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Assessing lending market concentration in Bulgaria: the application of a new measure of concentration

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Abstract:

This paper has a twofold interest. First, we construct new concentration measures that alleviate some shortcomings of the most frequently applied indexes, which are Herfindahl-Hirshman and Entropy measures. They also provide additional information about the way in which the loan portfolio is concentrated according to sectoral funding size. Second, we aim to find the factors that explain the banking lending concentration in Bulgaria. Applying a dynamic-panel model, it is shown that liquidity, loan portfolio level and the level of money in circulation influence the way in which the Bulgarian banks lend to different economic sectors. It should be mentioned that only liquidity level influences the loan concentration, if it is measured with Herfindahl-Hirshman and Entropy indexes, which suggest that these concentration measures perform worse than our global concentration index.

JEL Classification: G21, C43.

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1. Introduction

The issue of the measures of concentration is a long-standing debate. The most frequently applied measure of concentration, at least in banking, is the Herfindahl-Hirshman Index (HHI). It is used, for instance, in studies focusing on the relationship between market structure and banks' performance, but also by banking authorities to examine the impact on competition of the eventual mergers and acquisitions[2]. Despite its popularity, this concentration measure is much criticised. Its frequent usage is due to the fact that it is simple to calculate.

Another simply constructed concentration measure is the Entropy Index (EI). It was frequently applied to assess the industrial firms' strategy, and, to our knowledge, never to banking. The construction principle is the same as for the HHI, the weights attached to market shares are only different: HHI assigns higher weights to higher shares whereas the EI assigns to higher shares lower weights. Thus, both indexes are subject to "weight bias".

Many other measures have been proposed. Among them, market share inequality indexes of Rhoades (1995) reveal the inequality among firms even within markets with

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[2] The HHI plays a determinant role in the antitrust and merger guidelines of the US Justice Department. The Federal Reserve Board (see any published Board order on a bank merger), as well the European Central Bank (see EU banking structures), estimates regularly this concentration measure in order to assess the evolution of banking concentration and to reveal possible threats on competition.

similar HHIs. Nevertheless, they are not exempt from some weaknesses. As Rhoades (1995) mentions, two of them are very sensitive about the number of firms, which increase rapidly with the increment in number of firms. Another inequality measure is the difference between the largest and smallest market shares. The latter concentration measure has, as other concentration measures, a weight bias, placing greater weight on larger market share differences.

Two of the market share inequality measures of Rhoades (1995) have been used by Hannan (1997) along with the inequality part of the HHI, in order to assess their effects on the bank deposit and loan rates. His results are inconclusive in explaining the deposit interest rates. For the loan-rate analysis, it arises that only the number of firms influences the small business loan rates.

Even if some transformations have been made, all these inequality measures are not completely exempted from the effect of the number of firms. An original research is that of Melnik et al. (2008) where the authors propose a dominance measure in order to disclose the firm with the dominant position. For this reason it has a limited interest for assessing the market concentration[3]. Nevertheless, neither the inequality measures of Rhoades (1995) nor the dominance measure of Melnik et al. (2008) gauge the market concentration and so are not of interest in our study.

In our opinion, a concentration measure must not be influenced by the number of entities existing in the market, only the share they own should determine the market concentration. This could easily be corrected by the normalisation of the HHI and EI, as they take values between zero and one regardless of the number of firms on the market. However, the weight bias that characterises these concentration measures will always be present. As will be discussed below, this sensitivity on the weight attached to market shares makes different values for these two concentration measures and different rates of evolution, even if the sense of the evolution is the same. The measure we introduce in this paper avoids all weight problems.

Thus, this work presents a twofold interest. First, we propose a new methodology to estimate a concentration index that avoids any weight bias. It is based on the same approach as the Gini index and allows the determination of the shape of the Lorenz curve. We use this new measure to assess the sectoral lending concentration in Bulgaria. The market shares used are therefore the share of each economic activity in a lending portfolio. Thus, this new approach provides information on the loan distribution across economic sectors. The case of a small number of sectors receiving the most funding corresponds to what we call beta-concentration. In the case of a large number of highly financed sectors, the loan portfolio is said to be alpha-concentrated. Second, we assess the evolution of the sectoral concentration of bank loans and determine its factors for Bulgaria, and compare these results with those obtained with the normalised HHI and EI.

We choose to make our study on the case of the Bulgarian lending market since it underwent a marked evolution of the economic sectoral concentration due to several banking crises which occurred in the nineties and also experienced many banking

[3] On the market dominance see Hay and Vickers (1987). The authors explain the ways in which the dominance can be acquired, exercised and maintained.

reforms. Once the non-performing loans ratio began to decline, Bulgarian banks gradually adopted a new approach for financing the economy and it was reflected in the way in which the different sectors of economy are financed.

The rest of the paper is structured as follows. Section 2 provides a brief overview of the empirical studies on the use of the different concentration measures, and some reasons to be in search of other measures of concentration. In the third section we explain the similarities and dissimilarities between the Herfindahl-Hirschman and Entropy indexes, showing how they give different results for the same objective. In the fourth section, we explain the construction of a new concentration index that by its nature gives more information on the way in which the concentration occurs. Section 5 examines the determinants of loan concentration for Bulgarian banks by applying the new concentration indexes and compares the results with those obtained with the normalised HHI and EI. Section 6 summarizes the main ideas and concludes.

2. Brief literature review

Many studies have begun to consider the entropy index as a measure of concentration (or diversification, depending on the context) from the seventies[4], when the first works gave preference to this index with respect to the HHI. Jacquemin and Berry (1979, p. 363), for instance, affirm that, due to different weights that are assigned to market shares, small differences in large shares make little difference to the value of the EI, while the HHI responds more considerably. Conversely, very small shares are much ignored by the HHI. They estimate the role of the two concentration measures on the growth of the firms' assets and conclude on the advantage of the EI with respect to the HHI. This feature of the EI, which makes it more sensitive to small shares, led Gemba and Kodama (2001) to use this concentration measure in their research on diversification dynamics of the Japanese industry.

The majority of papers on diversification applied the EI as measure of diversification and not the HHI, as the former can be decomposed directly "into additive elements which define the contribution of diversification at each level of product aggregation to the total" (Jacquemin and Berry, 1979 p. 361). According to this, Raghunathan (1995) refines the entropy concept to measure the diversification as well as the entropy formula to estimate the firms' diversification. However, in his improved concept of entropy, the new measure is still a weighted index.

The EI's feature that consists of weighting the very small shares more, making it very sensitive to them and for which the cited authors used it in their concentration (or diversification) market research becomes a weakness for Stigler (1968, p. 33). He gives preference to the HHI as the more eloquent of the two as a measure of market concentration. For similar reasons, Grant et al. (1988) used the HHI but with the objective of studying industry diversification. Despite this, the HHI is the most applied index used to measure market concentration or market structure.

In banking it is the only index used. There are, for example, many studies that test the Structure-Conduct-Performance (SCP) hypothesis in the banking industry. Some

[4] See, among others, Horowitz (1970) and the works of Jacquemin (Jacquemin and Kumps, 1971; Jacquemin, 1975; Jacquemin and Berry, 1979).

papers examine the SCP hypothesis throughout the relationship between the market concentration, measured by the HHI, and the profit rates of banks. Pilloff (1999), Pilloff and Rhoades (2002) and Rhoades (1995) find a result that is consistent with current practice of bank antitrust; that is, a concentration market implies higher profit rates. This is not really the case for Berger (1995), who finds that a positive relationship between banking market concentration and banks' profits disappears when a measure of the cost efficiency of banks is added to the regression as an independent variable, which is consistent with the efficient-structure hypothesis. The HHI was also applied in regressions to estimate its effects on the interest rates that banks pay on deposits (Hannan, 1997; Sharpe, 1997) or charge on loans (Hannan, 1991, 1997; Hannan and Liang, 1995)[5]. The results are not conclusive in the case of the deposit interest rate and they are clearly in favour of the SCP hypothesis in the case of the loan rates. In the case of the deposit rates, also applying the HHI as measure of concentration, Hannan and Berger (1991) find that banks in more concentrated markets are less likely to change deposit rates. In a previous paper, these authors, with the same concentration measure, examine the price-concentration relationship and confirm the SCP hypothesis (Berger and Hannan, 1989).

