# MEASURING THE DEVELOPMENT OF EFFICIENCY AND PRODUCTIVITY OF BANKS IN THE VISEGRAD GROUP: AN APPLICATION OF HICKS-MOORSTEEN TOTAL FACTOR PRODUCTIVITY INDEX

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## ABSTRACT

The research on the banking efficiency all around the world has been one of the main topics for the international financial sectors over the last years. The special case is in Europe. Some of the countries are in the European Union. The European Commission creates the rules for safer and sounder financial sector in these countries. In the past, these rules brought a lot of controversy whether they help to all countries in the European Union or just some of them. The purpose of this article is to determine the development of different types of efficiencies for banking industry in the Visegrad Group. Generally, the development is measured by the Malmquist approach. Different type of index is used in this article, more precisely the Hicks-Moorsteen Total Factor Productivity index. It is one of the alternative indexes. The results have showed that the model with the variable return to scale assumption is better for the use in banking industry in the Visegrad Group, as this model is more precise about the results.

## KEY WORDS

CCR model, VRS model, the Visegrad group, Hicks-Moorsteen TFP index, efficiency

## JEL CODES

G01, G21

# 1   INTRODUCTION

The situation in countries at the European Union (EU) in recent history has been problematic. The crisis, wars and all kinds of conflicts in the past have affected the EU not only demographically, politically but mainly economically.

Since the World War II countries as Czechoslovakia, Hungary and Poland were part of a social bloc. The social block was influenced mainly by the Soviet Union. Economically it was characterized by a centrally planned economy with a focus on economic relations of

countries within the block. This had changed when the social block had fallen apart in 1989. The countries of the social block have to integrate into the international political and economic environment. This brought mutual cooperation in the region. In February 1991 the Visegrad Group (V4) was established. Since the split of Czechoslovakia in 1993, the Visegrad Group is consisted by four countries – the Czech Republic, Hungary, Poland and Slovakia. According to the new situation, it was necessary to create a market economy and gradually to open to the rest of the world. The transformation of the banking system was an essential part of the transformation, as banks play crucial role of financial intermediaries in market economies. Since 2004, all countries of the V4 are part of the EU. They are in the common internal market which includes the financial sector. This is good for further development of financial institutions. There may be problem with the new situation of the competition. In the EU the possibility of foreign financial institutions to enter domestic market is higher than it was in the past. Slovakia also joined the third stage of the European Monetary Union. They adopted the common European currency (euro) in 2009. The rest countries of V4 are still without the euro and they are preparing for the stage.

Nowadays, in time of the world wide globalization there are still differences between countries. These differences affect the structure, development and stability of the financial system. The V4 countries are geographically and historically close. So it should be assumed that the properties of their financial and banking systems should not show major differences. Identification of potential differences of the development in the V4 countries is one of the objectives of this paper.

This paper mainly focuses on a use of Hicks-Moorsteen Total Factor Productivity (TFP) index. It is one of the alternative TFP indexes instead of the popular Mamlquist productivity index (MPI) for measuring the TFP changes. This is due to the work of O'Donnell (2012). He had demonstrated that the MPI cannot be used to reliably measure TFP changes except in some special cases. The work of Kerstens et al. (2010) demonstrates as well that the MPI is not always the TFP index. The technology assumption for the return to scale – constant (CRS) or variable (VRS) is also discussed in literature a lot for MPI with different results, see for example work of Coelli and Rao (2005) or Ray and Desli (1997). For these reasons, this paper employs the Hicks-Moorteen TFP index to analyze banks's performance in the V4 countries for both assumptions – CRS and VRS. Results of both cases are then analyzed and compared.

The remainder of the paper is structures as followed. Next section discuss the review of the literature for the topic. In Section 3 it is exposed the methodology of Hicks-Moorsteen TFP index approach. Section 4 introduces the used data while Section 5 presents empirical results of the paper. Section 6 finally provides final considerations and conclusions.

## 2  LITERATURE OVERVIEW

The empirical analysis of banking efficiency and its decompositions are very frequently discussed topics in literature. In particular, great attention is now focused on the European banking industry. The banking sector is experiencing a difficult situation due to the crisis and all conflicts of the recent years and the pressure of globalization.

