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Regional Differences in the Efficiency of German Savings Banks

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Abstract

German savings banks play a key role in financing German SMEs. Accordingly, the analysis of their efficiency is of economic importance. We apply data envelopment analysis to explore the influence of the financial crisis (2007 to 2008) as well as the Eurozone crisis (since the end of 2009) on the efficiency of German savings banks. Although the Malmquist index, as a measure of efficiency change and technological change, is on average below one in our sample from 2003 to 2014, we conclude from our efficiency results that German savings banks recovered quickly after the financial crisis as well as the Eurozone crisis. We test for and explain regional efficiency differences between Eastern and Western German savings banks. Since Eastern and Western Germany represent two socio-economically different environments, we control for environmental variables. Our results show that Eastern German savings banks are less inefficient than Western German savings banks since other earning assets, i.e., securities and advances to banks, and refinancing costs are advantageous for their efficiency.

Regionale Unterschiede bei der Effizienz deutscher Sparkassen

Zusammenfassung

Deutsche Sparkassen spielen eine wichtige Rolle bei der Finanzierung deutscher KMUs. Die Analyse ihrer Effizienz ist daher von besonderer ökonomischer Bedeutung. Wir verwenden die Data-Envelopment-Analyse, um den Einfluss der Finanzkrise (2007 bis 2008) und der Eurokrise (seit Ende 2009) auf die Effizienz von deutschen Sparkassen zu untersuchen. Obwohl sich der Malmquist Index als ein Maß für Effizienz- und technologische Änderungen in unseren Daten von 2003 bis 2014 im Durchschnitt unter eins

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bewegt, schlussfolgern wir aus unserer Effizienzanalyse, dass sich die deutschen Sparkassen sowohl nach der Finanz- als auch im Verlauf der Eurokrise schnell erholen konnten. Wir testen und erklären regionale Effizienzunterschiede zwischen ostdeutschen und westdeutschen Sparkassen. Da es sich bei Ost- und Westdeutschland um zwei sozioökonomisch verschiedene Gebiete handelt, berücksichtigen wir Umweltvariablen. Unsere Resultate zeigen, dass ostdeutsche Sparkassen weniger ineffizient sind als ihre westdeutschen Pendants, da sich Vermögensgegenstände in Form von Wertpapieren und Forderungen gegenüber Kreditinstituten sowie die Refinanzierungskosten vorteilhaft auf ihre Effizienz auswirken.

Keywords: Data envelopment analysis, environmental variables, German banking system, Malmquist index

JEL Classifications: C33, C61, G21

I. Introduction

German savings banks provide financial products and services in their respective local region and play a key role in financing German SMEs (*Simpson* 2013). With a market share in corporate lending of 43 percent in 2014 under the common trade brand Sparkasse, the savings banks finance group constitutes a major part of German universal banks. The 416 publicly owned savings banks (including five joint-stock companies) each operate independently within their respective local region. Thereby, they are subject to a public mandate while simultaneously competing with other universal banks.

Due to their specific owner structure and public role as well as in view of the financial crisis, current regulatory issues and demographic change, the measurement of German savings banks' efficiency is a widely discussed topic (*Gubelt* et al. 2000; *Kositzki* 2004; *Padberg/Werner* 2005; *Poddig/Varmaz* 2005; *Bresler* 2007; *Tischer* 2011; *Conrad* et al. 2014; *Ahn/Le* 2015; *Christians/Hartl* 2015). Recently, the influence of environmental variables on German savings banks' efficiency receives increasing interest. Considering environmental variables is of importance when comparing savings banks in a heterogeneous environment.

Wutz (2002) was the first to integrate environmental variables in an efficiency analysis of the German banking market. Analyzing Bavarian cooperative banks, he finds positive influences of deposits per customer and the gross interest rate margin explaining up to 20 percent of inefficiencies. *Bresler* (2007) measures the efficiency of mergers of German savings banks considering variables that the management cannot influence in the short run. She does not find an influence of regional differences approximated by income per capita at the federal state level. *Tischer* (2011) divides German savings banks into four homogeneous clusters and analyzes efficient banks in structurally weak regions. He concludes that savings banks in structurally weak clusters are less inefficient since they concentrate on credit substitutes and the commission-based business.

Conrad et al. (2014) analyze the influence of environmental variables while considering demographic change. Competitive pressure shows the strongest influence and positively affects German savings banks' efficiency in their study. They cannot confirm regional differences of average bank efficiency between Eastern and Western German savings banks. *Christians/Hartl* (2015) study Eastern German cooperative and savings banks and conclude that efficient savings banks put more weight on cost reduction. They cannot classify efficient banks by federal state.

German savings banks' efficiency during times of crises is of interest when analyzing their contribution to the stability of the German financial system. The savings bank sector weathered the financial crisis and the Eurozone crisis relatively well showing stable performance figures (*Brämer* et al. 2010; *Gropp* et al. 2012; *Schrooten* 2013; *Detzer* et al. 2017; *Gärtner/Flögel* 2017). However, the analysis of savings banks' efficiency during times of crises is not widely covered. *Ahn/Le* (2015) find negative effects of the financial crisis on German savings banks' efficiency with a quick recovery. In this paper, we provide an efficiency analysis of 385 German savings banks from 2003 to 2014 based on the Bankscope database (we excluded banks with incomplete data). As we control for environmental variables, we are able to test for regional differences between Eastern and Western German savings banks.