Other series of papers examine, for example, the role of market concentration or competition, measured by the HHI, on the banks' efficiency scores. Maudos et al. (2002) find, on the European banks' example, that within a more concentrated market the banks' cost efficiency scores improve and the profit efficiency scores deteriorate. Other authors use the concentration HHI measure to control the cost function from which is extracted the cost efficiency scores (among others, Dietsch and Lozano-Vivas, 2000, and Staikouras et al., 2008).

The question which we raise in the next section is how well the HHI and EI describe the market structure. That is, how the assignation of different weights to market shares changes the values on market concentration. To assess these effects, we analyse the standard concentration measures and the differences among them.

3. The HHI and EI concentration measures

With respect to the loan market, the HHI and EI concentration measures differ according to the weight w_i attached to the share of the loan portfolio in the sector i, s_i. For the N sectors, both concentration indexes can be written as

$$CI = \sum_{i=1}^{N} w_i s_i \ . \qquad (1)$$

If the sectoral loan exposure is used as its own weight (w_i=s_i), then greater weights are attached to higher exposures, which is the case of the HHI. Conversely, if each sectoral loan exposure is weighted by the negative value of its logarithm (w_i=-ln(s_i)), then smaller weights are attached to higher exposures, which is the case of the EI.

[5] See Gilbert and Zaretsky (2003) for a detailed literature review on the Structure-Conduct-Performance hypothesis in banking.

3.1 The Herfindahl-Hirschman index

The HHI is the most widely applied concentration measure in economics, namely in banking, and it is written as follows:

$$HHI = \sum_{i=1}^{N} s_i^2 . \qquad (2)$$

It emphasises the importance of larger sectoral loans and takes its minimum for s_i=1/N, and its maximum for s_i=1. The results obtained with this method cannot be compared since the lower limit of the HHI changes with the number of sectors N. Thus, it is better to normalise the HHI so that it takes values within the range [0,1] regardless of the number N. In that case, the index will be written as:

$$HHI_n = \frac{HHI - 1/N}{1 - 1/N} . \qquad (3)$$

3.2 The Entropy measure of concentration

As for the EI, it has the following form:

$$EI = -\sum_{i=1}^{N} s_i \ln s_i . \qquad (4)$$

Thus, it ranges between 0, when loans are concentrated into a single sector, and ln(N), when loans are distributed equally among all sectors. Thus, the results obtained with this equation cannot be compared since the upper limit of the EI changes with the number of sectors N. The Entropy Index must be also normalised according to the following formula

$$EI_n = 1 - \frac{EI}{\ln(N)} . \qquad (5)$$

As it may be observed, both indexes imply the absence of the concentration for s_i=1/N; that is, when loans are distributed uniformly across the N sectors. Nevertheless, the "weight bias" implies different results (see Appendix), which leads us to propose a new concentration measure.

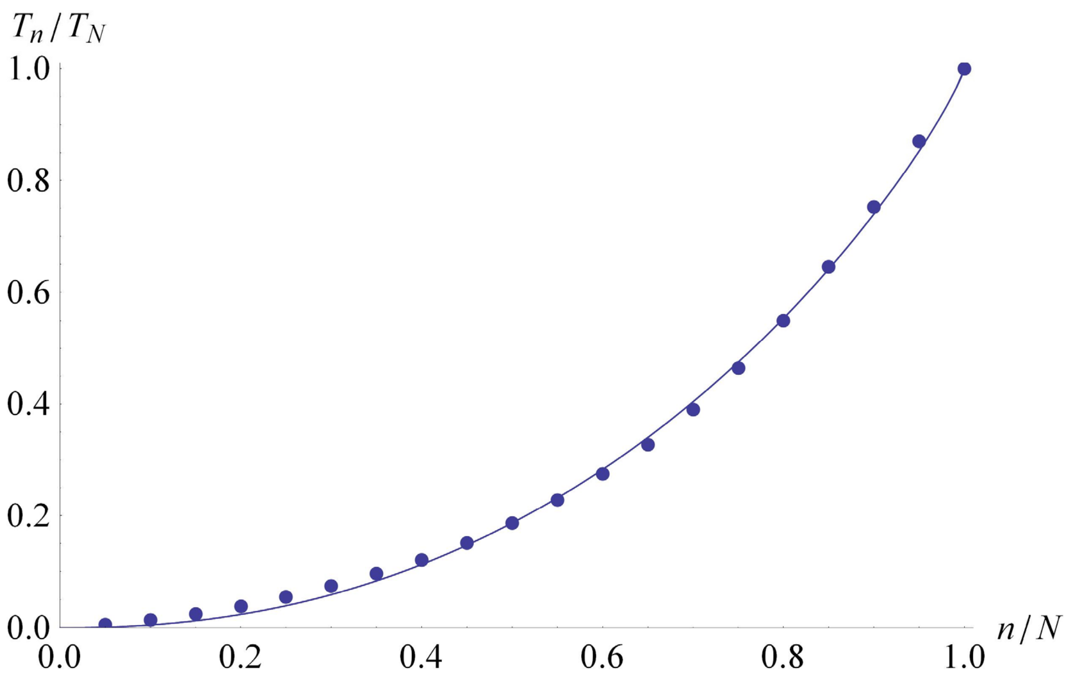
4. A new concentration index

In this section, we construct a new concentration index to avoid the "weight bias" of the HHI and EI by making use of a methodology that is completely different from that of equation (1). This methodology refers to the shape of the loan distribution function and does not assign a specific weight to sectoral exposure. In this section, the proposed methodology is described first. We then explain the alpha- and beta-concentrations and construct a global measure of concentration.

4.1 Methodology

Let us consider a loan portfolio with N economic sectors with amount G_i attributed to the sector i. A loan concentration can be depicted with a Lorenz diagram, which presents a relationship between the share of the first n sectors in the portfolio structure, T_n/T_N, and the proportion of these n sectors in the total number of economic sectors, n/N, where $T_n = \sum_{i=1}^{n} G_i$. In the Lorenz diagram (see Figure 1), sectors are ranked according to the loan size.

Figure 1. Lorenz diagram for loan distribution.



