

Galetić, Fran; Obradović, Tena

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## Measuring Concentration of the Banking Market of the Republic of Croatia

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## MEASURING CONCENTRATION OF THE BANKING MARKET OF THE REPUBLIC OF CROATIA

Fran Galetić, Tena Obradović

Faculty of Economics and Business, University of Zagreb, Zagreb, Croatia

Faculty of Economics and Business, University of Zagreb, Zagreb, Croatia

[fgaletic@efzg.hr](mailto:fgaletic@efzg.hr)

[tena.obradovic@gmail.com](mailto:tena.obradovic@gmail.com)

### Abstract

*Over the last twenty years, Croatian banking market has been extremely dynamic in terms of market concentration. The number of banks was cut in half, and more often than ever, the banks are merging and acquiring each other. In this thesis there are nine different indices of concentration. Today, there are 26 commercial banks active on the Croatian banking market, which has the elements of both, oligopoly and monopolistic competition. Indices that contribute to the larger banks lead the conclusion toward oligopoly, however indices that emphasize the importance of smaller banks point to moderate and even low concentration. From the year of 2000 until today, the number of banks was cut in half which resulted in increase of the concentration on the banking market. This trend is also expected in the future due to increased merging and acquisitions.*

**Keywords:** *banking market, concentration, Croatia*

Track: *Governance*

Word count: 7.322

### 1. Introduction

The concentration of the Croatian banking market has changed over last 20 years. The number of banks has almost halved, and more often than ever, the banks are merging and acquiring each other. Banks with larger market power have increased their assets and strengthened their position on the banking market thus made it difficult for new banks to enter the market.

The aim of this paper is to calculate and analyze concentration indices for the Croatian banking market. Based on the calculated values of individual indices, conclusions on the concentration can be made.

The paper analyzes the following indices: concentration ratio, Herfindahl-Hirschman's index, Hall-Tideman's, Rosenbluth's index, extensive industrial concentration index, Hannah-Kay's index, Index U, Hause's index and entropy measure. After calculating all of the indices, the analysis and comparison of their values will follow.

### 2. Methodology

The data used in this paper are taken from the official reports of the Croatian National Bank, which is, as the central bank of the Republic of Croatia, responsible for controlling banks' operations, as well as for collecting data on their operations. To determine market

concentration, market shares were determined. As the banking market is specific, the main question is how to measure market shares of each particular bank on the market.

All central banks as the market share criterion determine the share of assets of each bank in the total assets of the banking system. Accordingly, the data for this analysis were obtained from the total assets of each commercial bank. The share of bank's assets in the total assets of the banking system represents its market share.

For the calculation of market concentration indicators, this paper uses unaudited data for credit institutions in the Republic of Croatia on 31 March 2017.<sup>1</sup>

### 3. Literature review

Market concentration is covered in literature from various aspects, and one of these aspects is also banking. Below is an overview of selected researches related to concentration on banking markets. It is arranged chronologically.

Daskin and Wolken<sup>2</sup> indicate the existence of two different regimes in commercial loan banking markets in these states. Increases in concentration in markets that have a concentration below the estimated critical level of concentration are associated with increases in the Lerner index. Increases in concentration have no significant effect on performance in markets with a concentration above the estimated critical level. Increases in concentration in highly concentrated markets apparently provide only negligible gains in market power. The results suggest that market regulators should be more concerned with concentration increases in less concentrated markets and should devote scarce regulatory resources to monitoring those markets.

Weisman<sup>3</sup> explores the trade-off between market concentration and multi-market business through the merger dimension. The impact of multi-market business, which reduces the price, provides the opposite effect of increasing concentration, which increases the price. Higher levels of concentration can be consistent with prices that will not increase, despite the absence of a merger. In the case of a substitute, multi-market operations have an effect on price increases at higher concentrations. Merger guidelines which unnecessarily point out the market concentration can lead to disabling linking policies that improve consumer welfare and vice versa.

Wheelock<sup>4</sup> showed that the number of U.S. commercial banks and savings institutions declined by 12 percent between 2006 and 2010, continuing a consolidation trend begun in the mid1980s. Banking industry consolidation has been marked by sharply higher shares of deposits held by the largest banks - the 10 largest banks now hold nearly 50 percent of total U.S. deposits. However, antitrust policy is predicated on the assumption that banking markets are local in nature, and enforcement has focused on preventing bank mergers from increasing

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<sup>1</sup> Hrvatska narodna banka (2017) Tablica SP1: Privremeni nerevidirani podaci za kreditne institucije, 31 March 2017

<sup>2</sup> Daskin, A.J.; Wolken, J.D. (1989) An Empirical Investigation of the Critical Herfindahl Index in Banking, *Journal of Economics and Business*, Vol. 41, Iss. 2, p. 95 – 105

<sup>3</sup> Weisman, D.L. (2007) *Market Concentration, Multi-Market Participation and Antitrust*, *Research in Law and Economics*, Vol. 22, p. 233 – 257

<sup>4</sup> Wheelock, D.C. (2011) Banking industry consolidation and market structure: impact of the financial crisis and recession, *Federal Reserve Bank of St. Louis*, Vol. 93, Iss. 6, p. 419-438

the concentration of local banking markets. The author finds little change over time in the average concentration of local banking markets or the average number of dominant banks in them, even during the recent financial crisis and recession when numerous bank failures and several large bank mergers occurred. Concentration did not increase substantially, on average, in markets where mergers occurred among banks when both the acquiring and acquired banks had existing local offices, though rural markets generally saw larger increases in concentration from such mergers than did urban markets. Although the structures of local banking markets, on average, have changed little since the mid-1980s, deposit concentration has continued to increase at the level of U.S. Census regions. As technology evolves and the costs of obtaining banking services from distant providers fall further, local market characteristics may become less relevant for analysis of competition in banking

Perera, Skully and Nguyen<sup>5</sup> investigate whether the level of market concentration in Sri Lanka's banking sector is positively associated with bank-specific interest spreads after controlling for other bank-specific and exogenous influences. A pooled, time-series and cross-section model is utilized which distinguishes between banks' dominance in loan and deposit market segments. Changes in industry concentration do not affect bank-level interest margins of Sri Lankan banks. Nevertheless, the dominant Sri Lankan banks seem to extract them and banks' cost structures are priced in their interest spreads. The less-capitalized, high risk banks operate with narrow interest margins, possibly due to the relatively higher deposit rates they pay to attract deposits. Although regulatory changes seem to have no effect, the growing capital market exerts negative pricing pressure on Sri Lankan banks.

Giorgis Sahile, Kipkirong Tarus and Kimeli Cheruiyot<sup>6</sup> have tested market structure-performance hypothesis in banking industry in Kenya. The study used secondary data of 44 commercial banks operating from 2000 to 2009. Market concentration was measured using two concentration measures; the concentration ratio of the four largest banks and Herfindahl-Hirschman Index, while market share was used as a proxy for efficiency. The empirical results confirm that market efficiency hypothesis is a predictor of firm performance in the banking sector in Kenya and rejects the traditional SCP hypothesis. Thus, the results support the view that efficient banks maximize profitability. The study provides insights into the role of efficiency in enhancing profitability in commercial banks in Kenya. It has managerial implication that profitable banks ought to be efficient and dispels the notion of collusive behavior as a precursor for profitability.

Hanh Thi and Daly<sup>7</sup> were investigating the concentration on the banking market of six Asian countries (Bangladesh, Indonesia, India, Philippines, Malaysia and Vietnam) before and after the global financial crisis in 2008. Using the SUR (seemingly unrelated regression) and 3SLS (three-stage least squares) models, the equation system for estimating parameters in the model is evaluated, resulting in a negative correlation between concentration on the banking market and competition, indicating that banks merge to generate higher profits. Monopolistic

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<sup>5</sup> Perera, S.; Skully, M.; Nguyen, M. (2012) *Market concentration and pricing behaviour of Sri Lankan banks*, South Asian Journal of Global Business Research, Vol. 1 Iss. 1, p. 63 – 78, <https://doi.org/10.1108/20454451211205950>

<sup>6</sup> Giorgis Sahile, S.W.; Kipkirong Tarus, D.; Kimeli Cheruiyot, T. (2015) *Market structure-performance hypothesis in Kenyan banking industry*, International Journal of Emerging Markets, Vol. 10 Iss. 4, p. 697 – 710, <https://doi.org/10.1108/IJoEM-12-2012-0178>

<sup>7</sup> Hanh Thi M.P.; Daly, K. (2016) *Market Concentration and Bank Competition in Emerging Asian Countries*, Risk Management in Emerging Markets, p. 607 - 644

competition can best describe banking markets in most countries that are analyzed in this research.

Ab-Rahim and Nie Chiang<sup>8</sup> examine the relationship between the market structure and financial performance of Malaysian business banks over the period 2000-2011. The Malaysian banking market's concentration is in a downward trend. Malaysian banks are more competitive due to lower market concentration. In terms of efficiency, the results show that Malaysian banks operate below their capabilities at just 40 percent of efficiency. Malaysian banks could therefore reduce their use of inputs by 60 percent to operate at the efficiency limit.