In work of Fang et al. (2014) are identified three reasons for the interest. The first talks about many structural changes of banking regulation, financial market structure and competition environment in transition economies. The second discusses the development of security markets and the fact that more banks are treated publicly in stock market nowadays. The third focuses on the idea that there have been established the Basel Capital Accord. Under this the greater supervisory efforts have been focused on risk management and enhancing the capital ratio.

These and probably some other reasons let many authors to study the problematic banking industry all around the world, in Europe, in the V4 or even just in one exact country. For example the work of Lyroudi and Angelidis (2006) and Svitálková (2014) for the Europe may be mentioned as the inspiration. The countries which are part of the V4 were discuss in work of Řepková (2014) or Stavárek and Řepková (2012) for example.

In the literature, there are known two main approaches for evaluation of the bank efficiency as production unit. These approaches are based on the traditional microeconomic theory of the firm. The primary source of difference between them is the treatment of deposits. The approaches are as following:

*Production approach.* This approach views deposits as output. Banks are seen as producers of deposits, loans and other services. The inputs are define as physical variables – labour, material, space, information systems etc. This approach was found by Benston (1965). Benston also found out two main disadvantages of this approach – a detailed database is required (the number of deposit and loan accounts or the operational cost) and it does not take into consideration the interest cost.

*Intermediation approach.* It was found by Sealy and Lindley (1977). In this concept the bank produce intermediation services. Banks are as financial intermediaries channelling funds between depositors and creditors. They collect deposits and other liabilities to apply it as interest-earning assets, such as loans, securities and other investments. The deposits are considered as input in this approach. The advantage of this approach is that operating cost and interest cost are considered.

Nowadays, the second approach – the intermediation approach – is the most common for researchers. This paper is devoted to examining the bank efficiency based on the intermediation approach as well.

This paper is attempt to use the Hicks-Moorsteen TFP index to decompose TFP for banking sector in the V4. Generally for this type of study is used the popular MPI. This index was initially introduced by Caves et al. (1982) as theoretical index. Based on work of Farrell (1957), Färe et al. (1992) have developed a new MPI to measure the changes. They also showed that the new MPI could be decomposed into two change components: technical and efficiency. Later, Färe et al. (1992) made decomposition even further – pure technical efficiency change and change in scale efficiency. However, O'Donnell (2012) presented that the MPI as the TFP index cannot be used to reliably measure TFP changes except some cases. He and later other researches have pointed out that the distance functions constituting the MPI TFP index may well be undefined when estimated by general technologies. On the other hand the Hicks-Moorsteen productivity index is well-defined under weak conditions on technology (weak assumptions of strong disposability) and thus more reliable than the MPI TFP index. For these reasons some new studies employs the Hicks-Moorsteen TFP index, for example Arjomandi et al. (2014), Islam et al. (2014) and so on.

There are some discussions about the assumption of the return to scale. O'Donnell (2012) described that the Hicks-Moorsteen TFP index is better to use for the VRS. Generally, there are mixed results, see Coelli and Rao (2005) or Ray and Desli (1997). In this paper it is supposed that the VRS assumption should be better. The CRS assumption has in banking industry more troubles. The banking industry faces usually imperfect competition, government regulation, un-distinction of size or some other situations. These factors may with the CRS assumption lead to worst results then it would be with the VRS result.

This paper uses the intermediation approach to determine different efficiency changes for banks in the V4 through the Hicks-Moorsteen TFP index with two assumptions of return to scale – CRS and VRS. These analyses are made to better understand the past in this region to be able predicted the future and improve this industry in these countries. There have been some empirical researches on this topic, but the research for the V4 in this period is first.

# 3  METHODOLOGY

## 3.1  The Hicks-Moorsteen TFP index

The standard used definition of the TFP is following

$$\text{TFP}_{nt} = \frac{Y_{nt}}{X_{nt}}, \qquad (1)$$

where $\text{TFP}_{nt}$ is the TFP of the $n$-th decision making unit (DMU) in the period $t$, $X_{nt}$ and $Y_{nt}$ represents the vector of input and output variables, respectively.

