Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

Improving Service Performance in Banking using Quality Adjusted Data Envelopment Analysis

Juraj Kopecsni

IES Working Paper: 10/2010

Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Bibliographic information:
Kopecsni, J. (2010). "Improving Service Performance in Banking using Quality Adjusted Data Envelopment Analysis" IES Working Paper 10/2010. IES FSV. Charles University.

This paper can be downloaded at: http://ies.fsv.cuni.cz

Improving Service Performance in Banking using Quality Adjusted Data Envelopment Analysis

Juraj Kopecsni*

*IES, Charles University Prague
E-mail: jurajkopecsni@gmail.com

June 2010

Abstract:
The goal of this research is to describe the application of data envelopment analysis (DEA) to the performance evaluations of bank branches. Special attention is focused on how to incorporate the quality dimension into branch efficiency. DEA will apply to a set of micro-data from a Czech commercial bank branch network. In the banking sector, providing services quality is one of the key focuses. Therefore, the quality dimension should be incorporated into the DEA model. The goal of the quality adjusted DEA model is to identify best practice branches that work efficiently and at the same time provide services with high quality. This model avoids productivity-quality tradeoff, which is present by the 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.

Keywords: quality adjusted DEA, branch performance, scale efficiency, return to scale

JEL: C14, C44, C61, L8

1. Introduction

The service economy consists of a large proportion of developing countries' economic activity, and its growing development has raised the importance of maximizing organizations' productivity. Organizations are searching for a 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 analyses are not sufficient[1] to measure productivity for organizations using multiple resources and providing 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 require specification of the production function form, which is required by parametric methods. Therefore, managers are interested in supporting their decisions through 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). It is particularly difficult for service industries to improve productivity and find substantial cost saving without sacrificing service quality. There are many subjective factors that affect productivity and service quality. A good example of an industry in which the quality of services is an important issue is the banking sector. In banks, such subjective factors influencing productivity include customers' needs, behavior in receiving the service, service provider's judgment, and skills in providing service.

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

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

In the banking sector, providing services quality is a key focus. Therefore, the quality dimension should be incorporated into the DEA model. The goal of the quality adjusted DEA model is to identify best practice branches that work efficiently and at the same time provide high-quality services. This model avoids productivity-quality tradeoff, which is present in the 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 focused solely on the growth of new business volume and on new customer acquisition. Recently, due financial crises, however, they are encouraged to optimize their resources as well. They identified that with cost optimization, it 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 through high-quality service.

The essay is organized as follows. The following section contains a brief literature review on DEA research with special attention on studies with quality measurements. Section three discusses the details of how bank branch network provide services for clients, focusing on the input and output specification according to the motivation system and long-term strategy. Section four gives an overview of the theoretical DEA framework. It also specifies three different methods to incorporate the quality dimension. The fifth part summaries the results obtained by non-parametric methods, and the last section draws conclusions 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[2] like universities, non-profit organizations, hospitals, and banks. 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 the performance of financial and banking organizations. 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) was the first to evaluate branch efficiency with respect to size. It was followed by studies by Drake and Howcroft (1994), Tulkens (1995) and Schaffnit et al. (1997). 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. An efficiency review of financial institutions is described in Berger and Humphrey (1997).

Several studies have solely analyzed the efficiency of bank branches. Their comprehensive branch performance review was published by Camanho and Dyson (1999), where authors also describe an application of DEA used in the performance assessment of

[2] There are several McKinsey working papers dealing with operational excellence in several industries, which are based on McKinsey 7S framework. The main source of academic work on the 7S model has to be the papers of Waterman et al. (1980, 1982). One of the elements of this framework is the strategy, which is discussed in Lynch (2005) more in details.

Portuguese bank branches and show how DEA can complement profitability measures. 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. A dataset was provided by one of the leading banks in Slovakia. Most recently, Irsova (2009) compares two methods in bank efficiency, the stochastic frontier approach and DEA, which are supported by the meta-regression part including several studies on the United States and transitional countries.

Above mentioned DEA papers are dealing with efficiency from general perspective. The quality dimensions are getting part of efficiency analysis later on and they are discussed in the following section. Callen (1991) early identifies that most DEA studies do not consider the quality of services or products. Excluding quality can result in applying methods that increase efficiency by reducing quality. Quality in many areas is critical, but is not included in DEA models. These studies assume that 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, 1998) in his DEA studies of a Greek bank branch network considers the relationship of DEA productivity scores with quality. Bank branch operations are demonstrated by the effort made by management to pursue the banks' corporate objectives, which consist of the tangible part described by the operating efficiency and the intangible part characterized by the quality of the provided services. 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 quality into the effort effectiveness; the DEA scores are calculated without quality adjustment.