#### **4. Mergers and acquisitions and the influence on market concentration**

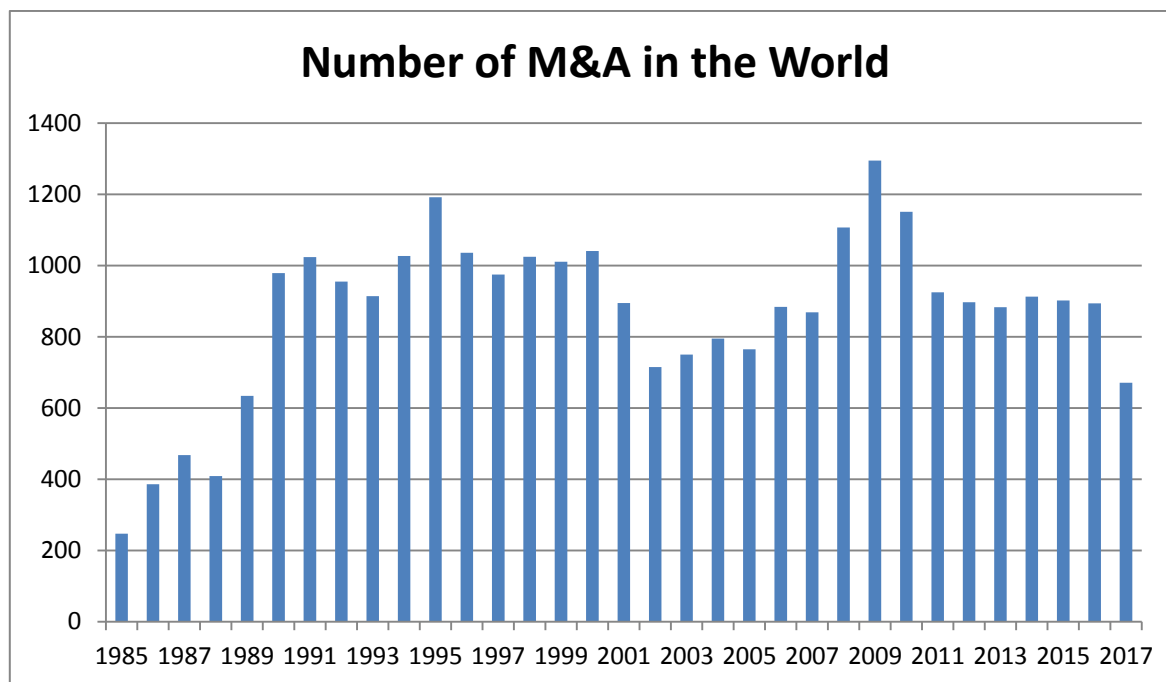
In considering different growth options for banks, a special place is occupied by mergers and acquisitions. Merger occurs when two banks merge their assets, creating a new bank. Acquisition refers to the takeover of one bank by another, whereby the bank taken over is removed and only the takeover bank continues to operate. In this way, the bank seeks to increase its value through the use of a larger market share in an existing market or by expanding into new markets. Growth through mergers and acquisitions is the fastest growing form, and its security is guaranteed in advance by a detailed analysis of the bank's operations that it wants to take over.

Intensifying the processes of M&A in banking in the eighties of the last century was the result of deregulation in the financial markets of developed countries, which have opened opportunities for mergers and acquisitions in banking markets. The technological progress enabled the beginning of significant M&A processes in different countries. Further deregulation of financial markets and the accelerated development of technology lead to an even greater number of M&A of banks at the end of the 20th and early 21st century. After several years of reduced consolidation, the process of joining and merging banks has been intensified again with the coming of the financial crisis.

Picture 1: Number of M&A in the world

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<sup>8</sup> Ab-Rahim, R.; Nie Chiang, S. (2016) *Market structure and performance of Malaysian banking industry*, Journal of Financial Reporting and Accounting, Vol. 14 Iss. 2, p. 158 – 177, <https://doi.org/10.1108/JFRA-11-2014-0086>



Source: Institute for Mergers, Acquisitions and Alliances

Causes of M&A of banks can be divided into external and internal.<sup>9</sup> External causes arise as a result of changes in the external environment, ie in the banking market. Banks need to adapt to these changes, and one of the ways of adjusting is to make mergers and mergers in the banking market. Internal causes are related to the management of a bank that wants to provide good business indicators.

According to a survey conducted in the United States<sup>10</sup>, the most significant motives that banks point to M&A are:

- increase profitability in bank operations;
- access to new markets;
- increase in market share;
- faster growth of the bank;
- increase in market value of shares;
- expansion in the area of existing services;
- increasing market power;
- lower M & A growth costs;
- better location;
- greater bank income stability.

It is obvious that the reasons for M&A are different, and are mostly reduced to attempting to influence the improvement of business operations in order to achieve greater profits over a longer period of time. The basic objective of any M&A in banking is to improve financial performance indicators, ie increase the value of the bank for its shareholders. Each M&A

<sup>9</sup> Stojanović, A. (2005) Okrupnjavanje i konglomerizacija banaka, Novac, bankarstvo i finansijska tržišta, Adverta, Zagreb, p. 267

<sup>10</sup> Gup, B. (1989) "Bank Mergers: Current Issues and Perspectives", Kluwer Academic Publishers, Boston

increases the level of market concentration on the banking market. With the takeover of a bank, the bank acquires its market share and through its market power while at the same time reducing the degree of competition in the market.

### 5. Croatian banking market and changes in the banking market structure

According to data from March 2017, there are 26 credit banks in the Republic of Croatia. It has characteristics of the bank centric model. Banks mobilize savings, capitalize and play a very important role in financial business trends. Total assets of banks are HRK 379,452,243.

There are large numbers of banks in different sizes. The products are similar but differentiated, which gives each bank the advantage over the others. It is concluded that monopolistic competition exists on the market.<sup>11</sup>

In 2016 there was a change in the structure of the banking market. The biggest changes were recorded by Hypo Bank, Vaba Bank and Société Générale – Splitska Bank.

11 July 2016 Hypo bank become an Adicco Bank after 18 years of operations. In 2014, the group Hypo Alpe-Adria-Bank was purchased by the Advent International and European Bank for Reconstruction and Development. Hypo Bank was burdened with mistakes from the past, and is restoring identity and rebranding. The new owners covered the losses. They are planning to expand their market and streamline the business model.<sup>12</sup>

1 January 2017 Vaba Bank changed its name and operates as J&T Bank. The new Bank is changing its business focus and wants to position itself as a provider of specialized business services. J&T Bank has a small share (of assets) in the total assets of all banks and because of that, the changes do not significantly affect the concentration on the market.<sup>13</sup>

2 July 2017 OTP Bank bought Société Générale – Splitska Bank. It is expected that the process of merging banks will last until the summer of 2018, and until then banks will operate as separate legal entities. The merger of these two banks will significantly affect the change in market concentration.<sup>14</sup> The new bank will have almost 11% of the market share. After a long time, Raiffeisenbank Austria Bank will not be in the fourth place by its size and market share.

Table 1: Credit institution data on 31st March 2017

| Ordinal number | Name of institution             | Total assets |
|----------------|---------------------------------|--------------|
| 1.             | ADDIKO BANK d.d.                | 20,861,026   |
| 2.             | BANKA KOVANICA d.d.             | 1,185,692    |
| 3.             | CROATIA BANKA d.d.              | 2,921,759    |
| 4.             | ERSTE&STEIERMÄRKISCHE BANK d.d. | 56,490,766   |
| 5.             | HRVATSKA POŠTANSKA BANKA d.d.   | 19,068,057   |

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<sup>11</sup> Samuelson, P.A.; Nordhaus, W.D. (2005) *Ekonomija*, Mate, Zagreb, p. 184-200

<sup>12</sup> Bašić T.(2016) *Lider*, Više od rebrandiranja: Kako je Hypo banka postala Addiko Bank [online]. <https://lider.media/aktualno/tvrtke-i-trzista/poslovna-scena/vise-od-rebrandiranja-kako-je-hypo-banka-postala-addiko-bank/>

<sup>13</sup> J&T banka d.d. (2017) [online]. <http://www.jtbanka.hr/o-banci/j-t-banka-d-d/89>

<sup>14</sup> Splitska banka (2017) [online]. <https://www.splitskabanka.hr/o-nama>

|  |                                      |                    |
|--|--------------------------------------|--------------------|
| 6.   | IMEX BANKA d.d.                      | 1,906,238          |
| 7.   | ISTARSKA KREDITNA BANKA UMAG d.d.    | 3,118,101          |
| 8.   | J&T BANKA d.d.                       | 1,411,236          |
| 9.   | JADRANSKA BANKA d.d.                 | 1,771,202          |
| 10.  | KARLOVAČKA BANKA d.d.                | 2,082,926          |
| 11.  | KENTBANK d.d.                        | 2,022,407          |
| 12.  | KREDITNA BANKA ZAGREB d.d.           | 3,493,231          |
| 13.  | OTP BANKA HRVATSKA d.d.              | 15,421,761         |
| 14.  | PARTNER BANKA d.d.                   | 1,642,544          |
| 15.  | PODRAVSKA BANKA d.d.                 | 3,229,592          |
| 16.  | PRIMORSKA BANKA d.d.                 | 626,052            |
| 17.  | PRIVREDNA BANKA ZAGREB d.d.          | 70,974,120         |
| 18.  | RAIFFEISENBANK AUSTRIA d.d.          | 30,829,578         |
| 19.  | SAMOBORSKA BANKA d.d.                | 520,121            |
| 20.  | SBERBANK d.d.                        | 9,122,568          |
| 21.  | SLATINSKA BANKA d.d.                 | 1,577,080          |
| 22.  | SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 26,198,707         |
| 23.  | ŠTEDBANKA d.d.                       | 857,389            |
| 24.  | TESLA ŠTEDNA BANKA d.d.              | 2,149              |
| 25.  | VENETO BANKA d.d.                    | 1,328,403          |
| 26.  | ZAGREBAČKA BANKA d.d.                | 100,789,541        |
| <b>Total assets for all banks and saving banks</b> |                                      | <b>379,452,243</b> |

Source: HNB

Table 1 lists the credit institutions operating on the Croatian banking market. Banks are ranked in an alphabetical order. The concentration indices are calculated based on the data of total bank assets.