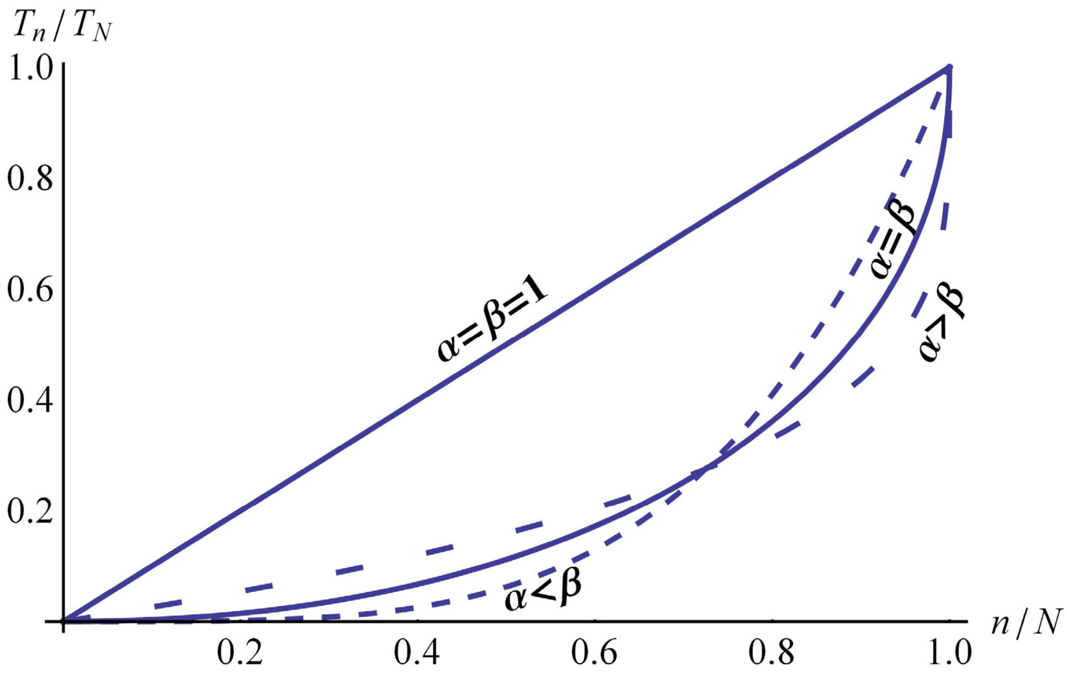
Note: This figure depicts the Lorenz diagram for a loan distribution across twenty sectors. The line passing through these points describes the sectoral loan distribution function that must be found.

The intent of our approach is to find an interpolation function that describes the loan distribution across economic sectors. Analysing the Lorenz diagram, this function could be derived from the following expression:

$$\left(1-\frac{T_n}{T_N}\right)^{\beta}+\left(\frac{n}{N}\right)^{\alpha}=1 \quad . \tag{6}$$

This function is depicted in Figure 2 for different values of parameters *a* and *β*. *a* and *β* describe the loan concentration on the bottom and on the top of the diagram, respectively, and both constitute concentration measures. Particularly, if *a*>*β*, the concentration is made rather on the bottom than on the top of the diagram. This signifies that there are very few sectors with small loans and the amounts allocated to them are incomparably small. Thus, the sectoral concentration is due to the presence of few very small sectors in the loan portfolio. Conversely, if *a*<*β*, the concentration is present on the top of the diagram. There are many sectors with small loans and few sectors with large loans. We will name the first kind of concentration as alpha-concentration (when *a*>*β*) and the second one as beta-concentration (when *a*<*β*). As is depicted in Figure 2, the concentration is considered without substantial amount differences among sectors when *a*=*β*. In particular, *a*=*β*=1 corresponds to the case where loans are distributed uniformly across sectors and where concentration is completely absent. Moreover, *β*=∞ implies that all loans are assigned to a single sector.

Figure 2. The function of loan distribution for different kinds of concentration.



Note: This figure shows the interpolation curve for different values of alpha and beta coefficients. a>β means that the concentration is made rather on the bottom than on the top of the Lorenz diagram. It is an alpha-concentration. If a<β, the concentration is more present on the top of the diagram. In this case, it is a question of beta-concentration. a=β=1 corresponds to uniform sectoral loan distribution. β=∞ implies that all loans are allocated to a single sector.

The great advantage of these coefficients is that they give essential information concerning the form of function of loan distribution, regardless of the weights attached to sectoral exposure. Moreover, the alpha- and beta-concentration measures are not bound, which make them more sensitive to the sectoral structure of a loan portfolio. They range from 1, for uniform loan distribution, to infinity, for loan concentration for a single sector (when *β*=∞).

The objective is thus to find the coefficients *a* and *β*. This will be done by applying the minimisation criterion of the distance between the interpolation distribution function and the distribution points. Consequently, according to the Lorenz diagram, one has to minimize the following function:

$$\sum_{n=1}^{N}\left\{\frac{T_n}{T_N}-\left[1-\left(1-\left(\frac{1}{N}\sum_{k=1}^{n}1\right)^{\alpha}\right)^{\frac{1}{\beta}}\right]\right\}^2 . \quad (7)$$

We take the square of difference in order to minimize the distance both for points above and below the interpolation function. Thus, with this methodology only the fact that the interpolation function must be nearest to the distribution points is explored.

4.2 Alpha- and beta-concentrations

In order to make clearer the role of *a* and *β* parameters, we take as an example the five scenarios presented in the Appendix. The values of these parameters are presented in Table 1. For Scenario 1, the alpha-concentration is justified by the fact that the first two sectors have a share in the portfolio that does not exceed 5%. This is also the case for the first half of the sectors of Scenario 2 and for the first sector of Scenario 3 for which the concentration remains to be of type alpha. The situation changes with Scenario 4, where the number of sectors with higher loans is much fewer than that of sectors with smaller loans. This scenario gives an example of beta-concentrated portfolio. If the loans are relatively concentrated on the one sector, which is the case for Scenario 5, the parameter *β* is very high.

Table 1. Alpha and beta parameters of the loan distribution for five scenarios described in Table A1.

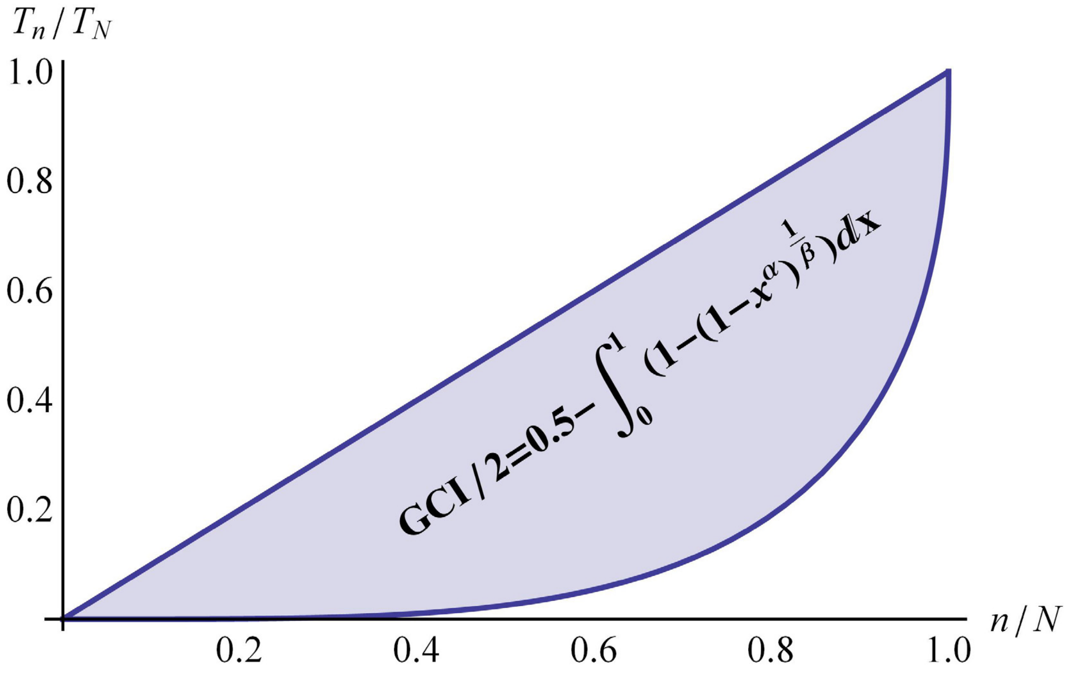
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
a	1.83	2.63	1.17	1.10	1.00
β	1.03	1.00	1.00	4.29	54.88
GCI	0.305	0.449	0.078	0.643	0.964
HHI_n	0.030	0.088	0.008	0.241	0.929
EI_n	0.066	0.209	0.024	0.462	0.906

Note: This table gives the results of parameters a and β of the loan distribution according to five scenarios described in Table A1. They are estimated minimizing the function (7). The alpha-concentration is present for the first three scenarios and beta-concentration for the last two. The GCI is estimated according to the equation (8).

