differs by branch size and region. Those branches that have high quality service measured by mystery shopping and mystery call have on other hand less number of client service meeting, which indicate a certain level of tradeoff. Findings demonstrate that large branches focus more on the information index and customer service meetings, while small branches are more interested in mystery shopping and mystery call). Interestingly branches in region with high purchasing power have worse results in terms of product penetration, mystery shopping and mystery call than branches with low purchasing power. Largest productivity-quality tradeoff was found at large branches with respect of quality indicators mystery shopping and mystery call.

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Appendix

Inputs	(in number of persons)
SME FTE	Average number of FTEs, advisors and firm bankers for non-retail clients
Retail FTE	Average number of FTEs, advisors and personal bankers for retail clients
UCO FTE	Average number of FTEs, universal client officers and a branch director
Outputs	**(in mln CZK), Model M–Volume***
Retail savings	Volume of new retail savings (current and saving accounts, term deposits, investment funds, pension funds, housing savings, single and regular life insurance)
SME deposits	Volume of new SME deposits (current and saving accounts, term deposits, investment funds)
Retail Loans	Volume of new retail loans (consumer loans, credit cards, overdrafts, housing loans, mortgages)
SME Loans	Volume of new SME loans (overdrafts, investment loans, revolving, factoring, leasing)
Outputs	**(in mln CZK), Model M–Volume**
Retail savings	Volume of new retail assets under management (current and saving accounts, term deposits, investment funds, pension funds, housing savings, single and regular life insurance) divided by branch's town purchasing power index
SME deposits	Volume of new SME assets under management (current and saving accounts, term deposits, investment funds) divided by branch's town purchasing power index
Retail Loans	Volume of new retail loans (consumer loans, credit cards, overdrafts, housing loans, mortgages) divided by branch's town purchasing power index
SME Loans	Volume of new SME loans (overdrafts, investment loans, revolving, factoring, leasing) divided by branch's town purchasing power index
Outputs	**(in number of contracts), Model M–Count**
Retail savings	Number of retail deposit products - current and saving accounts, term deposits, investment funds, pension funds, housing savings, single and regular life insurance
SME deposits	Number of SME deposit products - current and saving accounts, term deposits, investment funds
Retail Loans	Number of retail loan products - consumer loans, credit cards, overdrafts, housing loans, mortgages
SME Loans	Number of SME loan products - overdrafts, investment loans, revolving, factoring, leasing

Table A1 – *Description of input and output factors used in DEA models, data are related to one year period in 2007*

Quality indicators	Description
Service quality index , *SQI*	Measured by % and has three components: customer service, mystery shopping and mystery call
Customer service, *SQI I.*	Certain type of a meeting between a client officer and an existing customer in order to maintain a customer relationship, to indentify customer needs and increase probability to sell a new product. Measured as a fulfillment of the branch plan in %.
Mystery shopping, *SQI II.*	Certain type of a branch visit in order to evaluate several aspect of the service: quality and correctness of provided information and way of communication with a customer. Measured as a fulfillment of all mandatory factors in %.
Mystery call, *SQI III.*	Certain type of a phone call in order to evaluate several aspect of the service: quality and correctness of provided information and a way of communication with a customer by phone call. Measured as a fulfillment of all mandatory factors in %.
Client information index, *Information*	Average number of available client information: education, job, id card, phone number, e-mail, income and expense
Product penetration index, *Penetration*	Average number of products per customer based on Finalta definitions. Each of the following products is counted with equal weight: current account, saving account, term deposit, investment fund (including pension savings), life insurance, consumer finance (including consumer loan, overdraft, and credit card) and mortgage.
Client retention, *Retention*	Percentage of active customers at the end of the year 2006 that were still active customers at the end of the year 2007.