## 6. Concentration indices

### 6.1. The Concentration Ratio

The Concentration Ratio is the most commonly used measure of concentration. It shows the share of the largest banks in total banking industry.

The concentration index is defined as:

$$CR_k = \sum_{i=1}^k S_i$$

Where  $CR$  is the concentration ratio,  $k$  number of largest banks,  $S$  is the share of  $i$ -th bank.  $S_i$  has to be arranged by size, from the bank with the largest asset to the one with the smallest.

The Concentration ratio ranges from 0 to 100. If the ratio is 0, then there is infinite number of banks with the same amount of assets, which refers to perfect competition.



In this paper, the concentration ratios for four and eight largest banks in Croatia are calculated. The share of assets of the largest banks is taken, and the influence of smaller banks on the market is neglected.

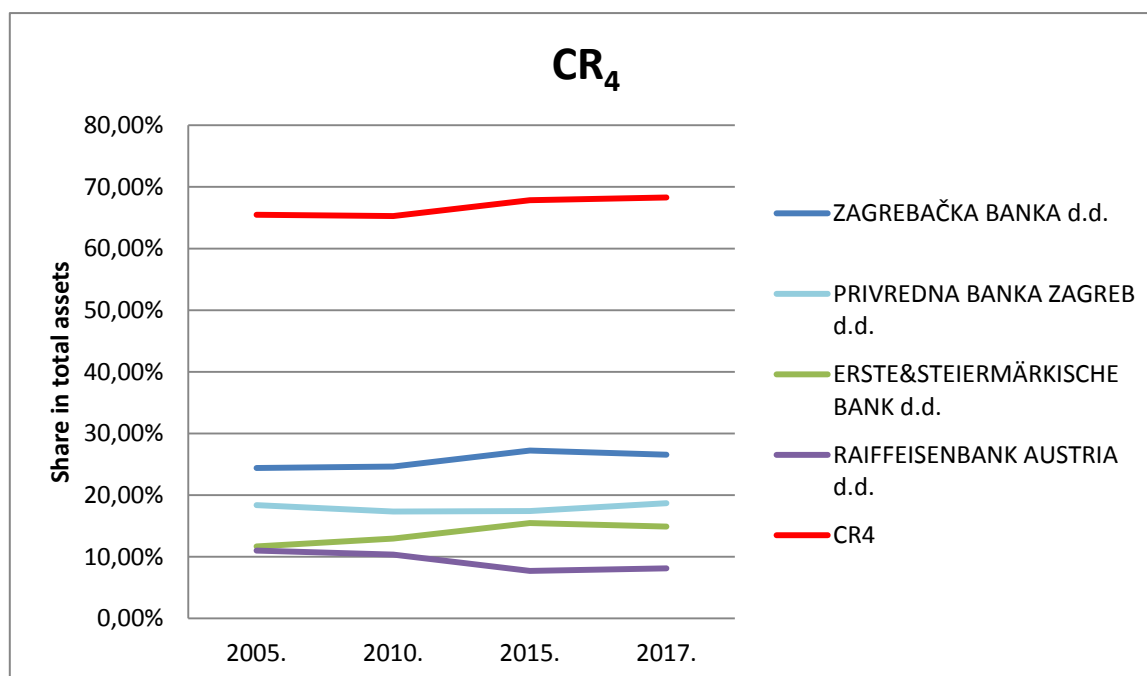
Table 2: The concentration ratio for the four largest banks

| Name of institution             | Total assets       | Share in total assets |
|---------------------------------|--------------------|-----------------------|
| ZAGREBAČKA BANKA d.d.           | 100,789,541        | 26.56%                |
| PRIVREDNA BANKA ZAGREB d.d.     | 70,974,120         | 18.70%                |
| ERSTE&STEIERMÄRKISCHE BANK d.d. | 56,490,766         | 14.89 %               |
| RAIFFEISENBANK AUSTRIA d.d.     | 30,829,578         | 8.12%                 |
| <b>CR<sub>4</sub></b>           | <b>259,084,005</b> | <b>68.28%</b>         |

Source: Authors' calculation

Table 2 shows the shares of the four largest banks in Croatia. The share of the four largest banks is 68.28%. A large part refers to Zagrebačka banka, whose share makes up 26.56%. Privredna banka Zagreb has total assets of HRK 70,974,120 and has a share of 18.70% along with Zagrebačka banka. It is concluded that this four banks have significant influence on the Croatian banking market and are geographically the most widespread subjects.

Picture 2: The concentration ratio for the four largest banks, from 2005 to 2017



Source: Authors' calculation

Picture 2 shows the movement of the concentration ratio of the four largest banks over the period from 2005 to 2017. The abscissa shows years, and on the ordinate is shown share in

total assets. The ranking of banks by size of assets has not changed. The concentration ratio between 2005 and 2010 is almost identical and it is 65.47% and 65.28% respectively. In 2015 it is 67.84%, while the highest is in 2017 when it amounts to 68.28%. Relatively speaking, the concentration ratio for twelve years has not changed drastically. But in absolute number the differences are significant. In 2005, the total assets of the four largest banks amounted to HRK 170,599,475, and in 2015 as much as HRK 276,298,938.

Table 3: The concentration ratio for the eight largest banks

| Name of institution                  | Total assets       | Share in total assets |
|--------------------------------------|--------------------|-----------------------|
| ZAGREBAČKA BANKA d.d.                | 100,789,541        | 26.56%                |
| PRIVREDNA BANKA ZAGREB d.d.          | 70,974,120         | 18.70%                |
| ERSTE&STEIERMÄRKISCHE BANK d.d.      | 56,490,766         | 14.89 %               |
| RAIFFEISENBANK AUSTRIA d.d.          | 30,829,578         | 8.12%                 |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 26,198,707         | 6.90%                 |
| ADDIKO BANK d.d.                     | 20,861,026         | 5.50%                 |
| HRVATSKA POŠTANSKA BANKA d.d.        | 19,068,057         | 5.03%                 |
| OTP BANKA HRVATSKA d.d.              | 15,421,761         | 4.06%                 |
| <b>CR<sub>8</sub></b>                | <b>340,633,556</b> | <b>89.76%</b>         |

Source: Authors' calculation

The eight of the largest banks make HRK 340,633,556 worth of assets out of total of HRK 379,452,243 worth of assets of all the credit institutions in the Croatia, which in relative terms is about 89.76%. Based on calculation, it is concluded that there is no monopolistic competition on the market. The banking system is characterized as oligopoly because eight banks control almost 90% of the market. The concentration is very high.

## 6.2. The Herfindahl-Hirschman's index

The Herfindahl-Hirschman's index is the most well-known indicator of industrial concentrations. The Croatian National Bank publishes HHI-score on the Banks Bulletin, which is used in decisions on future mergers and acquisitions of banks.

HHI is the sum of the squares of the market share and is defined as:

$$HHI = \sum_{i=1}^n S_i^2$$

where  $S$  is the market share of the  $i$ -th banks in the market and  $n$  the total number of banks.<sup>15</sup>

The US Central Bank defines conditions under which the value of HHI must not exceed 0,18. If the index exceeds this level, some banks could maintain prices above the competitor price.

<sup>15</sup> Ljubaj I. (2005) Indeksi koncentracije bankarskog sektora u Hrvatskoj [online].  
<http://old.hnb.hr/publikac/pregladi/p-021.pdf>

If the HII value is less than 0,1 the concentration is low, between 0,1 and 0,18 the concentration is medium. The concentration is high if the value is more than 0,18.