Further, Soteriou and Zenios (1999) gain superior insight by simultaneously analyzing 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).

Above mentioned results request research to find ways to properly combine quality and efficiency Sherman and Zhu (2006). Only few DEA studies explicitly address quality, and those that consider it have not fully adjusted for quality. This essay 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 measurements.

3. Banking sector providing services for clients

Each DEA model is constructed to solve a concrete requirement. Therefore, formulation of DEA problems require 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.

3.1 Strategy

The bank's long term goal is to grow business profit through selling deposit and loan products[3]. However, it is hard to manage new volumes. Branches have only limited control over new volumes that are determined by external factors, mainly by sales the potential of the region. Earning long-term profit growth in such a competitive industry is possible only by also focusing on other essential components. Therefore, banks' recent strategy has also focused 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 of service is provided to clients in order to meet their needs (step II).

The key activity of the bank is based on the operation of the branch network, which represents 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 high-quality services in order to receive loyalty and make customers more valuable. In order to operate efficiently, branches need to solve not only cost minimizing strategy, but also attract customers by offering high-quality services.

3.2 Branch network

Organization within the branch network and production process is a follows. There are large, medium, and small branches based on the 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, and bank checks). Officers deal with general and simple 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 the most valuable clients, caring for their product portfolios. Finally, branch directors manage client officers and attend to the most important issues.

3.3 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 savings accounts, term deposits, investment funds, pension funds, housing savings, and 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

[3] It is not a common practice that banks measure RAROC or RORAC on the level of an individual retail and SME branch. Profit before tax that includes credit provisions is, however, frequently used as a KPI on a branch level. As regards income, it is mostly broader and consists of NII from assets and liabilities, net fee and commission income and income from financial operations.

[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 of funds, and firm loan advisers help firms find the most appropriate loan for their business.

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

plan determined by top management and then the weighted averages of ranks in each category describe the final branch performance rank.

The second method emphasizes branch activities. Activities are defined as the number of sold products (investment, housing loans and mortgages, non-specified loans, and SME loans) within a year and net increase in the 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 to high growth in these factors but have a poor actual stage. Most of the branches already have a very good actual stage, but they also have slow growth in several indicators. The best branches have a very good actual stage and very high growth in most of variables, and they serve as best practice branches for others. On the other hand, opposite branches need a special focus because they have a poor actual situation and poor growth. It is necessary to discover the reasons for external factors or poor management.

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

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

3.4 Standard DEA application

The above mentioned methods do not take into consideration the employee structure of branches and external factors such as the region's purchasing power. They are unable to discover the source of inefficiency and how to deal with it in order to attain an efficient environment. Furthermore, even the second method does not take into account the quality of services. Considering activity alone is only a short-term issue. To maintain excellent long-term results, it is necessary to know more about the clients and their needs, increase product penetration, and have high client retention. This can only be reached through high-quality service. Models excluding quality dimensions assume that quality is homogenous through the branches.

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

The best indicator for branch resources is branch size. To estimate branch size, the number of branch employees is used because personal costs are 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[8], and SME FTE—advisors and firm bankers for non-retail clients. FTE means the number of full time

[7] Full definitions of these factors are in *Appendix, Table A1*
[8] Retail are all physical persons. SME are firms and physical entrepreneurs with annual turnover up to EUR 10 million. Corporate clients are above this threshold and are not be included in DEA analysis.

employees, which is adjusted to account for maternity leave, holidays, part-time workers, illness, and training. It explains how many full-time employees were present in a certain period in the branch.

There are four output[9] measures—retail loans (consumer loans, credit cards, overdraft, housing loans, and mortgages), retail savings (current and saving accounts, term deposits, investment funds, pension funds, housing savings, and single and regular life insurance), SME loans (overdraft, investment loans, revolving, factoring, and leasing), and SME deposits (current and saving accounts, term deposits, and investment funds).

There are three different specifications. First, output factors are measured as new volumes within a year. This method favors branches in large cities, where clients are more likely to invest higher amounts, buy mortgages with higher values, or where bigger firms that are searching for large investment loans are located. Second, output factors are measures as above, but the volumes are divided by each branch's town purchasing power index[10] in order to eliminate the effect of that external factor—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 the number of new sold products, which reflects the client officers' activities. The motivation behind this specification is that to measure what client officers are able to influence. They are able to use their services to influence certain clients to buy a mortgage at their bank instead of at a competitor's, but they are not able to influence the volume of the mortgages. We believe that client officers are able to influence the number of sold products with their services. Therefore, output in the model is measured by the number of sold products, which should be a result of high quality service, number of meetings with clients, and other officer efforts.

3.5 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 essay demonstrates short-term interaction among service quality and operating branch efficiency[11].