In the first part of this study, we apply data envelopment analysis (DEA) to compute technical efficiency under the production and the intermediation approach. Efficiency changes over time are analyzed by the Malmquist index (MI). We expect decreasing efficiencies during times of crises since changes in the term structure could have negative effects on interest margins. Moreover, depreciations of loans could increase and the business volume could decrease. In addition, we assume that higher regulatory requirements as a result of the financial crisis (Basel III) lead to higher costs, in particular for small banks.

In the second part, we adjust efficiency by integrating significant environmental variables. Subsequently, we test for average efficiency differences between Eastern and Western German savings banks and explain potential differences. We disaggregate our analysis only to the federal state level for two reasons. Firstly, we try to find evidence if differences in the business strategies of Eastern and Western German savings banks find expression in their average efficiencies. Secondly, disaggregating to the county level would induce assignment problems for some savings banks. In addition, there could be a bias for affluent suburbs that may average out at the federal state level.

Although MI is below one on average, we conclude from our efficiency results that German savings banks recovered quickly after the financial crisis as well as the Eurozone crisis, which implies stabilizing effects for the German banking system. We contribute to the existing literature on the stability of the German savings bank sector during times of crises as we cover efficiency changes of single savings banks. In addition, we find regional differences in efficiency between Eastern and Western German savings banks and, thereby, contribute to the existing literature on environmental variables. These differences can be explained by other earning assets in terms of securities and advances to banks and refinancing costs, which are advantageous for the efficiency of Eastern German savings banks.

The remainder of our paper is organized as follows. Section II illustrates the theoretical background of DEA. In section III, we set up the efficiency analysis and discuss our main findings in times of crises. Section IV addresses the environmental adjustment to test for regional differences. Section V briefly concludes our paper.

II. DEA Set-up

We use DEA since it does not require assumptions about the form of the production function except that it is convex to the origin. Instead, the production function is estimated from efficient decision making units (DMUs) of the sample – the benchmark technology. Thereby, DEA compares the input-output relation of each single DMU with the benchmark technology. An efficiency measure between zero and one is assigned to each DMU, where values below one indicate the degree of inefficiency. The efficiency measure dates back to *Farrell* (1957) and was transferred into a linear programming model by *Charnes* et al. (1978).

Considering German savings banks as similar but independently operating DMUs, we conduct an input-oriented and an output-oriented approach. The former one is characterized by the following optimization problem:

$$
\begin{aligned}
&\min\ \theta_B \\
&\text{s.t.} \sum_{i=1}^{n} \lambda_i \cdot x_{j,i} \le \theta_B \cdot x_{j,B} \quad \text{for } j = 1,\ldots,p \\
&\sum_{i=1}^{n} \lambda_i \cdot y_{k,i} \ge y_{k,B} \qquad \text{for } k = 1,\ldots,q \\
&\lambda_i \ge 0,\ \theta_B \ \text{free in sign}
\end{aligned} \tag{1}
$$

For all inputs $x_{j,B}$, DMU B's efficiency θ_B is minimized with respect to the corresponding linear combination of efficient DMUs (from the set of n DMUs) for a specified output level $y_{k,B}$. Thereby, λ_i serves as weight of the DMUs constituting the estimated benchmark technology for DMU B – which should be positive. The output-oriented optimization problem reads as follows:

$$
\begin{aligned}
& \max \phi_B \\
& \text{s.t.} \sum_{i=1}^{n} \lambda_i \cdot x_{j,i} \leq x_{j,B} \qquad \text{for } j = 1,\ldots,p \\
& \sum_{i=1}^{n} \lambda_i \cdot y_{k,i} \geq \phi_B \cdot y_{k,B} \quad \text{for } k = 1,\ldots,q \\
& \lambda_i \geq 0,\ \phi_B \ \text{free in sign}
\end{aligned} \tag{2}
$$

Here, input level $x_{j,B}$ of the considered DMU B is fixed while maximizing output-oriented efficiency ϕ_B over the benchmark technology. Both approaches work under constant returns to scale interpreted as technical efficiency (TE) (*Charnes* et al. 1978). To separate pure technical efficiency (PTE) from scale efficiency (SE), variable returns to scale in terms of the unity constraint of the benchmark DMUs weights, $\sum_{i=1}^{n} \lambda_i = 1$, are introduced. Thereby, DMU B is compared only with efficient DMUs of similar scale. The variable returns to scale efficiency measure leads to PTE, whereas SE can be obtained as follows: TE/PTE = SE (*Banker* et al. 1984). While PTE relates to the effort of the management, SE evaluates the scale of operation.