The equation 1 expresses the index number that measures changes in TFP as the ration of an output quantity index to an input quantity index. This index number is referred to as multiplicatively-complete index.

O'Donnell (2010, 2012) proved that the Hicks-Moorsteen TFP index is a consistent with the above equation 1 of TFP, so it may as well be define as multiplicatively-complete indexes. The additional value of this index is that it can be computed without required price data. The Hicks-Moorsteen TFP index is define as following:

$$\text{TFP}_{\text{HM}}^{t,t+1} = \left( \frac{D_o^{t+1}(x^{t+1}, y^{t+1})\, D_o^t(x^t, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^t)\, D_o^t(x^t, y^t)} \times \right.$$

$$\left. \times\, \frac{D_i^{t+1}(x^t, y^{t+1})\, D_i^t(x^t, y^t)}{D_i^{t+1}(x^{t+1}, y^{t+1})\, D_i^t(x^{t+1}, y^t)} \right)^{\frac{1}{2}}, \qquad (2)$$

where $D_o^T(x, y) = \min \left\{ \delta > 0 : (x, y/\delta) \in P^T \right\}$ and $D_i^T(x, y) = \max \left\{ \rho > 0 : (x/\rho, y) \in P^T \right\}$ are output and input distance functions, respectively. $P^T$ denotes the period-$T$ production possibilities set in these functions.

This paper is using the nonparametric DEA method to compute the distance functions. This method was also used by O'Donell (2010, 2012). The advantage of the DEA is that it does not require any restrictive assumptions regarding the functional form and efficiency distribution. On the other hand, the DEA has its own limitations and makes no allowance for stochastic noise. These disadvantages have to be taken in mind in interpreting the results. Due to this statistical shortcoming, any possible measurement errors in the data could make the

estimated efficiency and TFP indexes to some extent biased.

## 3.2  The decomposition of the Hicks-Moorsteen TFP index

Advantage of the Hicks-Moorsteen TFP index is also its decomposability. The decomposition is good for better understanding of the situation which is measured.

All detail may be seen in the work of O'Donell (2010, 2012). The general idea is that with some regards to the efficiency measures defined above, the following input-oriented decomposition can be defined as following:

$$\text{TFP efficiency} = \text{TFPE}_t = \frac{\text{TFP}_t}{\text{TFP}_t^*} =$$

$$= \frac{Y_t/X_t}{Y_t^*/X_t^*} = \text{ITE}_t \times \text{IME}_t \times \text{RISE}_t, \qquad (3)$$

where $\text{ITE}_t$ is input-oriented technical efficiency, $\text{IME}_t$ is input-oriented mix efficiency, $\text{RISE}_t$ is residual input-oriented scale efficiency and $\text{TFP}_t^*$ is defined as the maximum TFP possible using any technically feasible inputs and outputs.

The equation 3 may be rewritten as following:

$$\text{TFP} = \text{TFP}_t^* \left( \text{ITE}_t \times \text{IME}_t \times \text{RISE}_t \right). \qquad (4)$$

A similar equation can be formulated for any other DMU like $m$ in period $s$. So the index number which compares the TFP of DMU $n$ in period $t$ with the TFP of DMU $m$ in period $s$ is defined as following:

$$\text{TFP}_{ms,nt} = \frac{\text{TFP}_{nt}}{\text{TFP}_{ms}} = \frac{\text{TFP}_t^*}{\text{TFP}_s^*} \times$$

$$\times \left( \frac{\text{ITE}_{nt}}{\text{ITE}_{ms}} \times \frac{\text{IME}_{nt}}{\text{IME}_{ms}} \times \frac{\text{RISE}_{nt}}{\text{RISE}_{ms}} \right), \qquad (5)$$

technical change × overall efficiency change.

The first component in the brackets on the right-hand side of equation 5 measures technical change from time period $s$ to $t$, quantifying the ratio of the maximum TFP possible, using the technology feasible in period's $t$ and $s$ respectively. Depending on whether $\text{TFP}_t^*/\text{TFP}_s^*$ is greater or less than 1, it can quantify the extent

of technical improvement or technical decline, respectively. If it is equal to 1 the situation does not change. Note, equation 5 measures TFP efficiency change or overall efficiency change.