The banking market is very competitive, and banks can no longer grow rapidly just through new acquisitions. It becomes more important to attain valuable customers through selling more products to existing customers and maintaining customer retention. Both of them are only possible through high-quality service. Therefore, the bank's actual strategy is focused more on quality.[12] Service quality is considered very important because of high competition in the market and the value of retaining customers.

[9] Manager business objectives (MBOs) are building upon 4 elements in the bank: profit including risk element, volumes as a proxy for market share, activities of the sales force (measured through number of meetings and sales in pieces) and the last is quality of services or customer satisfaction. Managers have higher weigh on the profit KPI and employees more on activities and customer satisfaction.

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

[11] In reality, however, service quality has a substantial effect on branch efficiency rather on long-term prospects. Due to a lack of data for long-term forecast, we estimate only short-term interactions.

[12] A recent situation in the financial markets further confirms that quality of services is an important element. Customers require more explanations about investment products. They put their savings where they feel more

If you know more about your customers, you can better manage customer relationships and you can have a better idea of what customers need and their interests. 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 when the bank utilizes long-term business growth. Therefore, it is important to measure and be under the control of these indicators. There are several measurements of how banks currently control and try to increase service quality.[13]

First, the bank creates a service quality index, which has three parts: customer service, mystery shopping, and mystery call. Each of them is focused on the quality of officers' willingness and proficiency. Customer service is a certain type of meeting between a client officer and an existing customer in order to maintain the customer relationship, to identify customer needs, and finally, to increase the probability to sell a new product. Client officers 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 a 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 a customer from an external consulting firm. A mystery shopper visits a branch in order to receive information about certain types of products, advice in investment, or to receive mortgages and other loan products. During the visit, he evaluates several aspect of service, mainly quality and correctness of provided information and ability to communicate well with a customer. In advance, the mystery shopper is educated on what high-service quality looks like, correct answers, and what he can and cannot do. After the visit, he fills out an evaluation form, indicating which tasks were fulfilled and which are not. Based on these figures, a branch receives another quality score. Each time the mystery shopper visits, he focuses on a different topic, product need, or client officer's seniority level. A mystery call is very similar to mystery shopping, but in this case, the mystery customer calls the branch. Client officers have to give a correct answer on the counterparty question and offer a personal meeting at the branch. Based on the behavior of the officer and the accuracy of the answers, the branch receives a third quality score. Finally, these three quality scores are put together to create a complete service quality index, which is evaluated on a monthly basis.

Second, there is the client information index. Client officers should put information about clients into the internal system, like phone numbers, emails, ID cards, education, job, incomes, and expenses. The 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 customers and available customer information at the banks. Selling certain products like mortgages is conditioned to deliver a lot of special information from customers regardless of how active the officers are. 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 of which products they own.

---

safety or search for more appropriate mortgages that fit their needs and are flexible. If they do not see high-quality service or confidence, they quickly change banks or just leave their savings at home. Customers start to value the quality of services.

[13] A full definition of quality indicators are in *Appendix, Table A2*

Third, there is the product penetration index.[14] 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 good cross selling. Client officers are motivated to sell mortgages together with life insurance and possibly credit cards. With customers who just open a current account, officers attempt to sell them debit cards with advantaged travel insurance for the whole family. In this way, there is lower probability that customer is going to conduct business with competitors; customers will be more loyal, and the bank will generate higher profits.

Forth, there is client churn or retention. Monitoring the client churn (and the reasons for leave) is inevitable. Active customers are the most important assets. Clients who are dissatisfied with quality service are more likely to leave. Therefore, client retention is a good estimation of service quality.

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

4. Methodology

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

4.1 Standard DEA framework

DEA is a linear programming technique for measuring the relative efficiency of a homogenous set of Decision Making Units (DMUs, which in this study 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 of the branches, the magnitude of their inefficiency is measured by the distance from the envelope of best practice branches. DEA derives a 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 to not only 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, which evaluates technical efficiency in a multiple input and multiple output framework. The CCB model assumes constant return to scale, i.e., outputs increase by the same proportion 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. The banking sector is a good example because there is a significant difference between small and large branches' activities. This indicates the existence of a variable return to scale. Therefore, in this essay, the BCC model (Banker, Charnes and Cooper, 1984) is applied to estimate efficiency, which assumes a

[14] The 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 mortgages.

variable return to scale. During the 1990s, the DEA technique became a widely used approach for efficiency analysis in many public and private sectors, such as universities, non-profit organizations, hospitals, and banks. We use input-oriented[15] (cost-minimizing) BCC models; the envelopment model and its dual specifications are demonstrated in *Table 1*.