In the literature, there is no consensus how to select inputs and outputs in DEA (*Avkiran* 2006; *Fethi/Pasiouras* 2010; *Ahn/Le* 2015). Different models of the banking business are suggested in the banking industry literature. The most common approaches are the production, the intermediation, the user-cost and the value-added approach. In a survey of 130 academic articles measuring banking performance within a set of 21 countries, *Berger/Humphrey* (1997) conclude that the two mostly applied frameworks are the production and the intermediation approach. The production approach considers banks as providers of banking products and services; the intermediation approach relates to the transformation function of banks.

Fethi/Pasiouras (2010) review 196 studies and conclude that the profit-oriented intermediation approach receives limited attention. Since German savings banks are under a public mandate, profit maximization might not be a proper objective function. Consequently, *Ahn/Le* (2015) apply a decision-oriented performance measurement framework, which relates the input-output selection to the stakeholders' objective function. However, since savings banks act in the highly competitive market of universal banks, we apply the profit-oriented intermediation approach and the production approach. In addition, we compare efficiency changes over time from 2003 to 2014 applying the Malmquist index (MI) developed by *Malmquist* (1953) and introduced in DEA by *Färe* et al. (1992):

$$MI(X_B^{t+1}, Y_B^{t+1}, X_B^t, Y_B^t) = EC \cdot TC = \left[\frac{TE^t(X_B^{t+1}, Y_B^{t+1})}{TE^t(X_B^t, Y_B^t)} \cdot \frac{TE^{t+1}(X_B^{t+1}, Y_B^{t+1})}{TE^{t+1}(X_B^t, Y_B^t)}\right]^{1/2}$$

(3) $$EC = \frac{TE^{t+1}(X_B^{t+1}, Y_B^{t+1})}{TE^t(X_B^t, Y_B^t)}$$

$$TC = \left[\frac{TE^t(X_B^t, Y_B^t)}{TE^{t+1}(X_B^t, Y_B^t)} \cdot \frac{TE^t(X_B^{t+1}, Y_B^{t+1})}{TE^{t+1}(X_B^{t+1}, Y_B^{t+1})}\right]^{1/2}$$

MI decomposes efficiency changes into the efficiency change (EC) of all DMUs considered and the technological change (TC) of only efficient DMUs. EC evaluates TE by comparing the input vector X with the output vector Y of DMU B from point in time t to $t+1$. TC covers mixed-period effects, where $TE^t(X_B^{t+1}, Y_B^{t+1})$ compares TE of DMU B in $t+1$ to the benchmark technology at point in time t. This allows to measure efficiency changes over time, since merely considering EC would ignore level changes of the benchmark technology. Hence, MI above one is related to progress, MI below one indicates regress.

III. Efficiency of German Savings Banks

We apply our efficiency analysis from 2003 to 2014 covering two systemic influences in terms of the financial crisis and the Eurozone crisis. We consider 385 German savings banks as similar but independently acting DMUs. Input and output data are retrieved from financial statements provided by the Bankscope database. We excluded banks with incomplete information and average the efficiencies of the remaining banks.[1]

The production approach is input-oriented and focuses on the efficiency of the production of banking products and services. Therefore, we integrate physical inputs that are required in the production process (see table 1). The number of employees as well as fixed assets – including property, plant and equipment – serve as proxies for operating inputs. Different depreciation methods may influence fixed assets (*Padberg/Werner* 2005). However, due to unavailable market values, we refer to book values.

Since output activities are associated with risk, i.e., market risk and credit risk, the efficiency measure should be risk-adjusted (*Avkiran* 2006). The market values of assets and equity of German savings banks are not observable. Therefore, corresponding time series to estimate volatility do not exist. Based on the Basel Accords, risk is captured by banks' capital adequacy (*Kaparakis* et al. 1994). Accordingly, we integrate total equity – including common equity and reserves –

[1] Summary statistics are available from the authors upon request.

Table 1

Inputs and Outputs in the Production Approach

Inputs	*Outputs*
Number of employees	Total deposits
Fixed assets	Net loans
Equity	Other earning assets
	Total non-interest operating income

as an input variable (*Kaparakis* et al. 1994; *Avkiran* 2006; *Afsharian* et al. 2015).[2] Assuming a functional relationship between value at risk and book value of equity, equity serves as an input variable also in the profit-oriented intermediation approach.

The output side covers the main products and services provided by banks. Total deposits consist of customer deposits, deposits from banks, other deposits and short-term borrowing. Net loans are adjusted by reserves for impaired loans or non-performing loans. Other earning assets include securities as well as advances to banks. Total non-interest operating income covers net income from trading as well as net fees and commissions.

The profit-oriented intermediation approach is output-oriented and mainly based on the income statement. This approach focuses on the efficiency of transforming expenses into income from loans and investments as well as non-interest income. We integrate related revenues and expenses according to table 2. Here, total interest expenses cover interest expenses from customer deposits and interbank funding. Other non-interest expenses are composed of operating expenses in terms of depreciation and administrative expenses. In addition, we consider personnel expenses and equity as additional inputs. Including equity as a stock figure in the income statement-based profit-oriented approach can, again, be justified by the business-limiting role of equity according to the Basel Accords (*Gischer/Stiele* 2009).