This includes technical efficiency change, mix efficiency change and (residual) scale efficiency change.

# 4   DATA AND MEASUREMENT OF INPUTS AND OUTPUTS

This paper uses the intermediation approach, as it was chosen as the most improved in this area, see in Section 2. This concept sees banks as producers of intermediation services. Banks should collect deposits and other liabilities to apply it. According to the approach, the basic inputs are physical capital, labour and loanable funds. The basic output are advances and investments.

In previous studies by Hančlová and Chytilová (2015) have been shown that inclusion of the non-interest income into output vector is improving the results. The non-interest income represents in the model the non-traditional activities of banks. If banks are active in the non-traditional activities, it helps them with problematic situation of fee-generating activities. According to this previous analysis, the variable – non-interest income has been include into this model.

Tab. 1 provides the details about input and output variables. The finall model includes three variables in the input vector – physical capital, labour and loanable funds; and it has also three variables in the output vector – advances, investments and non-interest income. The required data have been collected from the BankScope (2015).

This paper is based on period between 2008 to 2013. The V4 countries had many banks during this period. Not all banks have been in this period for all time (bankruptcies, mergers etc.) or some data were missing. These banks were excluded from the analysis. It is due to the fact that a homogeneous set is required for Data Envelopment Analysis. Just banks from the V4 countries which were in the banking industry for whole period (2008–2013) and banks with all needed data from the BankScope were defined as DMUs of this paper. Finally, there have been 27 banks – eight banks from the Czech Republic and Poland, six from Slovakia and five from Hungary. The list of banks is in Tab. 4 in Annex. The fact that all banks have not been used may affect the results. This has to be kept in mind in the final analysis.

# 5   EMPIRICAL ANALYSIS RESULTS

This paper have examined the decomposition of TFP by the Hicks-Moorsteen TFP index for the V4 banks using constant and variable return to scale assumption. In this section are analyzed and presented the main results. There have been provide various efficiency measurements for each individual bank of the V4. To be clearer with the results, this paper presents two kinds of results: (1) results by each country (geometrical average of all banks in the country), and (2) results by over all banking industry in the V4 (geometrical average of all banks in the V4).

Tab. 2 and Tab. 3 report indexes measuring changes in total factor productivity (dTFP), the technology (dTech) and various other types of efficiency for the banking industry in each country of the V4 for each period. Tab. 2 is for index with CRS assumption and Tab. 3 shows results for the VRS assumption.

Tab. 2 with the CRS assumption is showing the following:

- Czech Republic – big improvement in TFP growth (dTFP) of above 31% (1.311) in period 2011–2012. However, there are there

Tab. 1: Description of inputs and outputs

| Variables | Description in the balance sheet | Unit |
|---|---|---|
| *Input variables* | | |
| Physical capital ($x_1$ – FA) | Fixed assets | th Euro |
| Labour ($x_2$ – LAB) | Number of employees | Number |
| Loanable funds ($x_3$ – LF) | Deposits + Short term funding | th Euro |
| *Output variables* | | |
| Advances ($y_1$ – ADL) | Loans + Advances to Banks | th Euro |
| Investments ($y_2$ – INV) | Other Securities | th Euro |
| Non-interest income ($y_3$ – NII) | Non-earning Assets | th Euro |

are two periods when the banking industry experienced a significant deterioration of dTFP of below 100%: the period 2008–2009 (91.7%) when it reached its lowest and the following period 2009–2010 (92.5%) during very slow recovery. This reflect the world-wide financial crisis and policy change in 2010 towards the risk management system of domestic and foreign banks.