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

	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	$x_{io}^{/} = \theta^* x_{io} - s_i^{-*}, i = 1,2,...,m$ $y_{ro}^{/} = y_{ro} + s_r^{+*}, r = 1,2,...,s$	

In the model, there are n branches, where every branch$_j$, $j = 1,2,\ldots,n$ produces s outputs in different amounts y_{rj} ($r=1,2,\ldots s$) using m inputs in different amounts x_{ij} ($i=1,2,\ldots,m$). 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 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 in more detail 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 to proportional and non-proportional slacks. It was followed by Sevcovic et al. (2001) that also analyzed several efficiency

[15] 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.

measures. The next sections describe how to enhance and fully adjust the standard DEA method using a quality dimension.

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

This is the first method that reflects the quality dimension in branch performance. In this specification basic DEA model is enhanced with one more output, a quality indicator. It is true that the DEA efficiency will not decrease if additional output is included. Therefore, some branches, which were inefficient in a standard DEA model, are becoming efficient. In addition, there could be several branches that are efficient but have low quality, as 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.[16] Benchmark branches should have high productivity with high quality. In Model II and III, there are suggestions on 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-dimensional chart. It is necessary to set a cut-off for high productivity and a cut-off for high quality in a way that meets operation objectives. Cut-off for high productivity should be 1, and for high quality, it should be the top 20 or 50 percentile through all branches. The two-dimensional 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 low productivity and low quality (LP-LQ). Branches in the quadrant HP-HQ are the best practice benchmark branches. In this two-dimensional chart, it is possible to depict the relationship between efficiency and quality. However, efficiency measurement with respect to quality is not possible to quantify this model.

A similar approach was done by Camanho and Dyson (1999), where the authors situated bank branches in an efficiency–profitability matrix and analyzed the relationship between the DEA efficiency measure and profitability measure used by a bank. Soteriou and Zenios (1999) published a similar method enhanced by the quality of 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 to eliminate the quality–productivity tradeoff and simultaneously quantify efficiency measurement with respect to quality is to apply a quality-adjusted DEA model. A 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 also includes the quality dimension. Those branches that are efficient but with low quality are eliminated and do not enter the next level.

[16] Or should be within a certain limit

This iteration is finishing at that level, where all efficient branches have high quality as well. Therefore, they are benchmark branches. The 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 reasonably homogenous. The input and output specification[17] of the standard DEA model with its descriptive statistics are in *Table 2*.

Table 2 Description statistics of inputs and outputs of the standard DEA model[18], data are related to the year 2007

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

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 regional purchasing power (M–Volume). Third, output factors are measured as the number of new products sold (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, identifies 54 branches as efficient, and the average efficiency is 84%. These results indicate that branches are more homogenous with respect to the number of new products sold and their variations are lower. However, the average efficiency, 74-84%, implies that there is room for improvement through optimal resource allocations.

[17] Defined earlier, located in *Appendix, Table A1*
[18] 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.

Table 3 Basic statistics and average efficiency of the branch network

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%

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 shown in *Table 4*. However, among efficient branches, there are 6-12 medium sized and 7-13 large branches as well. Advisors and personal and firm bankers are only efficient in medium and large branches. Most of the efficient branches are located in Region A and Region G.[19] In Region A, there is the highest purchasing power, which has a positive external effect on 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.

Table 4 Characteristics of efficient branches

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)

in bracket are number of branches with the most frequent characteristic

Findings indicate that an optimal branch network should contain a 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. Frequently, branch sizes of 4-6 FTEs indicate that the optimal branch size should be within this interval. Moreover, in the future, it will be optimal to open small branches or redeploy client officers from larger branches to several small ones.

Efficiency score was used to calculate performance rankings of the branches. The sensitivity of results with respect to input-output model specifications was evaluated by calculating the Spearman rank correlation[20] coefficients and by testing statistics for significance of rank correlation coefficients. Results in *Table 5* show 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 that operate efficiently with respect to sold products are not necessary operated efficiently with respect to new volumes on those products. These results suggest not a high sensitivity of input-output model specification.

Table 5 Spearman rank correlation coefficients among three standard DEA models

	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

[19] Regions are characterized by its purchasing power. Region A has the highest purchasing power, while Region G has the lowest purchasing power

[20] Defined in Spearman (1994), and it is commonly used to compare rankings

In order to identify determinants of efficiency, a correlation analysis was done.[21] 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 region's good purchasing power, they do not sell enough products, or they do not have high enough volumes of new products. They have comparable new volumes on deposit and loan products with branches in lower purchasing power regions,[22] but after eliminating the positive effect of purchasing power, the relative value of new volumes on products tend to be lower. In particular, is true for Region A, where the purchasing power is the highest.

Table 6 Correlation coefficients among average efficiencies of three standard DEA models, external factors like purchasing power (PP) and branch size (FTE)

	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)

P-values are in the brackets

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

Table 7 shows the reported average efficiency results with respect to region and branch size. There are significant variations among regions and branch sizes. Region A is the only region where the 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 least efficient according to the number of new sold products. There is room for improvement. The most efficient branches are located in Region D.