4.3 Global measure of concentration

The parameters *a* and *β* describe the form of the loan distribution function (equation 6), providing important information about the way in which the loans are distributed. However, they do not provide a global view on the loan distribution.

Figure 3. Geometrical interpretation of the Global Concentration Index.



Note: This figure presents the geometrical interpretation of the Global Concentration Index (GCI). The area between the curve of the Lorenz diagram and the bisecting line gives the value of half of the GCI. If loans are uniformly allocated across sectors, then the curve of the Lorenz diagram fits the bisecting line and the area between them is equal to zero. In this case, the GCI/2 is 0, and GCI=0. On the other hand, if all loans are allocated only to one sector, the curve of the Lorenz diagram lays out along the x-axis until 1 and then rises along the y-axis until 1. This implies GCI=1, as the area between the curve of the Lorenz diagram and the bisecting line is equal to 0.5.

In the Lorenz diagram, if loans are distributed uniformly, the distribution curve coincides with the bisecting line. In this case of absence of concentration, there is no region between the Lorenz curve and the bisecting line and the area between these two curves is thus zero. On the other hand, if all loans are allocated to a single sector, the curve of the Lorenz diagram lays out along the x-axis till x=1 and then rises along the y-axis till y=1. In that case, the area between the curve of the Lorenz diagram and the bisecting line is maximum and equal to 0.5. Thus, the area between the curve of the Lorenz diagram and the bisecting line could be a good measure of a Global Concentration Index (GCI) (see Figure 3). This index takes zero when there is no concentration on the market and loans are uniformly distributed across economic sectors and a maximum value when there is a complete concentration of loans to a single sector. In order to ensure that the GCI takes values between 0 and 1, like the normalised Herfindahl-Hirschman and Entropy indexes, we multiply by two the area between the curve of the Lorenz diagram and the bisecting line, as follows:

$$GCI = 1 - 2\int_0^1 \left[1 - \left(1 - x^{\alpha}\right)^{\frac{1}{\beta}}\right] dx, \qquad (8)$$

where $x=n/N$.

Thus, in our opinion, the GCI results in being a good global concentration index. Its main advantage is that it avoids the "weight bias" taking into consideration just the form of the loan function. Continuing the above example with five scenarios of loan distribution, we find that the GCI takes values that are very different from those of the HHI_n and EI_n (see Table 1). Being exempt from the "weight bias", we prefer the Global Concentration Index in order to find the determinants of sectoral loan concentration for Bulgarian banks.

5. Determinants of loan concentration for Bulgarian banks

We will try to find the determinants for the GCI and alpha-concentration index. The beta-concentration cannot be studied since there are too few cases where beta exceeds alpha. Thus, Bulgarian banks grant loans in the way in which there are few sectors with small loans. One could thus depict the factors that push banks to have many sectors with a high amount of loans in their portfolio, which would not be possible with the HHI_n and EI_n concentration indexes. To do this, we will first of all present the econometric methodology and then discuss the obtained results.

5.1 Econometric methodology

To study the determinants of sectoral loan concentration we use the panel data for all Bulgarian banks. With this data base, we apply the following panel model with fixed effects:

$$\begin{aligned} CI_{it} = \eta_i + \chi_t + \beta_1 Liq_{it} + \beta_2 Portf_{it} + \beta_3 Loan_{it} + \beta_4 IBIR_{t-1} + \beta_6 IM_{it-1} \\ + \beta_7 Size_{it} + \beta_8 Foreign_{it} + \beta_9 M3/GDP_{t-1} + \beta_{10} GDPGR_{t-1} + \varepsilon_{it}, \end{aligned} \tag{9}$$

where i represents the bank's index and t the temporal index. CI expresses the concentration index and characterizes two different concentration types: the alpha-concentration (*ac*) and Global Concentration Index. The former is estimated as a difference between parameters alpha and beta and is "truncated" below zero, which will reduce the number of observation compared to regressions with the GCI.

We could distinguish five types of factors that are likely to influence the way in which banks grant loans. The first type is related to prudential regulation that was introduced in Bulgaria in the late 1990s. Liquidity is one of such factors since banks must ensure a minimum level of liquidity in order to meet regularly and without delay their daily obligations. Such obligation was imposed to Bulgarian banks after the banking crisis of 1996.[6] Thus, it is not unlikely that in the conditions of scarce funds banks try to meet this obligation at the expense of loans, which explains the use of the liquidity level (*Liq*), measured as the ratio of the bank liquidities to bank total assets.

Another series of factors relates to the arbitrage investment policy of the banks: the increase in investment portfolio size is often made to the detriment of the loan portfolio. Thus, the level of investment portfolio (*Portf*) could indirectly influence the

[6] The Ordinance Liquidity Management and Supervision of Banks of the Bulgarian National Bank was approved and introduced in 1997.

concentration lending decision. It is determined as the ratio of the portfolio size to bank total assets.

The third type of factors directly influence the way in which loans are allocated. Among them, we will consider the size of loan portfolio (*Loan*), measured as the ratio of loan amount to total bank assets, and the profitability of the lending activity, expressed by the interest margin (*IM*). The profitability of lending activity can induce banks to lend more, which could imply a modification on the sectoral loan portfolio concentration. It is determined as the difference between the profitability of the interest-earning assets, measured as the ratio of interest revenues to total interest-earning assets, and the unitary cost of the interest-bearing liabilities, measured as the ratio of interest expenses to total interest-bearing liabilities.

As for bank characteristics, the size and type of banks could affect their activities, namely in such emerging countries as Bulgaria, where large banks and foreign institutions could have different lending strategies. The larger the banks are, the higher their market power and respectively the more aggressive their development strategy could be. This type of bank could therefore lend only to the highest performing firms, their loan portfolio being concentrated into few economic sectors. This could be the same for foreign banks, since in most cases they also have the highest assets. Moreover, these banks own external funds from their parent banks, giving them more power to gain the highest-yield market sectors. The bank's size (*Size*) is measured by the logarithm of its total assets and we include a dummy variable *Foreign* that takes one if more than 50% of bank capital is owned by foreign institutions, and zero otherwise.

We also add some control variables, which reflect the evolution of the economic environment in terms of monetary policy, the increase in money supply and economic growth. Den Haan et al. (2007), for instance, find that the banks' behaviour changes with the evolution of monetary policy: the restrictive monetary policy implies the concentration of the loans for the commercial and industrial sectors to the detriment of consumption and mortgage purposes. Since the exchange regime in Bulgaria is a currency board linked to the euro, there is no independent monetary policy. The inter-banking interest rate (*IBIR*) will therefore be considered as a proxy variable of the monetary policy in Bulgaria.

The money stock in circulation could describe the facility with which economic agents have access to bank financing. We consider the largest monetary aggregate M3 as a fraction of Gross Domestic Product. The last control variable is the real growth of Gross Domestic Product (*GDPGR*) since it allows for taking into account the demand factor for loan supply and thus could influence the sectoral concentration of the loan portfolio.