- Hungary – improvement in TFP growth (dTFP) of above 20% and 26% was period 2008–2009 and 2010–2012, respectively. There have been not be declare significant deterioration of dTFP. This is little bit surprising, but it may due to the fact that lot of many in Hungary was fixed in Swiss franc which was not effected by the the world-wide financial crisis so much. Also the government influence the banking sector a lot by some restrictions which may with CRS assumption cost some errors as it was mentioned earlier.
- Poland – it is not really seen improvement in TFP growth in first three periods. In fourth period, 2011–2012 there is big improvement in dTFP of 30%, but next year there is a significant deterioration of dTFP of below 100%.
- Slovakia – seems have very turbulent environment. Periods 2008–2009, 2010–2011 and 2012–2013 hows that the FP growth almost did not change. On the other hand, the significant deterioration of dTFP of below 100% are seen in period 2009–2010 (79.1%) and 2011–2012 (95.6%). The reason for the first and largest one is probably the change of currency.

The technological change (dTech) estimates for all countries similar results – in period from 2008 to 2010 the technological change declines. Specially in period 2008–2009 are the values lowest. From 2010 there is change and dTech is improving for all countries. So it again seen that the recovery from the world-wide financial crisis is seen everywhere. Also all countries of the V4 made big changes in the policy of banking risk management which helped also improved the dTech.

Tab. 3 with the VRS assumption is showing similar results as Tab. 2. The trends in TFP change for the Czech Republic and Hungary are same. In case of the Czech Republic it is seen that the values of TFP are more closer to 100%, except of the crisis period. The TFP change of banking in the Czech Republic has no improvement or deterioration since 2008–2009. It may be called stable by the model with VRS assumption. In case of Hungary, the values of TFP are lower – more skeptical about the improvement and more considered about the deterioration. This is more likely