Table 4: The calculation of Herfindahl-Hirschman's index

| Name of institution               | Total assets | Share in total assets ( $S_i$ ) | Squared shares ( $S_i^2$ ) |
|-----------------------------------|--------------|---------------------------------|----------------------------|
| ADDIKO BANK d.d.                  | 20,861,026   | 0.054976684                     | 0.003022436                |
| BANKA KOVANICA d.d.               | 1,185,692    | 0.003124746                     | 9.76404E-06                |
| CROATIA BANKA d.d.                | 2,921,759    | 0.007699939                     | 5.92891E-05                |
| ERSTE&STEIERMÄRKISCHE BANK d.d.   | 56,490,766   | 0.148874508                     | 0.022163619                |
| HRVATSKA POŠTANSKA BANKA d.d.     | 19,068,057   | 0.050251533                     | 0.002525217                |
| IMEX BANKA d.d.                   | 1,906,238    | 0.005023657                     | 2.52371E-05                |
| ISTARSKA KREDITNA BANKA UMAG d.d. | 3,118,101    | 0.008217374                     | 6.75252E-05                |
| J&T BANKA d.d.                    | 1,411,236    | 0.00371914                      | 1.3832E-05                 |
| JADRANSKA BANKA d.d.              | 1,771,202    | 0.004667786                     | 2.17882E-05                |
| KARLOVAČKA BANKA d.d.             | 2,082,926    | 0.005489297                     | 3.01324E-05                |
| KENTBANK d.d.                     | 2,022,407    | 0.005329806                     | 2.84068E-05                |
| KREDITNA BANKA ZAGREB d.d.        | 3,493,231    | 0.009205983                     | 8.47501E-05                |
| OTP BANKA HRVATSKA d.d.           | 15,421,761   | 0.040642166                     | 0.001651786                |
| PARTNER BANKA d.d.                | 1,642,544    | 0.004328724                     | 1.87379E-05                |
| PODRAVSKA BANKA d.d.              | 3,229,592    | 0.008511195                     | 7.24404E-05                |
| PRIMORSKA BANKA d.d.              | 626,052      | 0.001649884                     | 2.72212E-06                |
| PRIVREDNA BANKA ZAGREB d.d.       | 70,974,120   | 0.187043617                     | 0.034985315                |
| RAIFFEISENBANK AUSTRIA d.d.       | 30,829,578   | 0.081247584                     | 0.00660117                 |
| SAMOBORSKA BANKA d.d.             | 520,121      | 0.001370715                     | 1.87886E-06                |
| SBERBANK d.d.                     | 9,122,568    | 0.024041413                     | 0.00057799                 |

|                                      |                         |                 |                   |
|--------------------------------------|-------------------------|-----------------|-------------------|
| SLATINSKA BANKA d.d.                 | 1,577,080               | 0.00415620<br>2 | 1.7274E-05        |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 26,198,707              | 0.06904349      | 0.00476700<br>3   |
| ŠTEDBANKA d.d.                       | 857,389                 | 0.00225954<br>4 | 5.10554E-<br>06   |
| TESLA ŠTEDNA BANKA d.d.              | 2,149                   | 5.66343E-<br>06 | 3.20744E-<br>11   |
| VENETO BANKA d.d.                    | 1,328,403               | 0.00350084<br>4 | 1.22559E-<br>05   |
| ZAGREBAČKA BANKA d.d.                | 100,789,54<br>1         | 0.26561851<br>4 | 0.07055319<br>5   |
| <b>Total</b>                         | <b>379,452,24<br/>3</b> | <b>1</b>        | <b>0.14731887</b> |

Source: Authors' calculation

The Herfindahl-Hirschman's index can range from  $1/10.000 n$  to 1. It depends on whether the share in total asset is expressed as a percentage or a decimal number. In this paper, the range of  $1/10.000 n$  to 1 is used.

HHI represents a better measure of concentration than the concentration ratio since the calculation includes all banks, and does not account for four or eight largest banks. Also, this calculation places greater emphasis on the largest banks because market shares are squared.

In Croatian banking market, the HHI amounts to 0.14731887. The index value ranging from 0.1 to 0.18 indicates the medium concentration. Concentration ratios for four and eight banks are very high and emphasize the importance of large banks, while the Herfindahl-Hirschman's index highlights the importance of smaller banks.

### 6.3. Hall-Tideman's and Rosenbluth's index

Hall-Tideman's (HTI) and Rosenbluth's (RI) concentration index emphasize the importance of an absolute number of banks. It is assumed that it is easier to enter the market if there is large number of banks, and opposite of that, it is harder to enter the market if only several banks operate on the market.

HTI is expressed by following formula:

$$HTI = 1 / \left( 2 \sum_{i=1}^n i S_i - 1 \right)$$

Where  $S_i$  represents the market share of each bank, and  $i$  its corresponding rank. The market share of each bank is multiplied by corresponding rank. The highest-rated bank by asset is assigned rank  $i=1$ , and the smallest bank,  $i=n$ . HTI ranges from 0 to 1. In case of a pure monopoly the value of index is 1, while it is 0 in the case of an infinite number of same sized banks.

Table 5: The calculation of Hall-Tideman's index

| Name of institution                  | Total assets       | Share in total assets ( $S_i$ ) | Rank ( $i$ ) | Product ( $S_i*i$ ) |
|--------------------------------------|--------------------|---------------------------------|--------------|---------------------|
| ZAGREBAČKA BANKA d.d.                | 100,789,541        | 26.56%                          | 1            | 0.265619            |
| PRIVREDNA BANKA ZAGREB d.d.          | 70,974,120         | 18.70%                          | 2            | 0.374087            |
| ERSTE&STEIERMÄRKISCHE BANK d.d.      | 56,490,766         | 14.89%                          | 3            | 0.446624            |
| RAIFFEISENBANK AUSTRIA d.d.          | 30,829,578         | 8.12%                           | 4            | 0.32499             |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 26,198,707         | 6.90%                           | 5            | 0.345217            |
| ADDIKO BANK d.d.                     | 20,861,026         | 5.50%                           | 6            | 0.32986             |
| HRVATSKA POŠTANSKA BANKA d.d.        | 19,068,057         | 5.03%                           | 7            | 0.351761            |
| OTP BANKA HRVATSKA d.d.              | 15,421,761         | 4.06%                           | 8            | 0.325137            |
| SBERBANK d.d.                        | 9,122,568          | 2.40%                           | 9            | 0.216373            |
| KREDITNA BANKA ZAGREB d.d.           | 3,493,231          | 0.92%                           | 10           | 0.09206             |
| PODRAVSKA BANKA d.d.                 | 3,229,592          | 0.85%                           | 11           | 0.093623            |
| ISTARSKA KREDITNA BANKA UMAG d.d.    | 3,118,101          | 0.82%                           | 12           | 0.098608            |
| CROATIA BANKA d.d.                   | 2,921,759          | 0.77%                           | 13           | 0.100099            |
| KARLOVAČKA BANKA d.d.                | 2,082,926          | 0.55%                           | 14           | 0.07685             |
| KENTBANK d.d.                        | 2,022,407          | 0.53%                           | 15           | 0.079947            |
| IMEX BANKA d.d.                      | 1,906,238          | 0.50%                           | 16           | 0.080379            |
| JADRANSKA BANKA d.d.                 | 1,771,202          | 0.47%                           | 17           | 0.079352            |
| PARTNER BANKA d.d.                   | 1,642,544          | 0.43%                           | 18           | 0.077917            |
| SLATINSKA BANKA d.d.                 | 1,577,080          | 0.42%                           | 19           | 0.078968            |
| J&T BANKA d.d.                       | 1,411,236          | 0.37%                           | 20           | 0.074383            |
| VENETO BANKA d.d.                    | 1,328,403          | 0.35%                           | 21           | 0.073518            |
| BANKA KOVANICA d.d.                  | 1,185,692          | 0.31%                           | 22           | 0.068744            |
| ŠTEDBANKA d.d.                       | 857,389            | 0.23%                           | 23           | 0.05197             |
| PRIMORSKA BANKA d.d.                 | 626,052            | 0.16%                           | 24           | 0.039597            |
| SAMOBORSKA BANKA d.d.                | 520,121            | 0.14%                           | 25           | 0.034268            |
| TESLA ŠTEDNA BANKA d.d.              | 2,149              | 0.00%                           | 26           | 0.000147            |
| <b>Total</b>                         | <b>379,452,243</b> | <b>100.00%</b>                  |              | <b>4.180098</b>     |

Source: Authors' calculation

Table 5 shows the calculation of Hall-Tideman's index. Zagrebačka banka, the bank with highest asset is ranked first and its ranking multiplies with its share market.

$$HTI = \frac{1}{2 * 4,180098} - 1 \quad HTI = 0,135865933$$

The value of Hall-Tideman's index for Croatian banking market is 0.135865933. The index highlights the importance of an absolute number of banks. The number of banks is decreasing every year. The main difference between Hall-Tideman's and Rosenbluth's index is in the bank ranking.

RI is expressed by the following formula:

$$RI = 1 / \left( 2 \sum_{i=1}^n j S_i - 1 \right); j = n, \dots, 1$$

Where  $S_i$  represents the market share of each bank, and  $i$  its corresponding rank. The market share of each bank is multiplied by the corresponding rank. The development of small banks has a significant impact on Rosenbluth index. The denominator is growing in the case of a growth in number of banks, since the shares of the largest banks are multiplied by increasing absolute numbers. If a large number of small banks enter the market, the value of RI will decline significantly.