The control variables, but also the variables that reflect the banks' performance as the interest margin, are delayed by one period (quarter). The reason is that banks do not respond instantly to the evolution of the economic environment, monetary policy and the banking market situation, and to the changing of their profitability variables. We thus consider that lagged variables are economically more pertinent.

5.2 Data and results

From 2003 to 2006 the Bulgarian National Bank published the quarterly banks' balance-sheet, profit-and-loss accounts and the banks' loan portfolio decomposition by economic sector activity. Thanks to the complete data availability, the study concerns the whole Bulgarian banking sector that comprises 35 banks. We have 16 periods and the loan portfolio structure contains six sectors: 1) real estate and construction loans, 2) commercial loans, 3) agricultural loans, 4) consumer loans, 5) housing mortgage loans, and 6) other loans.

The use of data for all banks excludes any random effects; this is the reason why we rather consider the fixed effects in the equation (9). The structure of this equation and the nature of the dependent and independent variables suggest the use of the dynamic-panel methodology, developed by Arellano and Bond (1991). The following reasons lead us to apply dynamic-panel estimators to find the determinants of the sectoral loan portfolio concentration. First, there are few time periods, 16, compared with the number of banks, 35. Second, the equation (9) has a linear functional relationship. Third, the concentration indexes could also depend on their own past, realisations making them as dynamic variables. Fourth, the independent variables are not strictly exogenous, that is correlated with past and possibly current realisation of the error term. For instance, the amount of loans and the interest margin could cause and be influenced by the way in which the loan portfolio is concentrated. Thus, the causality may run in both directions: from *Loans* and the interest margin (*IM*) to concentration indexes (*CI*), and vice versa. Fifth, the equation (9) is characterized by fixed individual effects.

Thus, in order to find the determinants of the sectoral loan portfolio concentration for Bulgarian banks, we apply the Arrellano and Bond (1991) GMM difference estimator. The variables are instrumented by their own series. Only the concentration index, as a dependent variable, is instrumented by its difference series with lags 1 and 2. We limit to lag 2 due to the small number of periods in our sample.

There is a risk that some independent variables of the equation (9) are to be correlated, which is confirmed by the correlation coefficients and their statistical significance levels presented in Table 2. The liquidity level (*Liq*) is correlated with the level of loan portfolio (*Loan*), the interest margin (*IM*), the size and type of banks, and with economic environment variables (*IBIR* and *M3/GDP*). The level of investment portfolio (*Portf*) is correlated with the level of loan portfolio as bank substitutes, with the interest margin and with types of banks, the interest margin with the evolution of monetary policy, and the economic environment variables among them. To avoid the autocorrelation problems, the regressions will be made without variables that are correlated with those employed in regression. Therefore, we will regress three types of equation: one with *Liq*, *Portf* and *GDPGR* as explicative variables, second with *Loan*, *Size* and *IBIR* as explicative variables, and the last with *IM*, *Foreign* and *M3/GDP* as explicative variables.

The regression is made with a one-step GMM estimator, applying the heteroskedasticity and autocorrelation correction for standard errors as there could be heteroskedasticity and autocorrelation within banks. The results for determinants of the alpha-concentration, $ac=a-\beta$, are presented in Table 3 and those for determinants of the Global Concentration Index in Table 4. They are obtained with one and two lagged dependent variables. The *J*-statistics of Hansen allows testing and choosing the level of lag to take into regression. Moreover, the Arrellano-Bond autoregressive test in first differences A-B test ar(1) allows us to test whether the idiosyncratic disturbance term is auto-correlated of order one, which is a condition of a dynamic-panel model. This concerns the idiosyncratic component of the error term as the fixed effects are mutually eliminated.

Table 2. Correlation coefficients among explicative variables and their p-values.

Variables	**Liq**	**Portf**	**Loan**	**IM(-1)**	**Size**	**Foreign**	**IBIR (-1)**	**M3/GDP(-1)**	**GDPGR(-1)**
Liq	1	0.077	-0.355	-0.333	0.126	-0.151	0.182	0.104	0.076
Portf	0.077	1	-0.408	-0.151	0.010	-0.102	-0.006	-0.023	-0.085
Loan	< 0.001	< 0.001	1	0.478	0.053	0.014	-0.071	0.005	0.061
IM(-1)	< 0.001	0.001	< 0.001	1	-0.018	0.014	0.488	0.002	0.072
Size	0.004	0.819	0.225	0.674	1	0.278	0.024	0.250	0.120
Foreign	0.001	0.019	0.748	0.745	< 0.001	1	0.523	0.047	0.022
IBIR(-1)	< 0.0001	0.885	0.104	0.030	0.098	0.028	1	0.524	0.263
M3/GDP(-1)	0.017	0.596	0.900	0.965	< 0.001	0.282	< 0.001	1	0.141
GDPGR(-1)	0.081	0.052	0.161	0.097	0.005	0.608	< 0.001	0.001	1

Note: This table presents the correlation coefficients among explicative variables of the equation (9) and their statistical significance, expressed by the p-values. To the right of the figure 1 the correlation coefficients are presented and to the left of the figure 1 their p-values are presented.

Aiming to make a robustness check, we also regress equation (9) with a two-step GMM estimator (models from 1' to 6'). This estimator is asymptotically efficient and robust to patterns of heteroskedasticity and cross-correlation. In empirical literature, one-step results are often presented because of downward bias in the computed standard errors with two-step estimators, thus rendering some results statistically significant when they are not. But Windmeijer (2005) greatly reduced this problem. Thus, we apply the two-step GMM estimator with the Windmeijer's correction to the standard errors.

Effectively owing to the fixed effects, the error term is auto-correlated from order 1 in differences. Moreover, the A-B test ar(2) cannot reject the absence of autocorrelation of order 2 in differences, at 5% significance level, for all models (from 1 to 6, and from 1' to 6') and for both concentration indexes, *ac* and GCI (see Tables 3 and 4). This allows for using the lag 1 in difference to the dependent variable as instrument. The Sargan and *J*-Hansen statistics are used to test the validity of instruments. The main assumption for the validity of GMM estimates is that the instruments are exogenous. A test of the null hypothesis of the instrument variables' exogeneity is also performed. These statistics test for the joint validity of the moment conditions (identifying restrictions) that falls out of the GMM framework. The null hypothesis being the joint validity of instruments, the Sargan test rejects it for some models. But, this statistic is inconsistent if non-sphericity is suspected in error terms. In this case, a theoretically superior test is that based on the *J*-Hansen statistic. The results show that the Hansen test cannot reject the hypothesis of the joint validity of instruments and that is for all models and all concentration measures. Moreover, the null hypothesis of the instrument variables' exogeneity cannot also be rejected.

The results obtained for the alpha-concentration of the Bulgarian banks' loan portfolio reveal that the first type of factors, the ratio of liquid assets to total assets (*Liq*), implies a reduction in alpha-concentration (models 1 and 2). The banks which have a higher ratio of liquid assets have a loan portfolio that is lesser alpha-concentrated according to economic sectors. This is the same for the ratio of investment assets to total assets (*Portf*). The increase in economic growth reduces the loan portfolio concentration of type alpha too. Moreover, the higher the amount of loans with respect to total assets, the lesser the concentration of type alpha. This result must be considered cautiously since the coefficient of the *Loan* variable is significant only for a model with one lagged endogenous variable for *ac* on the right-side of the equation (9) and only for the one-step GMM estimation (model 4).