in this case, as this industry in Hungary is very restricted by government, so VRS assumption should be more useful. More skeptical situation by dTFP is also presented for Slovakia. Generally, the banking there industry experienced a significant deterioration of dTFP of below 100% or are close to 100% – 2010–2011 and 2012–2013. The low dTFP in first period is cost by he world-wide financial crisis and in the second period is cost by the changing to euro currency and transfer to the third stage of the European Monetary Union. On the other hand, the development of dTFP in Poland is

Tab. 2: Changes in productivity and efficiency by country – CRS assumption

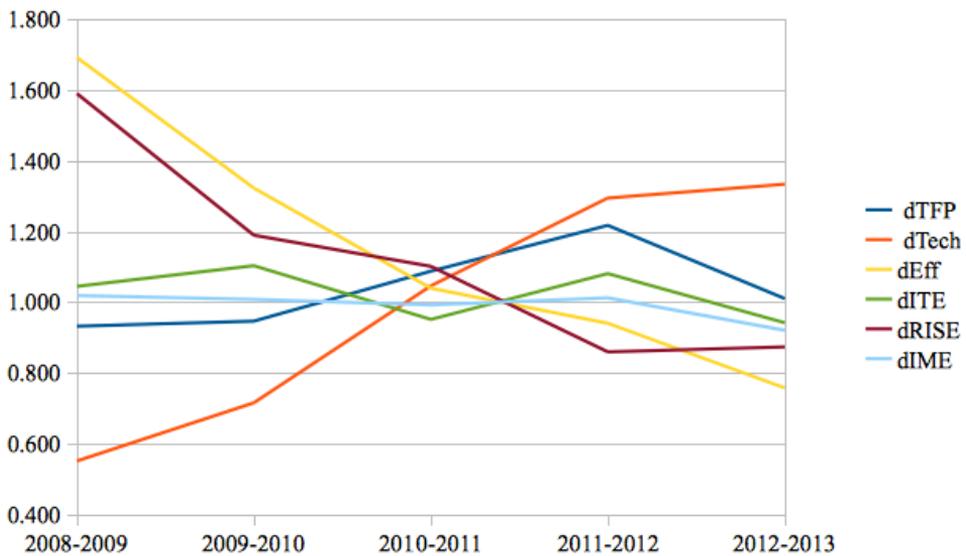| Country | Year | dTFP | dTech | dEff | dITE | dRISE | dIME |
|---|---|---|---|---|---|---|---|
| Czech Republic | 2008–2009 | 0.917 | 0.590 | 1.554 | 1.094 | 1.373 | 1.034 |
|  | 2009–2010 | 0.925 | 0.668 | 1.385 | 1.128 | 1.234 | 0.995 |
|  | 2010–2011 | 1.041 | 1.177 | 0.884 | 0.966 | 0.891 | 1.027 |
|  | 2011–2012 | 1.311 | 1.311 | 1.000 | 1.124 | 0.909 | 0.979 |
|  | 2012–2013 | 1.014 | 1.062 | 0.955 | 0.966 | 0.976 | 1.013 |
| Hungary | 2008–2009 | 1.206 | 0.572 | 2,110 | 1.363 | 1.443 | 1.074 |
|  | 2009–2010 | 0.970 | 0.679 | 1.429 | 1.407 | 1.036 | 0.980 |
|  | 2010–2011 | 1.260 | 1.139 | 1.106 | 0.972 | 1.073 | 1.061 |
|  | 2011–2012 | 1.134 | 1.304 | 0.870 | 1.000 | 0.924 | 0.941 |
|  | 2012–2013 | 0.997 | 1.024 | 0.974 | 0.983 | 0.992 | 0.999 |
| Poland | 2008–2009 | 1.024 | 0.579 | 1.770 | 1.160 | 1.378 | 1.107 |
|  | 2009–2010 | 1.044 | 0.613 | 1.703 | 1.376 | 1.285 | 0.963 |
|  | 2010–2011 | 1.012 | 1.072 | 0.943 | 0.922 | 1.053 | 0.972 |
|  | 2011–2012 | 1.304 | 1.145 | 1.140 | 1.139 | 1.001 | 0.999 |
|  | 2012–2013 | 0.953 | 1.071 | 0.889 | 0.907 | 0.980 | 1.000 |
| Slovakia | 2008–2009 | 1.040 | 0.748 | 1.390 | 1.183 | 1.173 | 1.002 |
|  | 2009–2010 | 0.791 | 0.788 | 1.004 | 0.968 | 1.089 | 0.952 |
|  | 2010–2011 | 1.061 | 1.069 | 0.992 | 1.008 | 0.992 | 0.993 |
|  | 2011–2012 | 0.956 | 1.087 | 0.880 | 0.871 | 0.998 | 1.013 |
|  | 2012–2013 | 1.002 | 1.031 | 0.972 | 0.993 | 0.979 | 1.000 |