Total interest income includes interest income from loans and securities. Total non-interest operating income is identical to the production approach. The interest margin covers the interest contribution and the maturity transformation contribution which includes term structure risk (*Padberg/Werner* 2005). Since

[2] There was a sharp increase of average equity of 23.18 percent in 2011, which is related to the conversion of hidden reserves (Bundesbank 2012). Based on our data, savings banks with higher equity show higher efficiency on average, which is significant in the intermediation approach. This result mirrors the findings of *Maurer* (2016) for German cooperative banks.

Table 2

Inputs and Outputs in the Intermediation Approach

Inputs	*Outputs*
Total interest expenses	Total interest income
Other non-interest expenses	Total non-interest operating income
Personnel expenses	
Equity	

we measure overall profit-efficiency and implicitly control for risk by the amount of equity, the use of total interest income and total interest expenses as output and input, respectively, is appropriate.

Our DEA results in the production approach are as follows. The yearly efficient frontier under constant returns to scales is spanned by 12 to 20 DMUs only slightly affected by the Eurozone crisis. Average TE over the total time span is 0.72. In this light, inputs could be reduced by 28 percent on average to obtain the same output. When decomposing TE, figure 1 shows that PTE drives the development of TE. Total-period average PTE amounts to 0.76. Under variable returns to scale, therefore, 24 percent of inputs could be reduced. Figure 1 illustrates that PTE gradually decreased during the financial crisis. We grouped savings banks according to their efficiency in five intervals. In 2009, we observe downward shifts of PTE in all groups except in the group of savings banks that constitute or are close to the benchmark technology. However, our data shows a fast recovery in 2010.

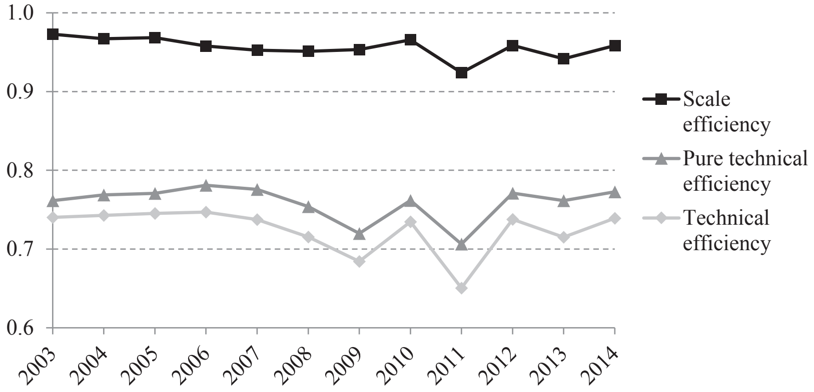

Figure 1: Technical, Pure Technical and Scale Efficiency Under the Production Approach

A stronger decrease of PTE down to 0.71 is visible during the Eurozone crises in 2011. In that year, the number of efficient savings banks decreased from 27 to 19, while the number of savings banks in the group with lowest efficiency sharply increased. However, the magnitude of the PTE decrease of five percentage points from 2010 to 2011 is rather small and followed by a fast recovery within one year. Hence, German savings banks were only marginally affected by global crises in their production of banking products and services and, thus, able to recover quickly. The potential gain of SE improvements compared to PTE is rather low. SE on average amounts to 0.96 and is rather stable and high in comparison to TE and PTE. While the optimal scale of operation is not affected by the financial crisis, the efficiency drop in 2011 shows a small influence with, again, a fast recovery within one year.

Since the maturity transformation contribution to the interest margin is related to term structure risk, its influence on efficiency can be explored by analyzing spot curves. The PTE decreases in 2009 and 2011 seem to be related to temporary inverse term structures (which is more visible in the intermediation approach). However, we could not find significant changes in the book values of net loans. We infer that the inverse term structure during these years did not lead to high depreciations of loans.

Additionally, we apply MI as introduced in section II to decompose efficiency changes over time into shifts of DMUs compared to the benchmark technology (EC) and changes of the technological frontier (TC). Figure 2 shows that MI is on average below one. Therefore, inefficiency is increasing in the savings banks sector in our sample. TC compensates the EC decrease during the financial cri-

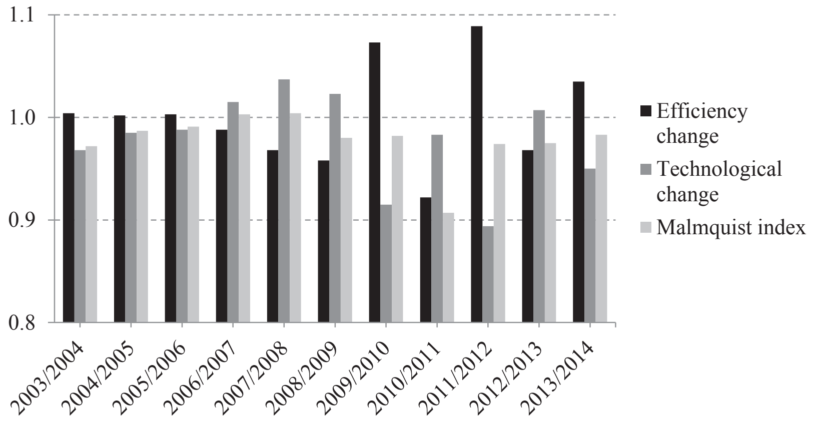

Figure 2: The Malmquist Index and its Components Under the Production Approach

Figure 3: Technical, Pure Technical and Scale Efficiency Under the Intermediation Approach

sis. This implies that efficient savings banks were not affected by the financial crisis, whereas inefficiency of inefficient savings banks increased. However, with a TC decrease of 10.6 percent in 2011/2012, efficient DMUs were also affected by the Eurozone crisis accompanied by a simultaneous EC increase.