Indices are sensitive to a change in the absolute number of banks, and their drastic reduction has influenced the rise in concentration. Reasons for reducing the number of banks are usually bankruptcies, mergers and acquisitions. A rise in concentration is expected in the future.

Table 6: The calculation of Rosenbluth's index

| Name of institution                  | Total assets | Share in total assets ( $S_i$ ) | Rank ( $i$ ) | Product ( $S_i * i$ ) |
|--------------------------------------|--------------|---------------------------------|--------------|-----------------------|
| ZAGREBAČKA BANKA d.d.                | 100,789,541  | 26.56%                          | 26           | 6.90608137            |
| PRIVREDNA BANKA ZAGREB d.d.          | 70,974,120   | 18.70%                          | 25           | 4.676090424           |
| ERSTE&STEIERMÄRKISCHE BANK d.d.      | 56,490,766   | 14.89%                          | 24           | 3.572988193           |
| RAIFFEISENBANK AUSTRIA d.d.          | 30,829,578   | 8.12%                           | 23           | 1.868694433           |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 26,198,707   | 6.90%                           | 22           | 1.518956772           |
| ADDIKO BANK d.d.                     | 20,861,026   | 5.50%                           | 21           | 1.154510361           |
| HRVATSKA POŠTANSKA BANKA d.d.        | 19,068,057   | 5.03%                           | 20           | 1.005030665           |
| OTP BANKA HRVATSKA d.d.              | 15,421,761   | 4.06%                           | 19           | 0.772201152           |
| SBERBANK d.d.                        | 9,122,568    | 2.40%                           | 18           | 0.43274543            |
| KREDITNA BANKA ZAGREB d.d.           | 3,493,231    | 0.92%                           | 17           | 0.156501716           |
| PODRAVSKA BANKA d.d.                 | 3,229,592    | 0.85%                           | 16           | 0.136179119           |
| ISTARSKA KREDITNA BANKA UMAG d.d.    | 3,118,101    | 0.82%                           | 15           | 0.12326061            |
| CROATIA BANKA d.d.                   | 2,921,759    | 0.77%                           | 14           | 0.107799141           |

|                         |                    |                |    |                    |
|-------------------------|--------------------|----------------|----|--------------------|
| KARLOVAČKA BANKA d.d.   | 2,082,926          | 0.55%          | 13 | 0.071360859        |
| KENTBANK d.d.           | 2,022,407          | 0.53%          | 12 | 0.063957677        |
| IMEX BANKA d.d.         | 1,906,238          | 0.50%          | 11 | 0.055260229        |
| JADRANSKA BANKA d.d.    | 1,771,202          | 0.47%          | 10 | 0.046677863        |
| PARTNER BANKA d.d.      | 1,642,544          | 0.43%          | 9  | 0.038958515        |
| SLATINSKA BANKA d.d.    | 1,577,080          | 0.42%          | 8  | 0.033249612        |
| J&T BANKA d.d.          | 1,411,236          | 0.37%          | 7  | 0.02603398         |
| VENETO BANKA d.d.       | 1,328,403          | 0.35%          | 6  | 0.021005062        |
| BANKA KOVANICA d.d.     | 1,185,692          | 0.31%          | 5  | 0.015623732        |
| ŠTEDBANKA d.d.          | 857,389            | 0.23%          | 4  | 0.009038176        |
| PRIMORSKA BANKA d.d.    | 626,052            | 0.16%          | 3  | 0.004949651        |
| SAMOBORSKA BANKA d.d.   | 520,121            | 0.14%          | 2  | 0.002741431        |
| TESLA ŠTEDNA BANKA d.d. | 2,149              | 0.00%          | 1  | 5.66343E-06        |
| <b>Total</b>            | <b>379,452,243</b> | <b>100.00%</b> |    | <b>22.81990183</b> |

Source: Authors' calculation

$$RI = \frac{1}{2 * 22.81990183} - 1 \quad RI = 0.022402$$

#### 6. 4. The extensive industrial concentration index

The extensive industrial concentration index (CCI) at the same time highlights the role of the largest banks on the market, but also the role of smaller banks that can influence the change in the market structure.

The CCI form is partially derived from HHI and is expressed by the formula:

$$CCI = S_1 + \sum_{i=2}^n S_i^2 (1 + (1 - S_i))$$

Where  $S$  represents the share of the  $i$ -th banks in the market, and  $n$  the total number of banks.

The extensive industrial concentration index distinguishes the share of the largest bank from the sum that is obtained by adding multiplications of the squared share of the  $i$ -th bank.

In this case,  $i$  ranges from 2 to  $n$ . The index is appropriate for market analysis in which there is one dominant bank, and the other group consists of other banks. The CCI ranges from 0 to 1. In case of a pure monopoly, it is 1.

Table 6: The calculation of CCI

| Name of institution               | Share in total asset ( $S_i$ ) | Squared shares ( $S_i^2$ ) | $(1+(1-S_i))$ | $S_i^2(1+(1-S_i))$ |
|-----------------------------------|--------------------------------|----------------------------|---------------|--------------------|
| ADDIKO BANK d.d.                  | 0.054976684                    | 0.003022436                | 1.945023316   | 0.005878708        |
| BANKA KOVANICA d.d.               | 0.003124746                    | 9.76404E-06                | 1.996875254   | 1.94976E-05        |
| CROATIA BANKA d.d.                | 0.007699939                    | 5.92891E-05                | 1.992300061   | 0.000118122        |
| ERSTE&STEIERMÄRKISCHE BANK d.d.   | 0.148874508                    | 0.022163619                | 1.851125492   | 0.04102764         |
| HRVATSKA POŠTANSKA BANKA d.d.     | 0.050251533                    | 0.002525217                | 1.949748467   | 0.004923537        |
| IMEX BANKA d.d.                   | 0.005023657                    | 2.52371E-05                | 1.994976343   | 5.03475E-05        |
| ISTARSKA KREDITNA BANKA UMAG d.d. | 0.008217374                    | 6.75252E-05                | 1.991782626   | 0.000134496        |
| J&T BANKA d.d.                    | 0.00371914                     | 1.3832E-05                 | 1.99628086    | 2.76126E-05        |
| JADRANSKA BANKA d.d.              | 0.004667786                    | 2.17882E-05                | 1.995332214   | 4.34748E-05        |
| KARLOVAČKA BANKA d.d.             | 0.005489297                    | 3.01324E-05                | 1.994510703   | 6.00994E-05        |
| KENTBANK d.d.                     | 0.005329806                    | 2.84068E-05                | 1.994670194   | 5.66623E-05        |
| KREDITNA BANKA ZAGREB d.d.        | 0.009205983                    | 8.47501E-05                | 1.990794017   | 0.00016872         |
| OTP BANKA HRVATSKA d.d.           | 0.040642166                    | 0.001651786                | 1.959357834   | 0.003236439        |
| PARTNER BANKA d.d.                | 0.004328724                    | 1.87379E-05                | 1.995671276   | 3.73946E-05        |
| PODRAVSKA BANKA d.d.              | 0.008511195                    | 7.24404E-05                | 1.991488805   | 0.000144264        |
| PRIMORSKA BANKA d.d.              | 0.001649884                    | 2.72212E-06                | 1.998350116   | 5.43974E-06        |
| PRIVREDNA BANKA ZAGREB d.d.       | 0.187043617                    | 0.034985315                | 1.812956383   | 0.06342685         |
| RAIFFEISENBANK AUSTRIA d.d.       | 0.081247584                    | 0.00660117                 | 1.918752416   | 0.012666011        |



|   |                 |                 |                 |                         |
|---|-----------------|-----------------|-----------------|-------------------------|
| SAMOBORSKA BANKA d.d.                   | 0.0013707<br>15 | 1.87886E-<br>06 | 1.9986292<br>85 | 3.75515E-<br>06         |
| SBERBANK d.d.                           | 0.0240414<br>13 | 0.0005779<br>9  | 1.9759585<br>87 | 0.0011420<br>83         |
| SLATINSKA BANKA d.d.                    | 0.0041562<br>02 | 1.7274E-<br>05  | 1.9958437<br>98 | 3.44762E-<br>05         |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA<br>BANKA d.d. | 0.0690434<br>9  | 0.0047670<br>03 | 1.9309565<br>1  | 0.0092048<br>76         |
| ŠTEDBANKA d.d.                          | 0.0022595<br>44 | 5.10554E-<br>06 | 1.9977404<br>56 | 1.01995E-<br>05         |
| TESLA ŠTEDNA BANKA d.d.                 | 5.66343E-<br>06 | 3.20744E-<br>11 | 1.9999943<br>37 | 6.41486E-<br>11         |
| VENETO BANKA d.d.                       | 0.0035008<br>44 | 1.22559E-<br>05 | 1.9964991<br>56 | 2.44689E-<br>05         |
| ZAGREBAČKA BANKA d.d.                   | 0.2656185<br>14 | 0.0705531<br>95 | 1.9294468<br>05 | 0.1361286<br>97         |
| <b>Total</b>                            | <b>1</b>        | <b>-</b>        | <b>-</b>        | <b>0.1424451<br/>74</b> |

Source: Authors' calculation

$$CCI = 0.265618514 + 0.142445174$$

$$CCI = 0.408063688$$

In the Croatian banking market, Zagrebačka banka is the dominant bank. Its share of assets is 26.56% and is separated from the sum obtained by adding multiplications of the squared share of the remaining 25 banks. An extensive industrial concentration index is 0.408063688 and indicates a high concentration.