Fig. 1: Changes in productivity and efficiency for the V4 – CRS assumption

Tab. 3: Changes in productivity and efficiency by country – VRS assumption

| Country | Year | dTFP | dTech | dEff | dITE | dRISE | dIME |
|---|---|---|---|---|---|---|---|
| Czech Republic | 2008–2009 | 0.848 | 0.475 | 1.785 | 1.079 | 1.633 | 1.013 |
| | 2009–2010 | 0.986 | 0.702 | 1.405 | 1.039 | 1.332 | 1.015 |
| | 2010–2011 | 1.075 | 0.991 | 1.085 | 1.011 | 1.074 | 0.998 |
| | 2011–2012 | 1.014 | 0.702 | 1.445 | 1.070 | 1.318 | 1.025 |
| | 2012–2013 | 1.025 | 1.408 | 0.728 | 0.972 | 0.919 | 0.816 |
| Hungary | 2008–2009 | 1.140 | 0.562 | 2,031 | 1.191 | 1.661 | 1.027 |
| | 2009–2010 | 0.963 | 0.782 | 1.232 | 1.015 | 1.146 | 1.059 |
| | 2010–2011 | 1.225 | 0.987 | 1.241 | 0.950 | 1.294 | 1.010 |
| | 2011–2012 | 1.093 | 1.383 | 0.790 | 1.088 | 0.705 | 1.030 |
| | 2012–2013 | 0.979 | 1.164 | 0.842 | 0.961 | 0.894 | 0.979 |
| Poland | 2008–2009 | 0.975 | 0.449 | 2,169 | 0.952 | 2,191 | 1.040 |
| | 2009–2010 | 1.048 | 0.697 | 1.504 | 1.339 | 1.118 | 1.004 |
| | 2010–2011 | 1.018 | 1.016 | 1.002 | 0.858 | 1.200 | 0.973 |
| | 2011–2012 | 1.101 | 1.061 | 1.038 | 1.018 | 1.019 | 1.001 |
| | 2012–2013 | 0.992 | 1.567 | 0.633 | 0.840 | 0.802 | 0.939 |
| Slovakia | 2008–2009 | 0.841 | 0.864 | 0.973 | 1.016 | 0.966 | 0.992 |
| | 2009–2010 | 0.770 | 0.705 | 1.093 | 0.990 | 1.146 | 0.964 |
| | 2010–2011 | 1.093 | 1.227 | 0.891 | 1.007 | 0.888 | 0.996 |
| | 2011–2012 | 0.938 | 1.189 | 0.788 | 0.874 | 0.915 | 0.987 |
| | 2012–2013 | 1.042 | 1.122 | 0.929 | 1.035 | 0.898 | 1.000 |
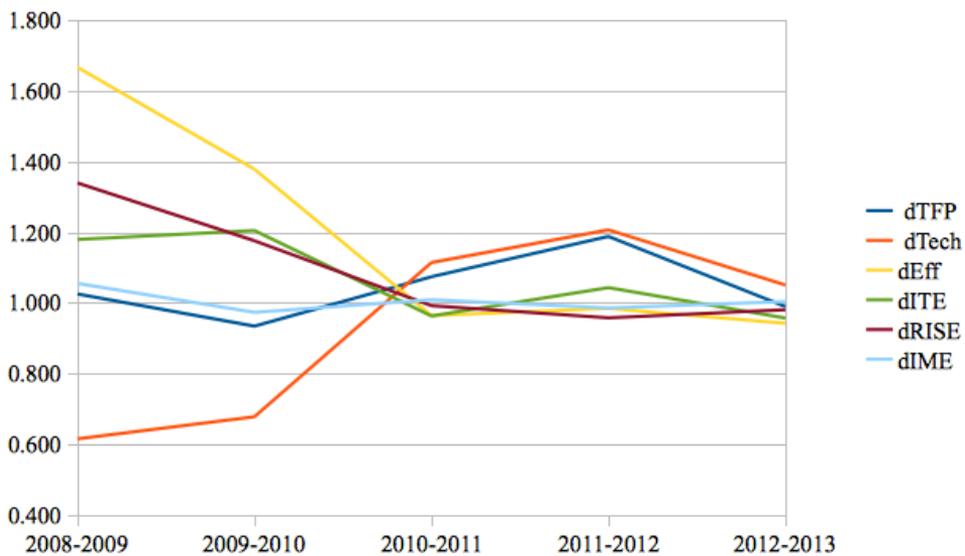


Fig. 2: Changes in productivity and efficiency for the V4 – VRS assumption

seen more positive by the model with VRS assumption.

The technological change (dTech) for model with VRS assumption has same trend for Poland and Slovakia. In case of the Czech Republic it is seen that with this model the dTech is the main trouble which was fixed just in last two periods. Hungarian banking industry struggles with deterioration of dTech mainly in first part of the analyzed period. Over all, for the dTech, the important year was mainly in 2010 – when the risk management was change.

Fig. 1 and 2 give overall total factor productivity change and its components for the V4 countries all together in time period 2008–2013 with the CRS assumption and the VRS assumption, respectively.

Fig. 1 shows that under the CRS assumption the main contributor of dTFP in the banking industry is mainly the technical change (dTech). This is mostly seen in period from 2010 to 2013. In the beginning of the period (2008–2010) it is also seen the influence of pure technical efficiency (dITE). Note, that efficiency changes (dEff) are in the period decreasing really fast until 2010 and then they have oscillate around the value one – so the efficiency changes in the V4 seems to be stable after the recovery from the global crisis. This is mainly cost by the change in residual scale efficiency (dRISE) and also pure technical efficiency (dITE). The

change of mix efficiency (dIME) have oscillate all the time around constant one.

Fig. 2 shows overall total factor productivity changes and its components for the period 2008–2013 with the VRS assumption. From the first look it may be said that Fig. 2 is very similar to Fig. 1. There are some small differences. Firstly, dTFP in first time period (2008–2009) does not decrease. This is cost by higher increase of the dTech and pure technical efficiency (dITE). Secondly, the influence of the pure technical efficiency (dITE) is much more seen in this case during all period. The rest of the changes seem to have very similar character.