Table A2 – *Description of quality indicators used in DEA models*

M-Count	Region A	Region B	Region C	Region D	Region E	Region F	Region G	All
Penetration	43% (3)	50% (2)	20% (1)	23% (3)	0% (0)	40% (4)	27% (4)	28% (17)
Product 1	10% (1)	30% (3)	57% (4)	69% (9)	71% (5)	58% (7)	71% (10)	53% (39)
Product 2+	57% (4)	25% (1)	20% (1)	25% (3)	0% (0)	30% (3)	20% (3)	26% (15)
Product 3+	25% (2)	50% (2)	33% (2)	15% (2)	17% (1)	50% (5)	40% (6)	32% (20)
SQI Total	83% (5)	20% (1)	29% (2)	38% (6)	17% (1)	9% (1)	31% (5)	31% (21)
SQI I	71% (5)	67% (4)	38% (3)	29% (5)	14% (1)	21% (3)	39% (7)	36% (28)
SQI II	67% (4)	17% (1)	38% (3)	38% (5)	17% (1)	50% (5)	29% (4)	37% (23)
SQI III	67% (4)	29% (2)	38% (3)	56% (9)	0% (0)	23% (3)	56% (9)	41% (30)
Retention	57% (4)	100% (4)	57% (4)	50% (6)	40% (2)	20% (2)	31% (5)	44% (27)
Information	33% (4)	75% (3)	60% (3)	46% (6)	60% (3)	73% (8)	56% (9)	55% (36)
M-Volume	**Region A**	**Region B**	**Region C**	**Region D**	**Region E**	**Region F**	**Region G**	**All**
Penetration	29% (2)	33% (1)	33% (1)	17% (1)	0% (0)	25% (2)	42% (5)	29% (12)
Product 1	17% (2)	33% (1)	50% (2)	60% (3)	67% (2)	50% (4)	60% (6)	44% (20)
Product 2+	71% (5)	50% (1)	33% (1)	20% (1)	0% (0)	25% (2)	36% (4)	36% (14)
Product 3+	29% (2)	33% (1)	67% (2)	0% (0)	33% (1)	14% (1)	42% (5)	30% (12)
SQI Total	100% (7)	0% (0)	0% (0)	40% (2)	33% (1)	0% (0)	36% (4)	34% (14)
SQI I	44% (4)	25% (1)	33% (1)	29% (2)	33% (2)	20% (2)	36% (4)	32% (16)
SQI II	100% (7)	0% (0)	0% (0)	75% (3)	33% (1)	0% (0)	25% (3)	31% (14)
SQI III	63% (5)	25% (1)	0% (0)	50% (3)	0% (0)	13% (1)	60% (6)	36% (16)
Retention	43% (3)	100% (2)	100% (3)	60% (3)	0% (0)	29% (2)	55% (6)	51% (19)
Information	25% (2)	33% (1)	0% (0)	60% (3)	100% (2)	29% (2)	80% (8)	47% (18)

Table A3 – *Tradeoff (percentage of effective branches with low quality) by quality indicator and region – Method I, in brackets are number of observations*

M – Volume	Average efficiency					Average value of quality indicator					
Quality indicator	**1**	**2**	**3**	**4**	**All**	**1**	**2**	**3**	**4**	**All**	**Cut-off**
Penetration	100% (22)	100% (12)	68% (71)	69% (80)	74%	1.61	1.48	1.60	1.47	1.54	1.54
Product 1	100% (14)	100% (20)	68% (75)	69% (76)	74%	0.62	0.54	0.64	0.55	0.59	0.58
Product 2+	100% (20)	100% (14)	69% (75)	68% (76)	74%	0.47	0.38	0.45	0.36	0.41	0.42
Product 3+	100% (22)	100% (12)	67% (73)	70% (78)	74%	0.12	0.08	0.12	0.08	0.10	0.10
SQI	100% (20)	100% (14)	71% (73)	67% (78)	74%	0.90	0.82	0.89	0.81	0.85	0.86
SQI I	100% (18)	100% (16)	68% (71)	69% (80)	74%	0.93	0.80	0.93	0.76	0.85	0.87
SQI II	100% (20)	100% (14)	71% (75)	66% (76)	74%	0.74	0.56	0.76	0.57	0.66	0.67
SQI III	100% (18)	100% (16)	72% (74)	65% (77)	74%	0.94	0.85	0.94	0.85	0.89	0.90
Retention	100% (15)	100% (19)	68% (71)	69% (80)	74%	0.94	0.91	0.93	0.91	0.92	0.92
Information	100% (16)	100% (18)	69% (75)	68% (76)	74%	2.04	1.66	2.01	1.66	1.84	1.81