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

	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

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

In general, larger branches are less efficient with respect to new volume. The explanation should be in the branch organization[23] and in fact that larger branches have larger customer portfolios that include a higher proportion of less valuable clients. The exception is in Region A, where large branches are the most efficient. Behind 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 detail.

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 products tend to have more loyal customers as well. There is a naturally negative correlation between all factors and product 1, which is defined as the percentage of customers with exactly one product. The most important part of the SQI index is mystery shopping (SQI II) and mystery calls (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 the number of customer service meetings is a rather quantitative indicator and other parts of the service quality index measure real quality service. Those branches that have high-quality service have, on other hand, less customer service meetings, which indicates a certain level of tradeoff.

Table 8 Correlation coefficients among quality indicators

	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

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

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

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

Table 9 Correlation coefficients among branch size (FTE), purchasing power (PP), average efficiency and quality indicators

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)

p-values are in the brackets

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

The average efficiency of M–volume and M–count models has a positive relationship with penetration index and SQI. These are the most important quality indicators that influence branch efficiency.[24] 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 the standard DEA model, where quality is included as an additional output factor. In order to test the sensitivity of results by adding one additional

[24] Again, a similar result is obtained by regression analysis.

quality output factor, the Spearman rank correlation coefficient was calculated. All estimated correlation coefficients are significant and their value range between 0.870-0.991, which suggests the 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.[25] The tradeoff is present and its magnitude differs with respect to a quality indicator, branch size, and region, as shown below in *Table 10-11*.[26]

Table 10 Tradeoff by quality indicator and model type

		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[27]	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%

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

The productivity-quality tradeoff ranges between 28-55% with a std. deviation of 9% in cases of M–Count model, and it ranges between 29-51% with a std. deviation of 8% in cases of M–Volume model. There is a high tradeoff in M–Count and M–Volume models with the mystery shopping quality indicator (SQI II), which are mainly valid at large branches (*Table 11*). Similar results were seen for mystery calls (SQI III). Here, high productivity compensates for low quality. Large branches have lower quality measured by mystery shopping and mystery calls, but they are more focused on quantity. As a consequence, there is a large productivity-quality tradeoff. Interestingly, a large tradeoff in the retention indicator is driven by smaller branches. On the other hand, lowest tradeoff is assigned to a DEA model with a penetration index. Penetration index itself is a good predictor of efficiency, and therefore, they off the lowest tradeoff.

Table 11 Tradeoff (percentage of effective branches with low quality) by quality indicator and branch size

	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)

LB – large branch, MB – medium sized branch, SB – small branch, in brackets are number of observations

[25] Cut-off for high productivity is set at 1, and cut-off for high quality is set in the 50% percentile through all branches.
[26] Tradeoff by quality indicators and region is shown in *Appendix, Table A3.*
[27] 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.

The volume of tradeoff by region is presented in the *Appendix, Table A3*. There is a large tradeoff in DEA models with a quality indicator service quality index of 83%-100% in Region A, which clearly indicates that in Region A, client officers are motivated by the quantity of the sold products, while quality takes second place. However, the lowest tradeoff is in Region F.

5.4 Method II — Quality indicator as an independent factor

In the second specification of the 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 presented in *Table 12* and in *Appendix, Table A4*.

The best practice branches are located in Quadrant 1. Their average efficiency score is 100%, and their average value of quality indicators is above the cut-off value. Branches in Quadrant 2 are those where efficiency is 1, but the value of quality indicators is low, below the cut-off.

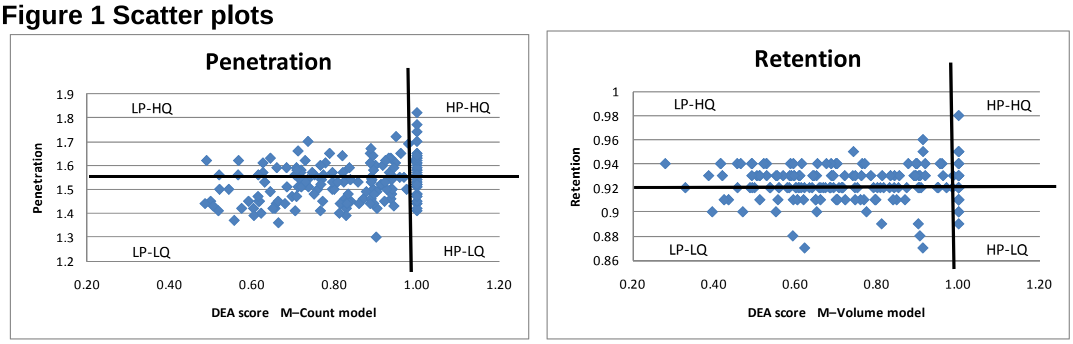
Table 12 Average efficiency and average value of quality indicators according to the quadrants

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

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 highlight which branches are the best practice branches and which are able to make improvements by increasing quality or productivity, branches are depicted in two-dimensional 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 in *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, the model is unable to quantify efficiency with respect to quality.