The *J*-statistic of Hansen, which is a GMM criterion function, allows for choosing the lag of the dependent variable, which means testing the relevance of additional restrictions. The more lags are introduced, the less restricted the model is. The *J*-statistic of the restricted model, J_r, must be larger than that of the unrestricted model, J_{ur}. Each *J*-statistic follows a chi-square, with degrees of freedom equal to the number of instruments minus the number of estimated parameters. The test of a restricted model with respect to an unrestricted one, that is to say the difference between J_{ur} and J_r, is itself asymptotically chi-square, with degrees of freedom equal to the difference between the degrees of freedom of each *J*-statistic (Greene 2003, p. 548-549). For instance, the identifying lag test for *ac* with *Liq* as an independent variable is performed between the restricted model (model 2) and unrestricted one (model 1). J_r=13.93 is higher than J_{ur}=10.17, and the difference between them is 3.76 which is lesser than the critical chi-squared value with one degree of freedom (number of degrees of freedom for J_r minus the number of degrees of freedom for J_{ur}, which is the difference between the numbers of instruments since the number of estimated coefficients is the same for restricted and unrestricted models), that is 3.84 for 95 percent significance. The equation with *Liq* variable cannot thus reject the one-lag model.

In the same way, we test the pertinence of the one-lag model with respect to two-lag one for two other regressions. The test suggests that only the results of the two-lag regressions must be taken into consideration, those of the models 3 and 5. We can thus conclude that only *Liq*, *Portf* and *GDPGR* variables influence the concentration of type alpha for Bulgarian banks' lending behaviour.

But previous results are obtained with one-step GMM regressions. Making two-step estimations we find some differences in our findings (the right-side of table 3). We find that the *Liq* and *GDPGR* variables have no more influence on the concentration of type alpha. On the other hand, the coefficients of the *IM* and *IBIR* variables become significant. Thus, the banks with a higher interest margin in the previous period have more an alpha-concentrated loan portfolio and the restriction in monetary policy reduces the alpha-concentration.

According to the results presented in Table 4, we will analyse only the one-lag models' results for the determinants of the Global Concentration measure, since one may not reject the hypothesis with restricted regressions. We find that the ratio of liquid assets reduces also the global concentration of the Bulgarian banks' loan portfolio. But there is no longer a case for the investment portfolio level and for the profitability of the banking activity. The coefficients of the *Portf* and *IM* variables are no longer statistically significant.

Among economic environment variables, only the level of money in circulation influences the global concentration of the Bulgarian banks' loan portfolios. This result is intuitively an expected one. More money in circulation facilitates the access to bank financing and reduces the constraint with respect to the choice of the sector to be financed. Thus, the banks are not constrained to lend only to some preferential economic sectors.

Concerning the two-step regressions, there are no additional revealed determinants and those found within one-step regressions keep the statistical significance of their coefficients. Thus, to summarize, the banks with a higher liquidity level have less global concentrated loan portfolio. On the other hand, the loans are more concentrated according to economic sectors for banks with a higher level of loans on total assets. If there is more money in circulation, the Bulgarian banks lend to more economic sectors, thus reducing the global concentration of their loan portfolios.

The use of the HHIn and EIn in the determination of the factors that influence the lending market concentration in Bulgaria provides some divergence (see tables 5 and 6). With these measures we find no more impact of the loan level on the concentration of the loan portfolio. We base our conclusions only on the results of the one-lag regressions since the tests cannot reject the hypothesis with restricted regressions for all models and for both concentration measures. Moreover, with HHIn and EIn the evolution of the money in circulation does not keep its effect on the loan concentration with more robust two-step estimations.

Thus, the only variable among those chosen to study the loan concentration of the Bulgarian banks that has a significant coefficient is the liquidity ratio. We therefore presume that the GCI performs better than the HHIn and EIn measures.

Table 3. Determinants of the alpha-concentration for the Bulgarian banks' loan portfolios.

Dep. var αc	1	2	3	4	5	6	1'	2'	3'	4'	5'	6'
αc (-1)	0.450**	0.516***	0.395**	0.383***	0.453**	0.548***	0.474***	0.546***	0.407***	0.411***	0.404**	0.595***
αc (-2)	-0.137		0.003		-0.209		-0.176		-0.039		-0.355	
Liq	-2.609*	-2.843**					-1.947	-1.443				
Portf	-7.180***	-7.661***					-6.629***	-6.304***				
Loan			-6.726	-8.215**					-2.802	-5.774		
IM(-1)					45.361	62.380					55.253*	76.049**
Size			-0.719	-0.768					-0.056	-0.299		
Foreign					-0.268	-0.201					-0.134	-0.420
IBIR(-1)			-29.963	-29.425					-28.012**	-36.998**		
M3/GDP(-1)					2.517	2.277					-1.419	2.430
GDPGR(-1)	-0.134*	-0.119*					-0.072	-0.059				
Nr. of obs.	420	456	420	456	420	456	420	456	420	456	420	456
Nr. of instr.	16	17	28	29	16	17	16	17	28	29	16	17
A-B test: ar(1)	-2.67***	-2.31**	-2.84***	-2.62***	-2.83***	-2.43***	-2.43***	-2.44***	-2.29**	-2.34**	-2.53***	-2.47***
ar(2)	0.27	-1.88*	-0.35	-1.50	0.68	-1.73*	0.51	-1.83*	-0.15	-1.68*	1.06	-1.70*
Sargan	18.67*	19.07	28.19	25.36	18.47*	16.67	18.67*	19.07	28.19	25.36	18.47*	16.67
J-Hansen	10.17	13.93	16.31	26.05	9.24	17.01	10.17	13.93	16.31	26.05	9.24	17.01
H0: IV exog	0.85	5.46	0.06	3.68	3.72	6.72*	0.85	5.46	0.06	3.68	3.72	6.72

*Note: This table presents the estimation results of the equation (9) with one- and two-steps GMM robust estimator for alpha-concentration Index. The left-side of the table presents the results with one-step estimator and the right-side those obtained with two-step estimator. J-statistic of Hansen allows choosing the level of lag of the dependent variable. Arrelano-Bond autoregressive test permits to test for dynamic-panel model, in which case ar(1) test must reject the null hypothesis of lack of autocorrelation and ar(2) test must not reject it. Sargan and Hansen test of overidentifying restrictions detects roughly the joint validity of instruments. The difference-in-Hansen tests checks for the exogeneity of instrument variables. ***, **, * mean that the coefficients are significant at 1%, 5% and 10% levels, respectively.*

Table 4. Determinants of the GCI for the Bulgarian banks' loan portfolios.

Dep. var GCI	**1**	**2**	**3**	**4**	**5**	**6**	**1'**	**2'**	**3'**	**4'**	**5'**	**6'**
GCI(-1)	0.637***	0.616***	0.672***	0.738***	0.819***	0.621***	0.638***	0.670***	0.702***	0.790***	0.964***	0.724***
GCI(-2)	-0.041		0.262		-0.204		-0.026		0.291		-0.299	
Liq	-0.167***	-0.175***					-0.153***	-0.173***				
Portf	-0.110	-0.098					-0.063	-0.069				
Loan			0.287***	0.259**					0.255**	0.226*		
IM(-1)					2.335	0.866					2.127	1.945
Size			0.031	0.009					0.030	0.007		
Foreign					0.030***	-0.018					0.031***	-0.041
IBIR(-1)			-0.430	-0.229					-0.113	-0.139		
M3/GDP(-1)					-0.789***	-0.736***					-0.703***	-0.574**
GDPGR(-1)	-0.0006	-0.00006					-0.0002	0.0005				
Nr. of obs.	420	456	420	456	420	456	420	456	420	456	420	456
Nr. of instr.	16	17	28	29	16	17	16	17	28	29	16	17
A-B test: ar(1)	-2.43***	-2.97***	-2.00**	-2.44**	-2.80***	-2.89***	-1.65*	-2.78***	-1.53	-2.67***	-2.09**	-2.82***
ar(2)	0.65	0.01	-1.38	-0.06	1.27	0.19	0.34	-0.03	-0.87	-0.08	1.06	0.14
Sargan	21.82**	22.53**	29.60	34.51	13.55	21.18*	21.82**	22.53**	29.60	34.51	13.55	21.18*
J-Hansen	14.62	14.96	26.96	28.04	11.83	13.69	14.62	14.96	26.96	28.04	11.83	13.69
H0: IV exog	3.51	4.03	1.82	0.90	2.50	2.66	3.51	4.03	1.82	0.90	2.50	2.66