Table A4 – *Average efficiency and average value of quality indicators according to the quadrants in Method II DEA model, 1 – high productivity and high quality, 2 – high productivity but low quality, 3 – low productivity but high quality, 4 – low productivity and low quality, Cut-off – is a cut-off value for high quality, defined as a 50% percentile value of quality indicator, in brackets are number of observations*

		No quality Standard DEA		Quality as output Method I		Quality adjusted Method III	
M–Volume	**Obs.**	**Efficiency**	**St. dev.**	**Efficiency**	**St. dev.**	**Efficiency**	**St. dev.**
Penetration	185	74%	19%	75%	19%	78%	19%
Product 1	185	74%	19%	79%	19%	83%	18%
Product 2+	185	74%	19%	75%	19%	80%	18%
Product 3+	185	74%	19%	75%	19%	77%	19%
SQI Total	185	74%	19%	75%	19%	78%	19%
SQI I	185	74%	19%	77%	19%	81%	19%
SQI II	185	74%	19%	76%	19%	80%	19%
SQI III	185	74%	19%	76%	19%	83%	17%
Retention	185	74%	19%	75%	19%	85%	16%
Information	185	74%	19%	75%	19%	77%	19%

Table A5 – *Comparison of average efficiency, No quality – standard DEA model, Quality as output – Method I where quality indicator is an additional output factor, Quality adjusted – Method III quality adjusted DEA , Efficiency – average efficiency, St. dev. – standard deviation of efficiency*

M – Volume			Average efficiency is below				
Quality indicator	Best practice	HP-LQ	90%	80%	70%	60%	50%
Penetration	32	15	117	101	70	36	14
Product 1	33	37	97	77	52	29	11
Product 2+	32	20	108	91	60	27	8
Product 3+	34	14	120	100	72	41	15
SQI	30	20	112	97	71	38	14
SQI I	35	27	101	82	60	33	13
SQI II	37	24	110	94	62	33	11
SQI III	37	31	95	80	53	19	6
Retention	36	33	95	75	38	17	3
Information	26	20	118	103	75	37	14

Table A6 – *Distribution of branches based on efficiency score by Method III - Quality adjusted DEA model, Best practice – number of best practice branches, HP-LQ – number of branches which have high productivity but low quality, Average efficiency is below X% – number of branches which have efficiency score below X%*

M – Volume		Best practice								
		Region			FTE			Branch category		
Quality factor	All	Region	#	%	FTE	#	%	Branch category	#	%
Penetration	32	Region G	7	22%	4	5	16%	SB	18	56%
Product 1	33	Region A	12	36%	6	5	15%	SB	20	61%
Product 2+	32	Region G	9	28%	4	4	13%	SB	18	56%
Product 3+	34	Region G	8	24%	4	8	24%	SB	19	56%
SQI	30	Region F	10	33%	5,6	4	13%	SB	22	73%
SQI I	35	Region F	8	23%	4	7	20%	SB	21	60%
SQI II	37	Region G	10	27%	5,6	5	14%	SB	26	70%
SQI III	37	Region F	10	27%	5	6	16%	SB	27	73%
Retention	36	Region F	10	28%	4	6	17%	SB	23	64%
Information	26	Region A and F	7	27%	4	6	23%	SB	19	73%

Table A7 – *Description of best practice branches in Method III with respect of region and branch size, SB – small branch, # – number of branches within benchmarks, % – percentage of best practice branches with a certain characteristic*