5.5 Method III — Quality adjusted DEA model

In the final specification of the standard DEA model, productivity-quality tradeoff is completely eliminated by the multi-stage quality adjusted DEA model.[28] Here, all inefficient branches are compared to the best practice branches, which are efficient and high quality. The average efficiency is the highest at this specification due to quality adjustment, as demonstrated in *Table 13.*[29]

Table 13 Comparison of average efficiency

		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%

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

When efficiency is increased, potential cost reductions decrease. Within the standard DEA model, the suggested cost saving is 16%. On other hand, the total potential cost reduction by the quality adjusted DEA model is about 10%, which is significantly lower than the amount suggested with the standard DEA model when it does not adjust for quality. It was also tested to see whether the average efficiency is the same using all methods and the results of t-tests demonstrate that there are significant differences in average efficiency on the significance level, 5%.[30] This result clearly indicates that service quality has significant impact on the efficiency of branch network, and it should be incorporated into DEA models and operational processes.

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 score low in service quality. There are 11-31 branches with an efficiency score below 70%, which means that costs (number of FTEs) can be reduce by at least 30% in order to operate efficiently.

[28] 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.
[29] Results for M–Volume models are in *Appendix, Table A5-A7*
[30] Due to limited space, detailed results are not reported in the paper

Table 14 Distribution of branches based on efficiency score by Quality adjusted DEA model

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

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, which has the lowest purchasing power; they are mainly small branches with 4-6FTEs. The proportion of small branches within the best practice branches is 39-67%, depending on the quality indicator used.

Table 15 Description of best practice branches with respect of region and branch size

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%

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 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 was assumed by the bank. These results, however, are in line with other DEA studies[31], such as Sherman and Zhu (2006).

6. Conclusion

In this chapter, there were three methods applied to incorporate the quality dimension into the performance of bank branches. Quality of service is measured through service quality, product penetration, client information, and retention index. We identified that the productivity–quality tradeoff exists and it is possible to avoid through multi-level quality adjusted DEA model, where benchmark branches have not only high productivity but high

[31] Some DEA studies show that optimal branch is about 6-9 FTEs. It might differ bank by bank depending on bank processes. However, most of benchmarking studies show that bigger branches (above 15FTEs) are mostly less efficient in terms of activities and customer satisfaction due likely to two reasons: lower complexity (higher manageability) and more human-client focused approach. Managers of small branches also act more as owners and not officers.

service quality as well. Results show that service quality has a significant impact on branch efficiency, and it should be incorporated into DEA models and operational processes. The essay demonstrates the short-term interaction among service quality and operating branch efficiency.

From a policy perspective, the essay provides evidence that there are real reserves for improvement, an average efficiency of 74-84%, which can be realized through optimal resource allocations and increasing service quality. We discovered 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 evidence that larger branches are less efficient than smaller ones. Results also show that branches in the region with the highest purchasing power are not able to fully utilize their opportunities, which implies lower efficiency. Branches that operate efficiently with respect to the number of sold products do not necessarily operate efficiently with respect to new volumes on those products. In addition, branches are less homogenous with respect to new volume than by number of new products sold.

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

Most importantly, the quality indicator that explains efficiency is product penetration. Further, the quality level and magnitude of the productivity-quality tradeoff differs by branch size and region. Those branches that have high-quality service are measured by mystery shopping and mystery calls, and they have less client service meetings, which indicates 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 calls. Interestingly, branches in regions with high purchasing power have worse results in terms of product penetration, mystery shopping, and mystery calls than branches with low purchasing power. The largest productivity-quality tradeoff was found at large branches with respect to quality indicators, mystery shopping, and mystery calls.