From Fig. 1 and 2 it is very clearly seen that the use of the VRS assumption is more convenient for this case. It is due to the fact that dTFP is mainly depending on dTech – technological changes. The technological part for the banking industry is most important. The technological changes (dTech) captures the effect of technological changes as well as the effects of government regulation, central bank policy or competition. And due to the theoretical knowledge these are factors which are not handled in the CRS assumption. Also the different size of analyzed bank is the factors which is better handled by the VRS assumption. Over all, the result from the model with the VRS assumption seems to fit better to the situation in the past as well.

# 6  CONCLUSION

This paper is focusing on measurement of the development of efficiency and productivity of banking industry in the Visegrad Group based on the application of the Hicks-Moorsteen Total Factor Productivity index. The decomposition of Hicks-Moorsteen Total Factor Productivity index is used to see the situation in time from 2008 to 2013. In this paper the Hicks-Moorsteen Total Factor Productivity index uses the DEA for measuring the distance function so this fact let to try which assumption of return to scale is more convenient for this case. There have been estimated many efficiency measurements and components of productivity changes of

the banking industry to better understand the situation in this industry.

Firstly, there have been made calculations for each bank. This brought too many information so the analysis for both models have been made just by the country. The analysis showed that both models give similar results. In the model with CRS assumption the main contributor of dTFP in the industry were just technical changes (dTech). Under the VRS assumption the main contributor of dTFP in the industry were dITE as well as technical changes (dTech) for all countries in the V4. These findings further support that scale inefficiency is a

significant reason behind TFP shortfalls in the industry.

The results from the previous analysis also have been confirmed by the analysis of the overall total factor productivity change and its components. So over all it would be better to use for the future studies the model with VRS assumption as the results seem to be more correct according to reality and the requirements for the technology more fit.

For future work the database should be extended – more banks or different variables as input or output should be tried, for example variable equity is sometimes used as quasi input variable. Also the results should be discuss and compare with some alternative Total Factor Productivity indices like the Färe-Primont or other indices (Fisher, Törnqvist and so on).

# 7  ACKNOWLEDGEMENT

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# 9 ANNEX

Tab. 4: List of banks

|   | Name of bank | Origin of bank |
|---|---|---|
| 1 | Bank Ochrony Środowiska S.A. – BOŚ Bank Ochrony Środowiska Capital Group | PL |
| 2 | Bank Zachodni WBK S.A. | PL |
| 3 | Bank BGŻ BNP Paribas S.A. | PL |
| 4 | Československá obchodní banka, a. s. – ČSOB | CZ |
| 5 | ČSOB stavebná sporiteľňa, a. s. | SK |
| 6 | Erste Bank Hungary Zrt. | HU |
| 7 | Euro Bank S.A. | PL |
| 8 | GE Money Bank, a. s. (MONETA) | CZ |
| 9 | ING Bank Śląski S.A. Capital Group | PL |
| 10 | J & T Banka, a. s. | CZ |
| 11 | mBank Hipoteczny S.A. | PL |
| 12 | mBank S.A. | PL |
| 13 | MKB Bank Zrt. | HU |
| 14 | Modra pyramida stavební spořitelna, a. s. | CZ |
| 15 | Nordea Bank Polska S.A. | PL |
| 16 | OTP Bank PLC | HU |
| 17 | OTP Banka Slovensko, a. s. | SK |
| 18 | Poštová banka, a. s. | SK |
| 19 | PPF banka, a. s. | CZ |
| 20 | Raiffeisen Bank Zrt. | HU |
| 21 | Raiffeisen stavební spořitelna, a. s. | CZ |
| 22 | Sberbank Slovensko, a. s. | SK |
| 23 | Stavební spořitelna České spořitelny, a. s. | CZ |
| 24 | Tatra banka, a. s. | SK |
| 25 | UniCredit Bank Czech Republic and Slovakia, a. s. | CZ |
| 26 | UniCredit Bank Hungary Zrt. | HU |
| 27 | Všeobecná úverová banka, a. s. | SK |

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