Our DEA results for the intermediation approach do not completely mirror our findings of the production approach. The yearly efficient frontier under constant returns to scale (TE) is spanned by six to 23 DMUs. In contrast to the production approach, the benchmark technology is also affected by the financial crisis. Average TE over the time span is 0.83 – eleven percentage points above the production approach. Consequently, on average 20 percent more output could be produced by the same input relative to the benchmark technology.

Similar to the production approach, PTE obviously determines the development of TE (see figure 3). The maximum decrease of PTE amounts to eleven percentage points in 2008. A large number of banks were affected by the financial crisis as they dropped to the lowest efficiency group (101 savings banks in 2008 after three in 2007). Compared with the production approach, the temporary influence of the financial crisis in the intermediation function of German savings banks is more severe. In the profit-oriented intermediation approach, the influence of the inverse term structure is more visible in terms of the lowest net interest incomes in our sample in the years 2007 and 2008.

In contrast to the production approach, the influence of the Eurozone crisis is only visible from 2013 on. In general, PTE is higher in the intermediation approach than in the production approach, which indicates that savings banks appear to be more efficient in their profit generation than in providing banking products and services. Similar to the findings in the production approach, scale

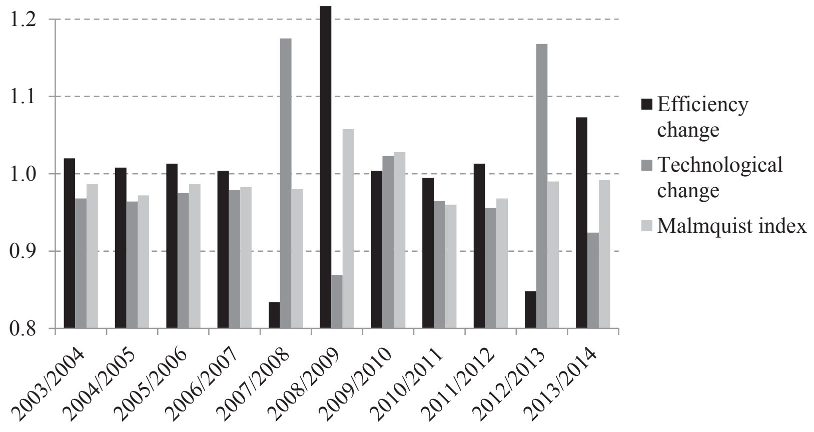

Figure 4: The Malmquist Index and its Components Under the Intermediation Approach

efficiency is high with an average of 0.96, where the scale of operation is slightly affected by the financial crisis.

Figure 4 shows that MI is also below one on average under the intermediation approach, so that efficiency decreases by 0.9 percent per year. As pointed out above, the TE drop (and, therefore, the EC drop) during the financial crisis is larger than in the production approach. However, compared to EC, MI remains rather constant as the technological frontier (TC) was affected with a one-year delay. This effect corresponds to changes in the size of the efficiency groups.

The sharp increase of banks in the lowest efficiency group in 2008 indicates decreasing efficiency from 2007 to 2008. This is compensated in 2009 since a drop of TC reduced the degree of inefficiency with increasing EC as a result. The same picture occurs with the EC drop in 2012/2013 and the TC drop in 2013/2014.

IV. Regional Differences

As discussed in section III, TE is mainly determined by management effort in terms of PTE. In this section, we analyze whether regional differences in the management component of efficiency between Eastern and Western German savings banks exist. We categorize 59 German savings banks from the new federal states into the Eastern group and 326 savings banks from the old federal states into the Western group. Standard DEA assumes similar DMUs with regard to factors that are not directly influenced by management decisions. These factors are referred to as external factors, such as legal form, regulation and en-