*Note: This table presents the estimation results of the equation (9) with one- and two-steps GMM robust estimator for Global Concentration Index. The left-side of the table presents the results with one-step estimator and the right-side those obtained with two-step estimator. J-statistic of Hansen allows choosing the level of lag of the dependent variable. Arrelano-Bond autoregressive test permits to test for dynamic-panel model, in which case ar(1) test must reject the null hypothesis of lack of autocorrelation and ar(2) test must not reject it. Sargan and Hansen test of overidentifying restrictions detects roughly the joint validity of instruments. The difference-in-Hansen tests checks for the exogeneity of instrument variables. ***, **, * mean that the coefficients are significant at 1%, 5% and 10% levels, respectively.*

Table 5. Determinants of the HHIn for the Bulgarian banks' loan portfolio.

Dep. var HHIn	1	2	3	4	5	6	1'	2'	3'	4'	5'	6'
HHIn(-1)	0.455***	0.496***	0.499***	0.588***	0.598***	0.546***	0.505**	0.548***	0.521***	0.647***	0.667***	0.603***
HHIn(-2)	-0.007		0.112		-0.101		0.05		0.095		-0.109	
Liq	-0.256***	-0.270***					-0.279**	-0.289***				
Portf	-0.090	-0.075					-0.098	-0.076				
Loan			0.324*	0.227					0.220*	0.198		
IM(-1)					1.625	0.283					1.349	0.833
Size			0.016	0.003					-0.007	-0.005		
Foreign					0.041***	-0.018					0.035**	-0.043
IBIR(-1)			-0.311	-0.281					-0.227	-0.312		
M3/GDP(-1)					-0.942**	-0.938**					-0.709*	-0.626
GDPGR(-1)	-0.002	-0.001					0.0001	0.001				
Nr. of obs.	420	456	420	456	420	456	420	456	420	456	420	456
Nr. of instr.	16	17	28	30	16	17	16	17	28	29	16	17
A-B test: ar(1)	-2.03**	-3.18***	-2.21**	-2.76***	-2.66***	-3.51***	-1.56	-2.98***	-1.90*	-2.88***	-2.06**	-3.11****
ar(2)	0.07	-0.77	-0.92	-0.87	0.66	-0.66	-0.22	-0.91	-0.64	-0.83	0.48	-0.62
Sargan	34.41***	32.89**	45.12***	43.21**	26.67***	30.84***	34.41***	32.89**	45.12***	43.21**	26.67***	30.84***
J-Hansen	12.52	13.71	24.58	25.46	14.07	14.35	12.52	13.71	24.58	25.46	14.07	14.35
H0: IV exog	1.76	0.87	1.72	3.17	2.42	3.38	1.76	0.87	1.72	3.17	2.42	3.38

*Note: This table presents the estimation results of the equation (9) with one- and two-steps GMM robust estimator for HHIn Index. The left-side of the table presents the results with one-step estimator and the right-side those obtained with two-step estimator. J-statistic of Hansen allows choosing the level of lag of the dependent variable. Arrelano-Bond autoregressive test permits to test for dynamic-panel model, in which case ar(1) test must reject the null hypothesis of lack of autocorrelation and ar(2) test must not reject it. Sargan and Hansen test of overidentifying restrictions detects roughly the joint validity of instruments. The difference-in-Hansen tests checks for the exogeneity of instrument variables. ***, **, * mean that the coefficients are significant at 1%, 5% and 10% levels, respectively.*

Table 6. Determinants of the EIn for the Bulgarian banks' loan portfolios.

Dep. var EIn	**1**	**2**	**3**	**4**	**5**	**6**	**1'**	**2'**	**3'**	**4'**	**5'**	**6'**
EIn(-1)	0.567***	0.579***	0.550***	0.668***	0.755***	0.613***	0.590***	0.631***	0.573***	0.728***	0.893***	0.711***
EIn(-2)	-0.033		0.186		-0.182		0.006		0.143		-0.287	
Liq	-0.208***	-0.218***					-0.200***	-0.216***				
Portf	-0.139	-0.123					-0.109	-0.110				
Loan			0.271**	0.144					0.185*	0.183*		
IM(-1)					2.367	1.262					2.108	2.041
Size			0.024	0.004					0.005	0.010		
Foreign					0.037***	-0.23					0.036***	-0.053
IBIR(-1)			-0.453	-0.462					-0.031	-0.318		
M3/GDP(-1)					-0.839***	-0.735**					-0.745**	-0.545
GDPGR(-1)	-0.002	-0.001					-0.001	-0.0001				
Nr. of obs.	420	456	420	456	420	456	420	456	420	456	420	456
Nr. of instr.	16	17	28	29	16	17	16	17	28	29	16	17
A-B test: ar(1)	-2.29**	-3.09**	-2.28**	-2.81***	-2.80***	-3.15***	-1.51*	-2.92***	-1.70**	-2.70***	-2.23**	-3.02***
ar(2)	0.40	-0.38	-0.98	-0.36	1.18	-0.24	0.08	-0.44	-0.58	-0.41	1.04	-0.21
Sargan	23.52***	25.93**	38.97**	37.55**	17.09*	24.25**	23.52***	25.93**	38.97**	37.55	17.09*	24.25**
J-Hansen	11.98	12.98	25.32	29.12	11.55	13.80	11.98	12.98	25.32	29.12	11.55	13.80
H0: IV exog	2.42	1.58	1.51	6.44**	0.97	1.90	2.42	1.58	1.51	6.44**	0.97	1.90

*Note: This table presents the estimation results of the equation (9) with one- and two-steps GMM robust estimator for EIn Index. The left-side of the table presents the results with one-step estimator and the right-side those obtained with two-step estimator. J-statistic of Hansen allows choosing the level of lag of the dependent variable. Arrelano-Bond autoregressive test permits to test for dynamic-panel model, in which case ar(1) test must reject the null hypothesis of lack of autocorrelation and ar(2) test must not reject it. Sargan and Hansen test of overidentifying restrictions detects roughly the joint validity of instruments. The difference-in-Hansen tests checks for the exogeneity of instrument variables. ***, **, * mean that the coefficients are significant at 1%, 5% and 10% levels, respectively.*

6. Conclusion

This study focused on the determinants of the sectoral loan portfolio concentration for Bulgarian banks. We chose this country because its banking sector evolved substantially as a result of the economic environment evolution and the regulatory requirements effect. But the main contribution of this paper is the construction of new concentration measures, which avoid the problem of correctly weighting the market shares that compose traditionally used concentration indexes.

Thus, the interest of the present work is twofold. In the first part of the paper we have proposed a methodology to estimate a new, more informative concentration index that makes it possible to avoid the "weight bias" distorting the usually applied Herfindahl-Hirshman and Entropy concentration measures. It has been shown that these two indexes are biased and this is why a new global concentration index has been constructed. Two new forms of concentration, named alpha-concentration and beta-concentration, have been revealed with our methodology. The first type of sectoral concentration is due to the presence of few very small sectors in the loan portfolio and the second one is the result of the presence of many sectors with small loans and few sectors with large loans. They consequently describe the loan distribution function and give information on the way in which economic sectors are financed.