#### 6.5. The Hannah-Kay's index

The Hannah-Kay's concentration index is defined as:

$$HKI = \left( \sum_{i=1}^n S_i^\alpha \right)^{1/(1-\alpha)}, \alpha > 0, \alpha \neq 1$$

Where  $S$  is the share of the  $i$ -th bank on the market,  $n$  is the total number of banks, and the parameter  $\alpha$  emphasizes the effect change in the number and size of banks. For the  $\alpha$  parameter, the values most frequently used are: 0.005; 0.25 ; 5 or 10. The lowest values (0.005 and 0.25) indicate the impact of smaller banks, and the highest values the impact of larger banks on concentration.

The Hannah-Kay's index is sensitive to specifying the  $\alpha$  parameter and is cautious with the analysis of the index result. When the parameter  $\alpha$  approaches the value 0, the index value moves like the number of banks in the market.

When calculating Hannah-Kay's index for the Croatian banking market, the parameters  $\alpha=0.005$  and  $\alpha=5$  were used. Parameters are arbitrarily chosen and will show the impact of smaller banks on the market when the parameter  $\alpha=0.005$  is used. To estimate the impact of larger banks on concentration, the parameter  $\alpha=5$  is taken.

Table 7: The calculation of Hannah-Kay's index

| Name of institution               | Total asset | Share in total asset | $S_i^{0.005}$ | $S_i^5$     |
|-----------------------------------|-------------|----------------------|---------------|-------------|
| ADDIKO BANK d.d.                  | 20,861,026  | 0.054976684          | 0.985600449   | 5.02218E-07 |
| BANKA KOVANICA d.d.               | 1,185,692   | 0.003124746          | 0.97156995    | 2.97902E-13 |
| CROATIA BANKA d.d.                | 2,921,759   | 0.007699939          | 0.975960939   | 2.70668E-11 |
| ERSTE&STEIERMÄRKISCHE BANK d.d.   | 56,490,766  | 0.148874508          | 0.990521945   | 7.3131E-05  |
| HRVATSKA POŠTANSKA BANKA d.d.     | 19,068,057  | 0.050251533          | 0.985157678   | 3.2044E-07  |
| IMEX BANKA d.d.                   | 1,906,238   | 0.005023657          | 0.973879222   | 3.19963E-12 |
| ISTARSKA KREDITNA BANKA UMAG d.d. | 3,118,101   | 0.008217374          | 0.976278365   | 3.74684E-11 |
| J&T BANKA d.d.                    | 1,411,236   | 0.00371914           | 0.972416261   | 7.11562E-13 |
| JADRANSKA BANKA d.d.              | 1,771,202   | 0.004667786          | 0.973521517   | 2.21592E-12 |
| KARLOVAČKA BANKA d.d.             | 2,082,926   | 0.005489297          | 0.97431095    | 4.98406E-12 |
| KENTBANK d.d.                     | 2,022,407   | 0.005329806          | 0.974167322   | 4.30088E-12 |
| KREDITNA BANKA ZAGREB d.d.        | 3,493,231   | 0.009205983          | 0.976833063   | 6.61227E-11 |
| OTP BANKA HRVATSKA d.d.           | 15,421,761  | 0.040642166          | 0.984112808   | 1.10888E-07 |
| PARTNER BANKA d.d.                | 1,642,544   | 0.004328724          | 0.973154509   | 1.51985E-12 |
| PODRAVSKA BANKA d.d.              | 3,229,592   | 0.008511195          | 0.976449872   | 4.46635E-11 |
| PRIMORSKA BANKA d.d.              | 626,052     | 0.001649884          | 0.96847244    | 1.22255E-14 |
| PRIVREDNA BANKA ZAGREB d.d.       | 70,974,120  | 0.187043617          | 0.991652964   | 0.000228936 |
| RAIFFEISENBANK AUSTRIA d.d.       | 30,829,578  | 0.081247584          | 0.987527168   | 3.5404E-06  |
| SAMOBORSKA BANKA d.d.             | 520,121     | 0.0013707            | 0.9675752     | 4.83878E-   |

|   |                         |                 |                        |                         |
|---|-------------------------|-----------------|------------------------|-------------------------|
|   |                         | 15              | 18                     | 15                      |
| SBERBANK d.d.                           | 9,122,568               | 0.0240414<br>13 | 0.9815327<br>61        | 8.03156E-<br>09         |
| SLATINSKA BANKA d.d.                    | 1,577,080               | 0.0041562<br>02 | 0.9729566<br>33        | 1.24018E-<br>12         |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA<br>BANKA d.d. | 26,198,70<br>7          | 0.0690434<br>9  | 0.9867238<br>23        | 1.56897E-<br>06         |
| ŠTEDBANKA d.d.                          | 857,389                 | 0.0022595<br>44 | 0.9699963<br>59        | 5.88985E-<br>14         |
| TESLA ŠTEDNA BANKA d.d.                 | 2,149                   | 5.66343E-<br>06 | 0.9413809<br>3         | 5.82635E-<br>27         |
| VENETO BANKA d.d.                       | 1,328,403               | 0.0035008<br>44 | 0.9721222<br>06        | 5.25852E-<br>13         |
| ZAGREBAČKA BANKA d.d.                   | 100,789,5<br>41         | 0.2656185<br>14 | 0.9933934<br>49        | 0.0013221<br>83         |
| <b>Total</b>                            | <b>379,452,2<br/>43</b> | <b>1</b>        | <b>25.397268<br/>8</b> | <b>0.0016303<br/>02</b> |

Source: Authors' calculation

$$HKI(S_i^{0.005}) = \left( \sum_{i=1}^n S_i^{0.005} \right)^{1/(1-0.005)}$$

$$HKI(S_i^{0.005}) = 25.3972688^{\frac{1}{(1-0.005)}} \quad \mathbf{HKI(S_i^{0.005}) = 25.81346155}$$

The parameter  $\alpha = 0.005$  indicates the impact of smaller banks on the market and follows the absolute number of banks. The index is 25.81346155, which is very close to the total number of banks in the Croatian market, 26.

$$HKI(S_i^5) = \left( \sum_{i=1}^n S_i^5 \right)^{1/(1-5)}$$

$$HKI(S_i^5) = 0.001630302^{1/(1-5)} \quad \mathbf{HKI(S_i^5) = 4.976602858}$$

From 2000 until today, the number of banks has almost halved, and consequently the Hannah-Kay's index fell. The index movement is negatively correlated with other indices. The long-term decline in the value of indices indicates the smaller impact of smaller banks, and the greater influence of leading banks in the market as well as the rise in concentration. The value of index for parameter  $\alpha = 5$  is 4.976602858 and highlights the influence of larger banks on concentration.

## 6.6. Index U

Index U equates the influence of the absolute number of banks and inequality between the sizes of the banks on concentration. Its form is as follows:

$$U = I^\alpha n^{-1}, \alpha \geq 0$$

Where  $I$  denotes the measure of inequality,  $n$  is the number of banks, and parameter  $\alpha$  attaches greater importance to the inequality of the total number of banks in the market. The value of the parameter  $\alpha$  is determined by the model, and the most frequently used values are 0.25, 1, 2, 3. In the paper the concentrations for  $\alpha = 0.25$  and  $\alpha = 3$  are calculated as the two end values of the parameter.

First, inequality (I) is defined, then index (U):

$$I = n \sum_{i=1}^n S_i^2 \quad U = \left( n \sum_{i=1}^n S_i^2 \right)^\alpha n^{-1}$$

Or simpler shown:

$$U = (nHHI)^\alpha n^{-1} = (HHI)^\alpha n^{\alpha-1}$$

From the last formula it can be seen that if the parameter  $\alpha=1$  the value of the index U is equal to the value of HHI.

$$\alpha = 0.25$$

$$I = 26 * 0.14731887 \quad I = \mathbf{3.830291}$$

$$U(\alpha = 0.25) = 3.830291^{0.25} * 26^{-1} \quad U(\alpha = \mathbf{0,25}) = \mathbf{0.05380648}$$

Index U for parameter  $\alpha=0.25$  is 0.05380648 and highlights the influence of the absolute number of banks on concentration. As with HTI and RI, the decrease in the number of banks over the years has had an impact on the rise in concentration.

$$U(\alpha = 3) = 3.830291^3 * 26^{-1} \quad U(\alpha = \mathbf{3}) = \mathbf{2.16133438}$$

When calculating the index for  $\alpha = 3$ , higher emphasis is placed on the impact of inequality among banks on concentration. Index U is 2.16133438.

#### 6.7. Hause's index

Concentration index where a parameter that indicates the degree of collapse (degree of tacit agreement and cooperation between companies in the market) is introduced. It is very difficult to prove that companies or banks are secretly cooperating. The index is expressed by the formula:

$$H(\alpha, \{S_i\}) = \sum_{i=1}^n S_i^{2-(S_i(HHI-S_i^2))^\alpha}$$

Where  $S$  represents the share of  $i$ -th bank on the market,  $n$  the total number of banks, and parameter  $\alpha$  indicates the degree of tacit agreement between banks. The parameter can reach the value of 0.25, 1 and 2. H index is equal to 1 in case of monopoly, and in case of perfect competition it is 0.