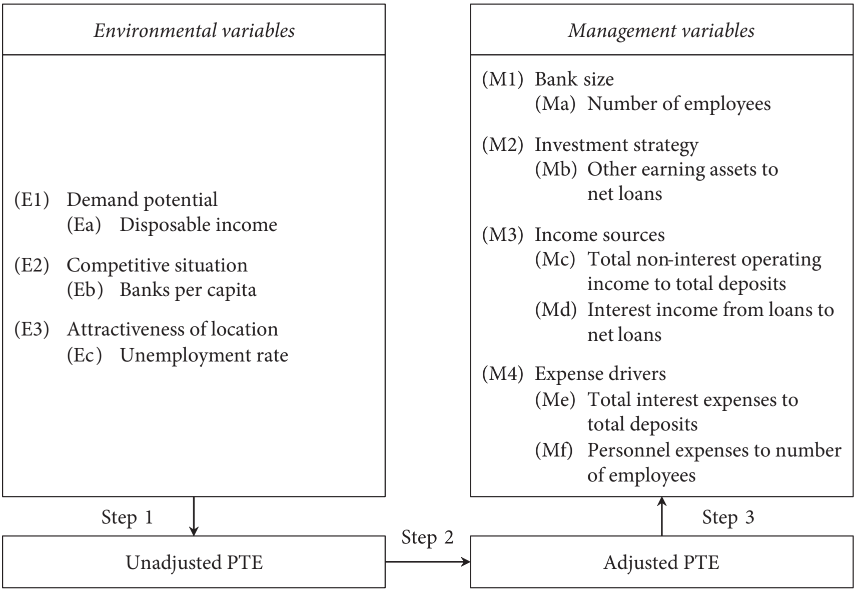

Figure 5: Procedure of Testing and Explaining Regional Differences

vironment (*Coelli* et al. 2005). We assume that savings banks are similar DMUs. However, as we compare the efficiency of two distinct regional subsamples, we control for potentially influencing environmental variables. For this, we test for environmental variables by employing regression analysis.

Subsequently, we integrate these variables as non-discretionary variables into our DEA as suggested by *Banker/Morey* (1986). This approach allows to distinguish inefficiencies from internal management variables and external environmental variables without a-priori assumptions about their direction and influence. Thus, we can test for and explain potential regional differences between Eastern and Western German savings banks. Figure 5 visualizes our procedure.

In step 1, we determine the significance and direction of potential environmental variables influencing (environmentally) unadjusted PTE. We analyze the external success factors suggested by *Riekeberg* (2003) in terms of demand potential (E1), competitive situation (E2) and attractiveness of location (E3). Annual disposable income (Ea) measures the demand potential of banking products and services. The number of banks per capita (Eb) approximates the competitive situation. Finally, the unemployment rate (Ec) serves as an indicator of the attractiveness of the location. All environmental data are on federal state level. We run a Tobit regression (*McCarty/Yaisawarng* 1993):

$$\text{PTE}_i^{\text{unadj.}} = \beta_0 + \beta_1 \cdot \text{dispos. income}_i + \beta_2 \cdot \text{banks per cap.}_i + \beta_3 \cdot \text{unempl. rate}_i + \varepsilon_i \quad (4)$$

where PTE_i is the average PTE of bank *i* in our sample period. The independent variables are also averages over time for the federal state where bank *i* is located. Since PTE ranges from zero to one, formula (4) is similar to standard regression; however, standard errors are different. Table 3 shows that nine percent of unadjusted PTE variance in the production approach and seven percent in the intermediation approach can be explained by environmental variables. Disposable income is significant and positively influences unadjusted PTE in the production as well as in the intermediation approach. Possible explanations are that higher disposable income increases the commission-based business of the bank, which might be highly efficient, and single transactions may show higher amounts, which could lead to better economies of scale.

Banks per capita shows a significant negative effect on unadjusted PTE only in the production approach. Savings banks in federal states with high unemployment rate are less inefficient; this holds for the production and the intermediation approach and mirrors the findings of *Gärtner/Flögel* (2017). A high unemployment rate associated with low income could result in lower-cost deposits. However, as the correlation between disposable income and unemployment rate is –0.29 and, therefore, not perfectly negative, there are also effects in the same direction.

In step 2, we integrate the significant environmental variables in the DEA, i.e., all three factors of table 3 in the production approach and disposable income and unemployment rate in the intermediation approach, to calculate environmentally adjusted PTE. Variables with positive effect are considered as additional inputs, which increase outputs under constant PTE. Variables with negative

Table 3

Impact of Environmental Variables on Unadjusted PTE

	Production approach ($R^2 = 0.09$)		*Intermediation approach* ($R^2 = 0.07$)	
	Coefficient	p-value	Coefficient	p-value
Disposable income in € 1,000	0.034	0.000	0.020	0.000
Banks per capita [m]	–0.002	0.013	0.000	0.794
Unemployment rate in percent	0.021	0.000	0.015	0.000

influence are integrated as outputs, which require more inputs holding PTE constant (*Fried* et al. 1999).

Environmental variables are included as fixed input and output variables, respectively, since the management cannot directly influence them (*Banker/Morey* 1986). Thus, savings banks are compared with an efficient set of banks, which – after weighting – shows similar values of environmental variables. As a result of these additional restrictions, adjusted PTE is technically equal or higher compared to unadjusted PTE. This allows to measure and separate the inefficiency based on regional conditions which may differently affect our two subsamples. The environmentally adjusted DEA for the input-oriented production approach is:

$$
\begin{aligned}
&\min \theta_B \\
&\text{s.t.} \sum_{i=1}^{n} \lambda_i \cdot x_{j,i} \le \theta_B \cdot x_{j,B} && \text{for } j = 1,\dots,p \\
&\sum_{i=1}^{n} \lambda_i \cdot x_{l,i} \le x_{l,B} && \text{for } l = 1,\dots,r \text{ fixed inputs} \\
&\sum_{i=1}^{n} \lambda_i \cdot y_{k,i} \ge y_{k,B} && \text{for } k = 1,\dots,q \\
&\sum_{i=1}^{n} \lambda_i \cdot y_{m,i} \ge y_{m,B} && \text{for } m = 1,\dots,s \text{ fixed outputs} \\
&\sum_{i=1}^{n} \lambda_i = 1 \\
&\lambda_i \ge 0,\ \theta_B \text{ free in sign}
\end{aligned}
\tag{5}
$$

and for the output-oriented intermediation approach:

$$
\begin{aligned}
&\max \phi_B \\
&\text{s.t.} \sum_{i=1}^{n} \lambda_i \cdot x_{j,i} \le x_{j,B} && \text{for } j = 1,\dots,p \\
&\sum_{i=1}^{n} \lambda_i \cdot x_{l,i} \le x_{l,B} && \text{for } l = 1,\dots,r \text{ fixed inputs} \\
&\sum_{i=1}^{n} \lambda_i \cdot y_{k,i} \ge \phi_B \cdot y_{k,B} && \text{for } k = 1,\dots,q \\
&\sum_{i=1}^{n} \lambda_i = 1 \\
&\lambda_i \ge 0,\ \phi_B \text{ free in sign}
\end{aligned}
\tag{6}
$$

Table 4 shows the average environmentally adjusted PTE per year for Eastern and Western German savings banks. Values in parenthesis correspond to unadjusted PTEs. We use the Wilcoxon rank sum test to find differences between Eastern and Western savings banks. Eastern German savings banks exhibit a significantly higher adjusted PTE on average for every year. The average efficiency difference between Eastern and Western savings banks in the production approach increases from 0.047 (= 0.799 – 0.752) to 0.086 (= 0.940 – 0.854) after adjusting for the environment. Thereby, environmental variables account for 70 percent of inefficiencies in the Eastern and 41 percent in the Western subsample.

The average efficiency difference in the intermediation approach slightly increases from 0.050 to 0.061 after adjusting for the environment, while environmental variables account for 60 percent of inefficiencies in the Eastern and 33 percent in the Western region. Since the increase in PTE differs in our two subsamples, Eastern and Western German savings banks cope differently with environmental variables.

In step 3, we define management variables that, according to our understanding, are influenced by the management to explain potential adjusted PTE differences between Eastern and Western German savings banks (see, again, figure 5).

Table 4

Efficiency Differences Between Eastern and Western German Savings Banks

	Production approach		*Intermediation approach*	
Year	Eastern	Western	Eastern	Western
2003	0.945*** (0.816***)	0.825 (0.751)	0.970*** (0.901***)	0.906 (0.845)
2004	0.957*** (0.822**)	0.840 (0.759)	0.961*** (0.902***)	0.914 (0.848)
2005	0.950*** (0.833***)	0.839 (0.760)	0.968*** (0.918***)	0.917 (0.856)
2006	0.950*** (0.828**)	0.878 (0.773)	0.971*** (0.918***)	0.918 (0.871)
2007	0.935*** (0.799)	0.874 (0.772)	0.977*** (0.930***)	0.918 (0.871)
2008	0.926*** (0.759)	0.857 (0.753)	0.967*** (0.853***)	0.847 (0.761)
2009	0.915*** (0.742)	0.841 (0.716)	0.981*** (0.933***)	0.916 (0.884)
2010	0.942*** (0.782)	0.868 (0.758)	0.967*** (0.914*)	0.921 (0.889)
2011	0.939*** (0.766***)	0.850 (0.696)	0.957*** (0.896)	0.920 (0.885)
2012	0.944*** (0.803*)	0.869 (0.765)	0.964*** (0.913*)	0.921 (0.888)
2013	0.946*** (0.819***)	0.846 (0.751)	0.913*** (0.843***)	0.828 (0.779)
2014	0.931*** (0.815**)	0.857 (0.765)	0.923*** (0.872***)	0.861 (0.819)
Average	0.940 (0.799)	0.854 (0.752)	0.960 (0.900)	0.899 (0.850)

Significance levels are *** $p < 0.1\%$, ** $p < 1\%$, * $p < 5\%$. Significance for Western German savings banks equals that of Eastern German savings banks.

Bank size (M1) is measured in terms of number of employees (Ma). The strategic asset investment decision (M2) is characterized by the ratio of other earning assets to net loans (Mb). The decision on main income sources (M3) is represented by the ratios of total non-interest operating income to total deposits (Mc) and interest income from loans to net loans (Md). The management decision on expense drivers (M4) is indicated by the ratios of total interest expenses to total deposits (Me) and personnel expenses to number of employees (Mf). We, again, run a Tobit regression for every year in our sample period:

$$\text{PTE}_i^{\text{adj.}} = \beta_0 + \beta_1 \cdot \text{Ma}_i + \beta_2 \cdot \text{Mb}_i + \beta_3 \cdot \text{Mc}_i + \beta_4 \cdot \text{Md}_i + \beta_5 \cdot \text{Me}_i + \beta_6 \cdot \text{Mf}_i + \varepsilon_i \tag{7}$$

where PTE_i is the PTE of bank i in the corresponding year. The independent variables $(\text{Ma}_i \text{ to } \text{Mf}_i)$ correspond to the values of management variables for every bank i. In addition, we use the Wilcoxon rank sum test to find differences between Eastern and Western savings banks. Table 5 depicts the direction of influence of management variables (by + and –) that are significant at the five percent level on adjusted PTE according to equation (7). Values in parenthesis indicate significantly higher management variables in the Eastern (E) and the Western (W) group, respectively. In table 5, only management variables that are significant in both tests are highlighted. The explanatory power of these variables on adjusted PTE variance ranges from four to 14 percent in the production approach.