We then estimated the determinants of the sectoral loan portfolio concentration of the Bulgarian banks for the 2003-2006 period. They cannot be found for beta-concentration due to the small number of cases associated with this kind of concentration. For alpha-concentration it has been shown that liquidity as well as the levels of investment portfolio influences it. The banks that are more liquid and have a larger investment portfolio have a loan portfolio that is lesser alpha-concentrated by economic sectors. Moreover, within an economically improving environment, the Bulgarian banks reduce the concentration of type alpha of their loan portfolio. Besides these results, with a two-step robust GMM estimator we found that the increase in interest margin leads the banks to grant loans in the way in which the loan portfolio becomes more alpha-concentrated. Another factor is the monetary policy, presented through the interbank interest rate. A restrictive monetary policy reduces the concentration of type alpha.

The results regarding the determinants of global concentration are not similar. Only the liquidity ratio has the same effect. Other determinants are the levels of loans on total assets and of money in circulation. More loans do not mean lesser concentration, but conversely the banks that have a higher fraction of loans to total assets have also a more global sectoral concentrated portfolio. On the other hand, more money in circulation facilitates the access to bank financing and reduces the constraint with respect to the choice of the sector to be financed. If we compare these results with those obtained with the traditional HHIn and EIn measures, then only the liquidity ratio influences the economic sectoral loan concentration, which suggests that these indexes perform worse than the GCI.

Appendix: How are differences between HHI and EI expressed?

The EI weights exposure to an economic sector by minus logarithm of this exposure and thus attaches more importance to least funded sectors. Inversely, the HHI weights exposure to an economic sector by its own value and assigns more share to most funded sectors. Thus, these indexes are biased and diverge in their results.

Table A1 presents our results for the normalised Herfindahl-Hirschman and Entropy indexes for a loan distribution of the same amount granted across ten sectors and for five scenarios. The sectors are ranked in ascending order according to the loan amount. In the first scenario, the distribution is such that the transition is smooth from one sector to the following; that is, the amount of granted loans between two neighbour sectors is equal to 10% of the most funded sector. The values of both normalised concentration indexes are very close to zero, even if they are far from a uniform distribution. Nevertheless, the EI_n is relatively much higher than the HHI_n, more than twofold. This difference also persists in the second scenario, in which the first half of sectors is financed with 3 monetary units (m.u.) and the second one with 52 m.u. The loan portfolio is thus clearly divided in two equal separate parts, each of them having uniform loan distribution. Since the distributed amounts differ a lot, concentration increases. We can see that the EI_n is more sensitive. The difference between the values of these two indexes appears to be even larger in the third scenario, for which we have the same maximum amount of 30 m.u. allocated to all sectors, except the first one for which the amount of 5 m.u. is granted. In scenario 4 the concentration of loans is already strong and the values of HHI_n and EI_n are higher. However, EI_n is approximately twice as high as HHI_n. Thus, the difference between these indexes is weakened when increasing the number of sectors endowed with the minimum amount of monetary units. If we attribute 1 m.u. for the first nine sectors and a maximum of 266 m.u. to the last sector, then the HHI_n even exceeds the EI_n (scenario 5).

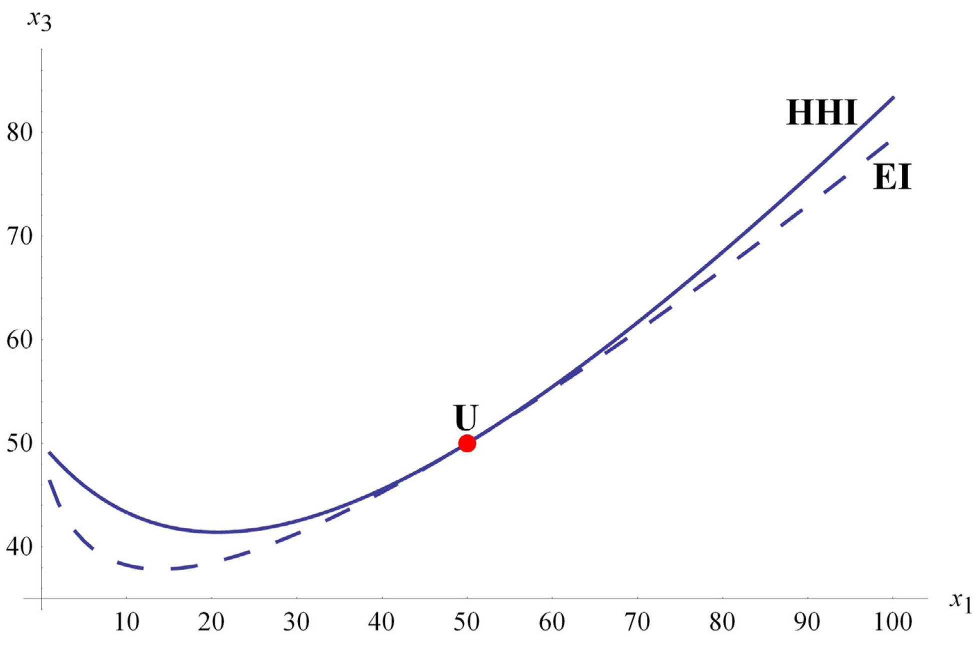
Table A1. HHIn and EIn for five different sectors.

Rank of sector by size (ascending order)	Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5
1	5	3	5	1	1
2	10	3	30	1	1
3	15	3	30	1	1
4	20	3	30	1	1
5	25	3	30	1	1
6	30	52	30	1	1
7	35	52	30	1	1
8	40	52	30	89	1
9	45	52	30	89	1
10	50	52	30	90	266
Sum	275	275	275	275	275
HHI_n	0.030	0.088	0.008	0.241	0.929
EI_n	0.066	0.209	0.024	0.462	0.906

Note: This table depicts five different scenarios of loan distribution among ten projects, which are ranged in ascending order according to their loan size. The normalised Herfindahl-Hirschman (HHIn) and Entropy (EIn) concentration indexes are estimated according to equations (3) and (5) respectively.

This simple exercise shows that the EI_n is more sensitive for smaller sectors when they are fewer and the HHI_n is more sensitive for larger sectors when they are fewer. This is not the only difference. Our results also differ when adjusting the loan portfolio in order to obtain a minimum concentration. Consider a portfolio of three sectors with amounts of x_1, x_2 and x_3, respectively. Let the second sector be financed with 50 m.u. The question is to find the portfolio structure, - that is, the amounts invested in the first and third sectors -, so that the portfolio concentration is minimum. Minimising the equation (2) and maximising the equation (4) for different values of x_1 and for x_2=50, the results for x_3 are different. As is depicted in Figure A1, for the same amount invested in the first sector x_3 is greater with HHI than with EI. The only point for which we obtain the same result is the point U, where x_1=x_2=x_3=50, that is for a uniform loan distribution.

Figure A1. Minimum portfolio concentration composed of three sectors, one of which contains 50 m.u, made with HHI and EI indexes.



Note: This figure presents the combination of the amounts lent to the first and third sectors (x_1 and x_3 respectively) so that to obtain a minimum concentration, with 50 m.u. allowed to the second sector. For the same amount invested in the first sector, the HHI, which is minimized, gives a higher value for x_3 than the EI, which is maximized. The only configuration for which the two concentration indexes give the same values is the uniform resource distribution, that is when loans are distributed equally (point U, x_1=x_2=x_3=50).

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