In the calculations, the values of parameter  $\alpha=0.25$  and 2 will be used as two final values. High degree of collapse is to be emphasized at  $\alpha=0.25$  while  $\alpha=2$  is suitable for the low degree of collapse.

Table 8: The calculation of Hausse's index for parameter  $\alpha=0.25$

| Name of institution                  | Share in total asset ( $S_i$ ) | Squared share ( $S_i^2$ ) | 2- ( $S_i(\text{HHI}-S_i^2)$ ) <sup>0.25</sup> | $S_i^{2-(S_i(\text{HHI}-S_i^2))^{0.25}}$ |
|--------------------------------------|--------------------------------|---------------------------|--|--|
| ADDIKO BANK d.d.                     | 0,054976684                    | 0,003022436               | 1,701558967                                    | 0,007183556                              |
| BANKA KOVANICA d.d.                  | 0,003124746                    | 9,76404E-06               | 1,853525815                                    | 2,27287E-05                              |
| CROATIA BANKA d.d.                   | 0,007699939                    | 5,92891E-05               | 1,816497195                                    | 0,000144814                              |
| ERSTE&STEIERMÄRKISCHE BANK d.d.      | 0,148874508                    | 0,022163619               | 1,630540062                                    | 0,044797154                              |
| HRVATSKA POŠTANSKA BANKA d.d.        | 0,050251533                    | 0,002525217               | 1,707938232                                    | 0,006048438                              |
| IMEX BANKA d.d.                      | 0,005023657                    | 2,52371E-05               | 1,835069493                                    | 6,04243E-05                              |
| ISTARSKA KREDITNA BANKA UMAG d.d.    | 0,008217374                    | 6,75252E-05               | 1,813491736                                    | 0,000165343                              |
| J&T BANKA d.d.                       | 0,00371914                     | 1,3832E-05                | 1,8470093                                      | 3,25525E-05                              |
| JADRANSKA BANKA d.d.                 | 0,004667786                    | 2,17882E-05               | 1,838070387                                    | 5,19591E-05                              |
| KARLOVAČKA BANKA d.d.                | 0,005489297                    | 3,01324E-05               | 1,831375155                                    | 7,24781E-05                              |
| KENTBANK d.d.                        | 0,005329806                    | 2,84068E-05               | 1,832613081                                    | 6,82247E-05                              |
| KREDITNA BANKA ZAGREB d.d.           | 0,009205983                    | 8,47501E-05               | 1,80812444                                     | 0,000208346                              |
| OTP BANKA HRVATSKA d.d.              | 0,040642166                    | 0,001651786               | 1,722613981                                    | 0,004016096                              |
| PARTNER BANKA d.d.                   | 0,004328724                    | 1,87379E-05               | 1,841093832                                    | 4,44956E-05                              |
| PODRAVSKA BANKA d.d.                 | 0,008511195                    | 7,24404E-05               | 1,811848005                                    | 0,000177606                              |
| PRIMORSKA BANKA d.d.                 | 0,001649884                    | 2,72212E-06               | 1,875139259                                    | 6,05811E-06                              |
| PRIVREDNA BANKA ZAGREB d.d.          | 0,187043617                    | 0,034985315               | 1,619273507                                    | 0,066233303                              |
| RAIFFEISENBANK AUSTRIA d.d.          | 0,081247584                    | 0,00660117                | 1,673005991                                    | 0,015000522                              |
| SAMOBORSKA BANKA d.d.                | 0,001370715                    | 1,87886E-06               | 1,880793476                                    | 4,12277E-06                              |
| SBERBANK d.d.                        | 0,024041413                    | 0,00057799                | 1,756287516                                    | 0,001433838                              |
| SLATINSKA BANKA d.d.                 | 0,004156202                    | 1,7274E-05                | 1,842700982                                    | 4,09232E-05                              |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 0,06904349                     | 0,004767003               | 1,685026577                                    | 0,01106346                               |
| ŠTEDBANKA d.d.                       | 0,002259544                    | 5,10554E-06               | 1,864927783                                    | 1,16263E-05                              |

|                         |             |             |             |                    |
|-------------------------|-------------|-------------|-------------|--------------------|
| TESLA ŠTEDNA BANKA d.d. | 5,66343E-06 | 3,20744E-11 | 1,969777219 | 4,62099E-11        |
| VENETO BANKA d.d.       | 0,003500844 | 1,22559E-05 | 1,849305035 | 2,8736E-05         |
| ZAGREBAČKA BANKA d.d.   | 0,265618514 | 0,070553195 | 1,622117871 | 0,116433826        |
| <b>Total</b>            | 1           | 0,14731887  | 46,5297249  | <b>0,273350632</b> |

Source: Authors' calculation

The Huse's index for the Croatian banking market amounts to 0.273350632 and marks the concentration on the market during a high degree of secret agreement. The higher the  $\alpha$  parameter is, the closer the index gets to the value of HHI.

Table 9: The concentration of Huse's index for parameter  $\alpha=0.25$

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| <b>Name of institution</b>           | <b>Share in total assets (<math>S_i</math>)</b> | <b>Squared share (<math>S_i^2</math>)</b> | <b>2- (<math>S_i(\text{HHI}-S_i^2)</math>)<sup>2</sup></b> | <b><math>S_i^{2-(S_i(\text{HHI}-S_i^2))2}</math></b> |
|--------------------------------------|---|---|--|--|
| ADDIKO BANK d.d.                     | 0.0549766<br>84                                 | 0.0030224<br>36                           | 1.9999370<br>68  | 0.0030229<br>88                                      |
| BANKA KOVANICA d.d.                  | 0.0031247<br>46                                 | 9.76404E-<br>06                           | 19999997<br>88   | 9.76405E-<br>06                                      |
| CROATIA BANKA d.d.                   | 0.0076999<br>39                                 | 5.92891E-<br>05                           | 19999987<br>14   | 5.92894E-<br>05                                      |
| ERSTE&STEIERMÄRKISCHE BANK d.d.      | 0.1488745<br>08                                 | 0.0221636<br>19                           | 19996528<br>33   | 0.0221782<br>79                                      |
| HRVATSKA POŠTANSKA BANKA d.d.        | 0.0502515<br>33                                 | 0.0025252<br>17                           | 19999470<br>58   | 0.0025256<br>16                                      |
| IMEX BANKA d.d.                      | 0.0050236<br>57                                 | 2.52371E-<br>05                           | 19999994<br>52   | 2.52372E-<br>05                                      |
| ISTARSKA KREDITNA BANKA UMAG d.d.    | 0.0082173<br>74                                 | 6.75252E-<br>05                           | 19999985<br>36   | 6.75257E-<br>05                                      |
| J&T BANKA d.d.                       | 0.0037191<br>4                                  | 1.3832E-<br>05                            | 1.9999997<br>05  | 13832E-<br>05  |
| JADRANSKA BANKA d.d.                 | 0.0046677<br>86                                 | 2.17882E-<br>05                           | 1.9999995<br>27  | 2.17883E-<br>05                                      |
| KARLOVAČKA BANKA d.d.                | 0.0054892<br>97                                 | 3.01324E-<br>05                           | 1.9999993<br>46  | 3.01325E-<br>05                                      |
| KENTBANK d.d.                        | 0.0053298<br>06                                 | 2.84068E-<br>05                           | 1.9999993<br>84  | 2.84069E-<br>05                                      |
| KREDITNA BANKA ZAGREB d.d.           | 0.0092059<br>83                                 | 8.47501E-<br>05                           | 1.9999981<br>63  | 8.47509E-<br>05                                      |
| OTP BANKA HRVATSKA d.d.              | 0.0406421<br>66                                 | 0.0016517<br>86                           | 1.9999649<br>51  | 0.0016519<br>71                                      |
| PARTNER BANKA d.d.                   | 0.0043287<br>24                                 | 1.87379E-<br>05                           | 1.9999995<br>93  | 1.87379E-<br>05                                      |
| PODRAVSKA BANKA d.d.                 | 0.0085111<br>95                                 | 7.24404E-<br>05                           | 1.9999984<br>29  | 7.2441E-<br>05                                       |
| PRIMORSKA BANKA d.d.                 | 0.0016498<br>84                                 | 2.72212E-<br>06                           | 1.9999999<br>41  | 2.72212E-<br>06                                      |
| PRIVREDNA BANKA ZAGREB d.d.          | 0.1870436<br>17                                 | 0.0349853<br>15                           | 1.9995585<br>26  | 0.0350112<br>17                                      |
| RAIFFEISENBANK AUSTRIA d.d.          | 0.0812475<br>84                                 | 0.0066011<br>7                            | 1.9998692<br>87  | 0.0066033<br>36                                      |
| SAMOBORSKA BANKA d.d.                | 0.0013707<br>15                                 | 1.87886E-<br>06                           | 1.9999999<br>59  | 1.87886E-<br>06                                      |
| SBERBANK d.d.                        | 0.0240414<br>13                                 | 0.0005779<br>9                            | 1.9999875<br>54  | 0.0005780<br>16                                      |
| SLATINSKA BANKA d.d.                 | 0.0041562<br>02                                 | 1.7274E-<br>05                            | 1.9999996<br>25  | 1.7274E-<br>05                                       |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA BANKA d.d. | 0.0690434<br>9                                  | 0.0047670<br>03                           | 1.9999031<br>3   | 0.0047682<br>38                                      |
| ŠTEDBANKA d.d.                       | 0.0022595<br>44                                 | 5.10554E-<br>06                           | 1.9999998<br>89  | 5.10554E-<br>06                                      |