We identify three explanatory management variables in the production approach. Firstly, the ratio of other earning assets to net loans (Mb) positively influences adjusted PTE over the entire time period, where a higher value is related to Eastern German savings banks. In this light, the business strategy of a bank with surplus of liabilities at low costs to invest in government bonds appears to be efficient. We note, that this will not hold in the long run if the current period of low interest rates continues.

Secondly, savings banks with a higher ratio of total non-interest operating income to total deposits (Mc) are less inefficient in the majority of analyzed years. A higher value of this ratio is linked to Eastern German savings banks. Again, a higher disposable income that may be related with higher non-interest operating income does not necessarily imply that this part of the revenues is earned in an efficient way. Thirdly, the ratio of personnel expenses to number of employees (Mf) positively influences adjusted PTE over the entire time period, where higher values occur in the Western subsample. We reckon that a positive correlation of salary and educational level of the employees, e.g., more specialists, drives this effect. However, this does not compensate the mentioned advantages of Eastern German savings banks.

Table 5

Impact of Management Variables on Adjusted PTE in Eastern and Western Banks

Year	*Production approach*					*Intermediation approach*				
	Mb	Mc	Md	Me	Mf	Mb	Mc	Md	Me	Mf
2003	+(E)				+(W)			+(E)	−(W)	
2004	+(E)	−(E)			+(W)				−(W)	
2005	+(E)				+(W)				−(W)	
2006	+(E)	+(E)	+(E)	+(W)	+(W)				−(W)	
2007	+(E)	+(E)	+(E)	+(W)	+(W)		+(E)		−(W)	
2008	+(E)	+(E)		+(W)	+(W)		+(E)		−(W)	
2009	+(E)				+(W)				−(W)	
2010	+(E)	+(E)			+(W)			+(E)	−(W)	
2011	+(E)				+(W)			+(E)	−(W)	
2012	+(E)	+(E)			+(W)			+(E)	−(W)	
2013	+(E)	+(E)			+(W)	+(E)	+(E)			−(W)
2014	+(E)	+(E)			+(W)	+(E)	+(E)			

Positive (negative) influence of significant management variables on adjusted PTE is indicated by + (–); E (W) denotes a significantly higher value of the management variable in the Eastern (Western) subsample.

The explanatory power of management variables for adjusted PTE variance in the intermediation approach ranges from seven to 27 percent. Here, we identify only one explanatory management variable: lower refinancing costs (Me) increase adjusted PTE and are associated with Eastern German savings banks. In sum, table 5 provides evidence that the ratio of other earning assets to net loans (production approach) and refinancing costs (intermediation approach) are main drivers of the PTE advantage of Eastern German savings banks.

V. Conclusions

We use data envelopment analysis to explore the influence of the financial crisis (2007 to 2008) as well as the Eurozone crisis (since the end of 2009) on the efficiency of German savings banks. We also test for and explain regional differences between Eastern and Western German savings banks. Since Eastern and

Western Germany represent two socio-economically different environments, we control for environmental variables.

To evaluate the efficiency of German savings banks, we apply the Malmquist index, which is below one on average in our sample period from 2003 to 2014. Therefore, inefficiency increased in the savings banks sector. Efficiency change – a factor of the Malmquist index besides technological change – measures the change of technical efficiency and is driven by pure technical efficiency (PTE). We apply the production and the intermediation approach to compute PTE, which we use to group savings banks to find efficiency migration during times of crises.

PTE of efficient and nearly efficient savings banks (group with highest degree of efficiency) in the production approach was not affected by the financial crisis while the Eurozone crisis influenced the efficiency of all savings banks (in terms of group migration). However, turning upwards within one year, savings banks efficiency could recover quickly. Applying the intermediation approach, efficiency change and technological change appear to be affected to a larger extent, whereas the Malmquist index only slightly decreased since technological and efficiency changes compensate each other.

We test for the influence of environmental variables on PTE and include significant environmental variables as fixed inputs and fixed outputs to compute adjusted PTEs. Our results show that Eastern German savings banks are on average less inefficient than Western German savings banks. The average efficiency difference of our regional subsamples nearly doubled in the production approach and slightly increased in the intermediation approach after controlling for environmental variables. These differences are mainly driven by the ratio of other earning assets to net loans in the production approach and the ratio of total interest expenses to total deposits (refinancing costs) in the intermediation approach. We conclude that other earning assets, i. e., securities and advances to banks, and refinancing costs are advantageous for the efficiency of Eastern German savings banks.

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