APPENDIX

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

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 A2 Description of quality indicators used in DEA models

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 A3 Tradeoff (percentage of effective branches with low quality) by quality indicator and region – Method I

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)

in brackets are number of observations

Table A4 Average efficiency and average value of quality indicators according to the quadrants in Method II DEA model

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

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

Table A5 Comparison of average efficiency

		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%

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

Table A6 Distribution of branches based on efficiency score by Method III - Quality adjusted DEA model

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

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%

Table A7 Description of best practice branches in Method III with respect of region and branch size

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%

SB – small branch, # – number of branches within benchmarks, % – percentage of best practice branches with a certain characteristic

REFERENCES

Athanassopoulos AD (1997): Service quality and operating efficiency synergies for management control in the provision of financial services: Evidence from Greek bank branches, *European Journal of Operational Research*, 98(2):300-313

Athanassopoulos AD (1998): Nonparametric frontier models for assessing the market and cost efficiency of large-scale bank branch networks, *Journal of Money, Credit and Banking*, 30(2):172-192

Athanassopoulos AD, Giokas D (2000): The Use of Data Envelopment Analysis in Banking Institutions: Evidence from the Commercial Bank of Greece, *Interfaces*, 30(2):81-95

Banker RD, Charnes A, Cooper WW (1984): Some models for estimating technical and scale inefficiencies in Data envelopment analysis, *Management Science*, 30(9):1078-1192

Beamon BM (1999): A model and measurement approach for studying retail productivity, *International Journal of Operational and Production Management*, 19(3):275-292

Berger AN, Humphrey DB (1997): Efficiency of financial institutions: international survey and directions for future research, *European Journal of Operational Research*, 98(2):175-212

Brazdik F, Druska V (2005): Too large or too small? Returns to scale in a retail network, CERGE-EI Working Paper, no. 273

Callen JL (1991): Data Envelopment Analysis: Partial Survey and Applications for Management Accounting, *Journal of management accounting research*, 3:35-56

Camanho AS, Dyson RG (1999): Efficiency, size, benchmarks and targets for bank branches: an application of data envelopment analysis, *Journal of the Operational Research Society*, 50(9):903-915

Charnes A, Cooper WW, Rhodes E (1978): Measuring the efficiency of decision making units, *European Journal of Operational Research*, 2(6):429-444

Cook WD, Seiford LM, Zhu J (2004): Models for performance benchmarking: Measuring the effect of e-commerce activities on banking performance, *Omega*, 32(4):313-322

Cooper WW, Seiford ML, Zhu J (2004): *Handbook on Data Envelopment Analysis*, Kluwer Academic Publisher, UK

Drake L, Howcroft B (1994): Relative efficiency in the branch network of a UK Bank: an empirical study, *Omega*, 22(1):83-90

Emrouznejad A, Barnett RP, Tavares G (2008): Evaluation of research in efficiency and productivity: A survey and analysis of the first 30 years of scholarly literature in DEA, *Socio-Economic Planning Sciences*, 42(3):151-157

Giokas D (1991): Bank branch operating efficiency: a comparative application of DEA and the loglinear model, *Omega*, 19(6):549-557

Irsova Z (2009): Measuring bank efficiency, Master thesis at the Institute of Economic Studies, Charles University

Lynch R (2005): *Corporate Strategy*, Prentice Hall, UK

Oral M, Kettani O, Yolalan R (1992): An empirical study of analyzing the productivity of bank branches, *Institute of Industrial Engineers Transactions*, 24(5):166-176

Oral M, Yolalan R (1990): An empirical study on measuring operating efficiency and profitability of bank branches, *European Journal of Operational Research*, 46(3):282-294

Reynolds D (2004): An exploratory investigation of multiunit restaurant productivity assessment using data envelopment analysis, *Journal of Travel and Tourism Marketing*, 16(2-3):19-26

Schaffnit C, Rosen D, Paradi JC (1997): Best practice analysis of bank branches: an application of DEA in a large Canadian bank", *European Journal of Operational Research*, 98(2):269-289

Sevcovic D, Halicka M, Brunovsky P (2001): DEA analysis for a large structured bank branch network, *Central European Journal of Operational Research*, 9:329-342

Sherman HD, Ladino G (1995): Managing bank productivity using Data envelopment analysis (DEA), Interfaces, 25(2):60-73

Sherman HD, Zhu J (2006): *Service productivity management, Improving service performance using Data Envelopment Analysis*, Springer Science + Business Media, LLC, USA

Soteriou A, Zenios SA (1999): Operations, Quality and Profitability in the provision of banking services", *Management sciences*, 45(9):1221-1238

Spearman C (1994): The Proof and Measurement of association between two things, *American Journal of Psychology*, 15(1):72-101

Tone K (1993): An epsilon-free DEA and a new measure of efficiency, *Journal of the Operational Research Society Japan*, 36(3):167-174

Tulkens H (1993): On FDH efficiency analysis: some methodological issues and applications to retail banking, courts and urban transit, *Journal of productivity analysis*, 4(1-2):183-210

Waterman R et al. (1980): Structure Is Not Organization, *Business Horizons*, 23(3):14–26

Waterman R et al. (1982): *In Search of Excellence*, New York, Harper & Row

Zhu J (2009): *Quantitative models for performance evaluation and benchmarking*, Worcester Polytechnic Institute, Worcester, MA, USA