|                         |             |                   |                    |                    |
|-------------------------|-------------|-------------------|--------------------|--------------------|
| TESLA ŠTEDNA BANKA d.d. | 5.66343E-06 | 3.20744E-11       | 2                  | 3.20744E-11        |
| VENETO BANKA d.d.       | 0.003500844 | 1.22559E-05       | 1.999999734        | 1.22559E-05        |
| ZAGREBAČKA BANKA d.d.   | 0.265618514 | 0.070553195       | 1.999584232        | 0.070592093        |
| <b>Total</b>            | <b>1</b>    | <b>0.14731887</b> | <b>51.99839442</b> | <b>0.147402897</b> |

Source: Authors' calculation

Hause's index for parameter  $\alpha=2$  is 0.147402897. The parameter indicates a lower degree of collapse or a secret agreement between the banks which means that the H index is smaller.

### 6.8. The entropy measure

The entropy measure is often used when calculating concentrations in a particular industry.

Expressed by the formula:

$$E = - \sum_{i=1}^n S_i \log_2 S_i$$

Index value is not restricted by [0,1] interval as most other concentration indices are, but ranges from 0 to  $\log 2n$ . In case the monopoly reaches 0, and when the market shares of all banks are equal, the value of entropy is  $\log 2n$  and then the concentration is the smallest. This indicator emphasizes the importance of smaller banks in the market. The value of the indicator moves in an inverse increase in concentration. The increase in concentration over the last few years has had an impact on the decline in the index value.

Table 10: The calculation of the entropy measure

| Name of institution             | Total assets | Share in total assets ( $S_i$ ) | $\log_2 S_i$ | $S_i * \log_2 S_i$ |
|---------------------------------|--------------|---------------------------------|--------------|--------------------|
| ADDIKO BANK d.d.                | 20,861,026   | 0.054976684                     | -4.185036302 | -0.230079418       |
| BANKA KOVANICA d.d.             | 1,185,692    | 0.003124746                     | -8.322045214 | -0.02600428        |
| CROATIA BANKA d.d.              | 2,921,759    | 0.007699939                     | -7.02093733  | -0.054060787       |
| ERSTE&STEIERMÄRKISCHE BANK d.d. | 56,490,766   | 0.148874508                     | -2.747831354 | -0.409082041       |

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|                                   |            |             |                  |                  |
|-----------------------------------|------------|-------------|------------------|------------------|
| HRVATSKA POŠTANSKA BANKA d.d.     | 19,068,057 | 0.050251533 | -<br>4.314688574 | -<br>0.216819716 |
| IMEX BANKA d.d.                   | 1,906,238  | 0.005023657 | -<br>7.637046257 | -<br>0.038365903 |
| ISTARSKA KREDITNA BANKA UMAG d.d. | 3,118,101  | 0.008217374 | -<br>6.927106853 | -<br>0.056922628 |
| J&T BANKA d.d.                    | 1,411,236  | 0.00371914  | -<br>8.070815244 | -<br>0.030016491 |
| JADRANSKA BANKA d.d.              | 1,771,202  | 0.004667786 | -<br>7.743045756 | -<br>0.036142883 |
| KARLOVAČKA BANKA d.d.             | 2,082,926  | 0.005489297 | -<br>7.509162927 | -<br>0.041220024 |
| KENTBANK d.d.                     | 2,022,407  | 0.005329806 | -<br>7.55170115  | -<br>0.040249105 |
| KREDITNA BANKA ZAGREB d.d.        | 3,493,231  | 0.009205983 | -<br>6.763212464 | -<br>0.062262021 |
| OTP BANKA HRVATSKA d.d.           | 15,421,761 | 0.040642166 | -<br>4.620878903 | -<br>0.187802527 |
| PARTNER BANKA d.d.                | 1,642,544  | 0.004328724 | -<br>7.851842495 | -<br>0.033988458 |
| PODRAVSKA BANKA d.d.              | 3,229,592  | 0.008511195 | -<br>6.876422594 | -<br>0.058526573 |
| PRIMORSKA BANKA d.d.              | 626,052    | 0.001649884 | -<br>9.243420115 | -<br>0.015250566 |
| PRIVREDNA BANKA ZAGREB d.d.       | 70,974,120 | 0.187043617 | -<br>2.418553361 | -<br>0.452374969 |
| RAIFFEISENBANK AUSTRIA d.d.       | 30,829,578 | 0.081247584 | -<br>3.621531276 | -<br>0.294240667 |
| SAMOBORSKA BANKA d.d.             | 520,121    | 0.001370715 | -<br>9.510855319 | -<br>0.013036675 |
| SBERBANK d.d.                     | 9,122,568  | 0.024041413 | -<br>5.378334513 | -<br>0.12930276  |

|   |                         |                 |                               |                               |
|---|-------------------------|-----------------|-------------------------------|-------------------------------|
| SLATINSKA BANKA d.d.                    | 1,577,080               | 0.0041562<br>02 | -<br>7.9105186<br>67          | -<br>0.0328777<br>1           |
| SOCIÉTÉ GÉNÉRALE-SPLITSKA<br>BANKA d.d. | 26,198,70<br>7          | 0.0690434<br>9  | -<br>3.8563508<br>06          | -<br>0.2662559<br>17          |
| ŠTEDBANKA d.d.                          | 857,389                 | 0.0022595<br>44 | -<br>8.7897526<br>99          | -<br>0.0198608<br>32          |
| TESLA ŠTEDNA BANKA d.d.                 | 2,149                   | 5.66343E-<br>06 | -<br>17.429893<br>31          | -<br>9.87129E-<br>05          |
| VENETO BANKA d.d.                       | 1,328,403               | 0.0035008<br>44 | -<br>8.1580816<br>26          | -<br>0.0285601<br>69          |
| ZAGREBAČKA BANKA d.d.                   | 100,789,5<br>41         | 0.2656185<br>14 | -<br>1.9125723<br>86          | -<br>0.5080146<br>35          |
| <b>Total</b>                            | <b>379,452,2<br/>43</b> | <b>1</b>        | <b>-<br/>176.37163<br/>75</b> | <b>-<br/>3.2814164<br/>69</b> |

Source: Authors' calculation

$$E = 3,281416469$$

The entropy measure for the Croatian banking market is 3.281416469.

## 7. Conclusion

There are 26 credit institutions operating in the Republic of Croatia, offering similar, but differentiated products. According to these basic features, monopoly competition exists on the market.

Concentration ratios for four and eight largest banks are very high and suggest a strong concentration. Calculations show that there is no monopolistic competition on the market, but an oligopoly. Herfindahl-Hirschman's index represents a better concentration measure than the concentration ratio because all banks are included in the calculation. HHI is 0.14731887 and indicates a medium concentration.

Hall-Tideman's and Rosenbluth's concentration index emphasize the importance of an absolute number of banks, and every drop in the number of banks is affecting market concentration. An extensive index of industrial concentration at the same time emphasizes the role of the largest banks in the market as well as smaller banks. The CCI amounts to 0.408063688 and points to the central concentration of the Croatian banking market. The Hannah-Kay's index for  $\alpha=0.005$  is 25.81346155 and is very close to the total number of banks in the market, 26. The index for  $\alpha=5$  is 4.976602858 and highlights the influence of larger banks on concentration.

Index U equally highlights the impact of the absolute number of banks and the inequality between the sizes of banks on concentration. U index for parameter  $\alpha=0.25$  is 0.05380648 and highlights the influence of the absolute number of banks on concentration. For the parameter  $\alpha=3$  the index amounts to 2.16133438 and highlights the impact of bank inequalities. Hausse's concentration index introduces a parameter that indicates the degree of tacit agreement between companies in the market. The Hausse's index at  $\alpha=0.25$  is 0.273350632 and indicates the concentration on the market at a high degree of secret agreement. For the  $\alpha=2$  index the value is 0.147402897. The parameter indicates a lower degree of collapse among banks and the index H is smaller in this case. The entropy measure is used to calculate concentration in a particular industry and emphasizes the importance of smaller banks in the market. The increase in concentration over the last few years has had an impact on the decline in the index value. The entropy measure for the Croatian banking market is 3.281416469.

Based on the calculations, it is concluded that oligopoly operates in the market because eight banks control almost 90% of the market. The merger of OTP banka and Société Générale - Splitska banka is expected to increase the concentration on the Croatian banking market. Smaller-serving banks do not significantly affect the market, although it is expected to group them in the future.

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