IES Working Paper Series

2009

1. František Turnovec : *Fairness and Squareness: Fair Decision Making Rules in the EU Council?*
2. Radovan Chalupka : *Improving Risk Adjustment in the Czech Republic*
3. Jan Průša : *The Most Efficient Czech SME Sectors: An Application of Robust Data Envelopment Analysis*
4. Kamila Fialová, Martina Mysíková : *Labor Market Participation: The Impact of Social Benefits in the Czech Republic*
5. Kateřina Pavloková : *Time to death and health expenditure of the Czech health care system*
6. Kamila Fialová, Martina Mysíková : *Minimum Wage: Labour Market Consequences in the Czech Republic*
7. Tomáš Havránek : *Subsidy Competition for FDI: Fierce or Weak?*
8. Ondřej Schneider : *Reforming Pensions in Europe: Economic Fundamentals and Political Factors*
9. Jiří Witzany : *Loss, Default, and Loss Given Default Modeling*
10. Michal Bauer, Julie Chytilová : *Do children make women more patient? Experimental evidence from Indian villages*
11. Roman Horváth : *Interest Margins Determinants of Czech Banks*
12. Lenka Šťastná : *Spatial Interdependence of Local Public Expenditures: Selected Evidence from the Czech Republic*
13. František Turnovec : *Efficiency of Fairness in Voting Systems*
14. Martin Gregor, Dalibor Roháč : *The Optimal State Aid Control: No Control*
15. Ondřej Glazar, Wadim Strielkowski : *Turkey and the European Union: possible incidence of the EU accession on migration flows*
16. Michaela Vlasáková Baruníková : *Option Pricing: The empirical tests of the Black-Scholes pricing formula and the feed-forward networks*
17. Eva Ryšavá, Elisa Galeotti : *Determinants of FDI in Czech Manufacturing Industries between 2000-2006*
18. Martin Gregor, Lenka Šťastná : *Mobile criminals, immobile crime: the efficiency of decentralized crime deterrence*
19. František Turnovec : *How much of Federalism in the European Union*
20. Tomáš Havránek : *Rose Effect and the Euro: The Magic is Gone*
21. Jiří Witzany : *Estimating LGD Correlation*
22. Linnéa Lundberg, Jiri Novak, Maria Vikman : *Ethical vs. Non-Ethical – Is There a Difference? Analyzing Performance of Ethical and Non-Ethical Investment Funds*
23. Jozef Barunik, Lukas Vacha : *Wavelet Analysis of Central European Stock Market Behaviour During the Crisis*
24. Michaela Krčílková, Jan Zápal : *OCA cubed: Mundell in 3D*
25. Jan Průša : *A General Framework to Evaluate Economic Efficiency with an Application to British SME*
26. Ladislav Kristoufek : *Classical and modified rescaled range analysis: Sampling properties under heavy tails*
27. Natálie Švarcová, Petr Švarc : *Diffusion Processes on Complex Networks*

28. Goran Serdarević, Petr Teplý : Efficiency of EU Merger Control in the 1990-2008 Period
29. Jiri Novak, Dalibor Petr : *Empirical Risk Factors in Realized Stock Returns*
30. Karel Janda, Eva Michalíková, Věra Potácelová : *Vyplácí se podporovat exportní úvěry?*
31. Karel Janda, Jakub Mikolášek, Martin Netuka : *The Estimation of Complete Almost Ideal Demand System from Czech Household Budget Survey Data*
32. Karel Janda, Barbora Svárovská : *Investing into Microfinance Investment Funds*

2010

1. Petra Benešová, Petr Teplý : *Main Flaws of The Collateralized Debt Obligation's Valuation Before And During The 2008/2009 Global Turmoil*
2. Jiří Witzany, Michal Rychnovský, Pavel Charamza : *Survival Analysis in LGD Modeling*
3. Ladislav Kristoufek : *Long-range dependence in returns and volatility of Central European Stock Indices*
4. Jozef Barunik, Lukas Vacha, Miloslav Vosvrda : *Tail Behavior of the Central European Stock Markets during the Financial Crisis*
5. Onřej Lopušník : *Různá pojetí endogenity peněz v postkeynesovské ekonomii: Reinterpretace do obecnější teorie*
6. Jozef Barunik, Lukas Vacha : *Monte Carlo-Based Tail Exponent Estimator*
7. Karel Báťa : *Equity Home Bias in the Czech Republic*
8. Petra Kolouchová : *Cost of Equity Estimation Techniques Used by Valuation Experts*
9. Michael Princ : *Relationship between Czech and European developed stock markets: DCC MVGARCH analysis*
10. Juraj Kopecsni : *Improving Service Performance in Banking using Quality Adjusted Data Envelopment Analysis*

All papers can be downloaded at: http://ies.fsv.cuni.cz

Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz