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Efficiency, scale and scope economies in the Ukrainian banking sector in 1998

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Abstract

This paper evaluates the current development of the Ukrainian banking system. The research was concentrated on the evaluation of cost and profit efficiency and scale and scope economies for 79 from 168 Ukrainian commercial banks in 1998. There is evidence that small banks operate more efficiently in cost terms but are less efficient in profit terms and furthermore, there is a substantial difference in scale economies between small and large banks. Large banks show significant diseconomies of scale while small ones show significant scale economies. This result could suggest that current technology in the financial sector does not allow efficient growth and concentration of the financial sector in Ukraine.

JEL classifications: C30; D2; G21

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1. Introduction

Rapid changes in the structure of the financial system worldwide have attracted a great deal of attention in academic and policy circles. Berger and Humphrey

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(1998) surveyed 130 papers analyzing efficiency for 21 countries. However, most of the existing studies are devoted to the financial sector of developed economies, the only exception being a recent special issue of the *Journal of Banking and Finance* (2000) that provides an overview of issues related to the development of the financial system in transition economies. This paper complements these latter studies, concentrating on the evaluation of the banking system in Ukraine and sheds some light on the impact on this country of dramatic changes in financial structure, the role of financial institutions in the process of reform and economic development.

The banking system is a key element of the modern market economy. The availability of finance for enterprises, and the potential to restructure and improve competitiveness in transition economies critically depends on the efficiency of the banking system. In this research we focus on the evaluation of the operational efficiency of commercial banks in the Ukraine. The methodology used in this study to test for efficiency is the 'efficiency frontier analysis' consisting of estimating the efficient level of cost (or profit) for a given volume of operations of a commercial bank and comparing those figures with the efficient level. This methodology (Berger and Humphrey, 1998) is particularly suitable first of all to draw conclusions about the influence of changes in the structure of the financial system and assessment of the effects of government policy on efficiency. Second, to evaluate the efficiency of an industry and to propose a methodology for ranking firms according to their efficiency of operation. Third, to improve managerial performance primarily on the basis of the identification of the best-performing firms and best practices in the industry.

The research is based on a unique data set containing broad information on 79 Ukrainian banks. We test for alternative dimensions of efficiency, in particular cost and profit efficiency, scale and scope economies, and the determinants of the interest margins enjoyed by commercial banks.

The paper is structured as follows. Section 2 shortly introduces the concepts of efficiency and the functional form used in the empirical implementations. The empirical results are reported in Section 3. After a brief description of the current situation in the Ukrainian banking sector (Section 3.1) and a description of the data set used for estimation (Section 3.2), we present the estimation results for cost and profit (Section 3.3) and other determinants (Section 3.4) of efficiency and, finally, the estimates of scale and scope economies (Section 3.5). Section 4 concludes.

2. Efficiency and functional form

The analysis of the efficiency of the operations of commercial banks is often based on the estimation of the cost or profit function of the commercial bank. In general, a cost function could be expressed as:

$$C = C(p, y, z, u, \varepsilon) \tag{1}$$

where C is bank cost, y is the vector of outputs (interbank loan, clients' loans, investment in securities, etc.), p the vector of input prices (prices of deposits, purchased funds, labor), z the vector of fixed bank parameters (bank capital, fixed assets, off-balance sheet items, etc.), u represents the inefficiency term that captures the difference between the efficient level of cost for given output levels and input prices and the actual level of cost and, finally, ε is the random error term. Alternatively, we may use a profit function such as:

$$P = P(p,\pi,z,u,\varepsilon) \tag{2}$$

where, in addition to the variables described above, π is the vector of output prices. To simplify the estimation of the inefficiency term, multiplicative separability of the random error and the inefficiency term is usually assumed. In this case, Eq. (1) can be rewritten in the logarithmic form as:

$$\ln C = \varphi(p,y,z) + \ln u + \ln \varepsilon. \tag{3}$$

Following Berger and Mester (1997), we define the *cost efficiency* of a bank as the estimated cost needed to produce the bank's output vector if the bank was as efficient as the best-practice bank in the sample. This condition is usually expressed as:

$$\frac{\hat{u}_{\min}}{\hat{u}}, \tag{4}$$

where $\hat{u}$ is the estimation for the inefficiency term for a given bank, $\hat{u}_{\min}$ is the minimum across all banks. Otherwise, *profit efficiency* is defined as the actual profit level of a bank divided by the profit level which could be obtained if the bank was as efficient as the best-practice bank.

The main estimation problem that a practitioner has to face is to distinguish the inefficiency term ($\ln u$) from the random error term ($\ln \varepsilon$). There are alternative methods that may be used to solve this problem involving both parametric and non-parametric techniques. Following best practice, we prefer parametric techniques mainly because they concentrate on the evaluation of not only technological but also of economic factors. We apply the stochastic frontier approach (SFA) and thick frontier approach (TFA). In SFA one has to make clear assumptions about the distributions of the regression residuals $\ln u$ and $\ln \varepsilon$.[1] On the other hand, TFA

[1] Usually $\eta = \ln \varepsilon$ is assumed to be normally distributed, while the distribution of $\ln u$ is asymmetric: half-normal; log-normal; or other. A consistent (but not efficient) estimation of regression (3) could be obtained using least squares. If $\ln u = |\xi|$ is half-normally distributed, then:

$$E[\eta + |\xi|] = \mu_\eta + \mu_\xi + \delta_\xi \sqrt{\frac{2}{\pi}} = 0, \quad E[\xi] \equiv \mu_\xi = 0, \quad E[\eta] \equiv \mu_\eta = -\delta_\xi \sqrt{\frac{2}{\pi}},$$

The estimation (consistent but again not efficient) of the parameters δ_η and δ_ξ could be obtained using the method of moments. Having parameters of distribution of $\ln u$ and $\ln \varepsilon$, the inefficiency term for a given bank is estimated as $\ln \hat{u} = E[\ln u | \ln u + \ln \varepsilon]$.

assumes that deviations from the predicted values of cost or profit within the highest and lowest quartiles is a random error but inefficiency is represented by deviations between quartiles. We report empirical results from both SFA and TFA approaches that, as the discussion above suggests, may give different results.

In the study we adopt the transcendental logarithmic (or translog) functional form for cost or profit, widely used in the literature. The full specification of the translog cost function (one of the input prices p_{i^*} and one of the inputs z_{k^*} are used as a numeraire') is:

$$\ln\frac{C}{p_{i^*}z_{k^*}} = \beta_0 + \sum_{i\neq i^*}\beta_i \ln\frac{p_i}{p_{i^*}} + \sum_j \gamma_j \ln\frac{y_i}{z_{k^*}} + \sum_{k\neq k^*}\lambda_k \ln\frac{z_k}{z_{k^*}}$$

$$+\frac{1}{2}\sum_{i\neq i^*}\sum_{l\neq i^*}\beta_{il}\ln\frac{p_i}{p_{i^*}}\ln\frac{p_l}{p_{i^*}} + \frac{1}{2}\sum_j\sum_l \gamma_{jl}\ln\frac{y_j}{z_{k^*}}\ln\frac{y_l}{z_{k^*}} + \frac{1}{2}\sum_{k\neq k^*}\sum_{l\neq k^*}\lambda_{kl}\ln\frac{z_k}{z_{k^*}}\ln\frac{z_l}{z_{k^*}}$$

$$+\sum_{i\neq i^*}\sum_{k\neq k^*}\delta_{ik}\ln\frac{p_i}{p_{i^*}}\ln\frac{z_k}{z_{k^*}} + \sum_{i\neq i^*}\sum_j \rho_{ij}\ln\frac{p_i}{p_{i^*}}\ln\frac{y_j}{z_{k^*}} + \sum_j\sum_{k\neq k^*}\nu_{jk}\ln\frac{y_j}{z_{k^*}}\ln\frac{z_k}{z_{k^*}} + \xi. \tag{5}$$

If we assume the allocative efficiency of production, then, according to Shepard's lemma, the levels of inputs we get is:

$$s_i = \frac{\partial \ln C}{\partial \ln p_i}, \tag{6}$$

where s_i is input shares in cost.

For the profit function, Hotelling's lemma could be applied: if profit is maximized, then:

$$s_j = \frac{\partial \ln P}{\partial \ln \pi_j}, \tag{7}$$

where s_j is a share of j-th output in profit.

In the following section, we provide a brief description of the Ukrainian banking sector in 1998 and of the data set used, then we report various empirical results of efficiency for Ukrainian banks, using the framework introduced above.

3. Empirical results

3.1. The Ukrainian banking system in 1998

Like Russia [see Ogluzdin and Urga (1999) and Dmitriyev et al. (1999)] and

Table 1
Commercial banks in Ukraine (end of 1998)

Total number of banks	214
State	2 (Oshchadbank and Ukreximbank)
Private	212
With foreign capital	28
With 100% foreign capital	6
Banks with license for currency exchange operations	161
Statutory funds, UAH bn	2.097

Source: NBU.

other CIS countries, Ukraine has a two-level banking system with a Central bank (National Bank of Ukraine, henceforth NBU) and more than 200 commercial banks, only approximately 170 of which actively operate now.[2] The main law, introduced in 1992, is 'on banks and banking activity'. All new regulation is provided by the NBU. Ukrainian banks are much more closely regulated than in Russia, for example, in order to police reserve and liquidity requirements the NBU requires detailed balance sheets every day from Ukrainian banks. Ukraine's electronic payment system is much more efficient than Russias, payments are executed in a few minutes.

Commercial banks can be divided into several groups (see Table 1). First, state-owned and former state-owned banks: Prominvestbank (largest Ukrainian commercial bank); Bank 'Ukraine' (former 'Agroindustrial' bank); Ukreximbank (former Ukrainian part of Soviet eximbank); Oshchadbank (the analog of Russian Sberbank); and Ukrsotsbank. Second, foreign banks: ING Barings Ukraine; CS First Boston Ukraine; Societe Generale Ukraine; Raiffaisen Ukraine; Kreditanshaldt Ukraine; Inkombank Ukraine (Russia). Third, group of new private banks that now are large enough to be very important for the whole financial system. Largest in that group are Privatbank (eastern industrial region, but it has subsidies everywhere in Ukraine) and Aval (so-called 'post and pension bank'). Fourth, middle-sized and small-sized new commercial bank.

1998 was one of the most difficult years for the Ukrainian banking system. The Russian crisis and its combination with very similar domestic problems produced a number of difficulties for all banks in Ukraine. First, the Ukrainian government did not default on internal debt in the true sense, but all commercial banks were compelled to 'convert' T-bills into obligations with much longer maturity. Second, to eliminate the consequences of the crisis, the NBU was compelled to introduce several restrictions on the operations of commercial banks (primarily on the currency market) and increased reserve requirements in September from 15 to 16.5% of the total sum of deposits (reserve requirements had already risen in

[2] According to *Groshi ta Svit* information agency, which specializes on Ukrainian banking statistic.

November 1997 from 11 to 15%). As a result, in September 1998 80 banks could not meet their reserve requirements mainly because of the forced conversion of T-Bills. In addition, some of the largest banks also faced major difficulties in performing regular operations, the most important example is Bank Ukraine that had a large portfolio of T-Bills and a large amount of non-performing loans. Finally, it is worth mentioning that it was also required for commercial banks to have at least 1 million Euro of equity.

In sum, the Association of Ukrainian Banks has estimated the total losses of the banking sector caused by the crisis at approximately 30% of bank capital. However, the consequences of the crisis for the economy as a whole and the banking sector in particular were much less severe than in Russia. Most importantly, banks did not default on clients' deposits, the amount of deposits in the banking system did not decrease and the credibility of the banking system was saved. The crisis in the second half of 1998 produced huge (but less than in Russia) devaluation of the domestic currency (approx. 70%) and an increase in interest rates already at a high level. To prevent the destabilization of the currency market, the NBU, as already noted above, was compelled to tighten bank liquidity by increasing reserve requirements and the refinancing rate. Some nominal growth of credit to the private sector was mainly caused by the devaluation (because credits were partly denominated in hard currency) and it does not represent a real improvement in banking system operations. In Appendix A, Table A1 provides some general information about the development of the Ukrainian banking system in 1998, while Table A2 presents some key macroeconomic parameters describing the environment in which Ukrainian banks operate.

Generally, we may conclude that the Ukrainian banking system is still underdeveloped. Ukrainian banks are very small from an international point of view, the largest Ukrainian bank has less than USD 2 billion of gross total assets. The volume of loans to enterprises is extremely low. The main reason is in the high level of interest rates due to an extremely restrictive monetary policy and the poor quality of borrowers, but also in the poor quality of banking services themselves and the inefficiency of the management.

For all those reasons a study of the efficiency of the banking sector could be very useful if it can help to discover sources of inefficiency and formulate policy recommendations in this field. Another important question is the evaluation of the consequences of changes in the structure of the banking industry. Current capital requirements may cause the closure of small banks and a wave of mergers and acquisitions.

3.2. Data

We acknowledge that this research was made possible by close co-operation with the Ukrainian Interbank Currency Exchange (UICE). The data set used includes aggregated balance sheets and income statements calculated at UICE from the original detailed balance sheets of commercial banks using UICE's own methodology of aggregation. In addition, the data includes all the financial parameters

needed for the estimations from the banks' financial reports for 1998. The sample contains information for approximately 79 Ukrainian banks including two state banks (Oshchadbank and Ukreximbank), large former state banks (except Ukrainian largest Prominvestbank which does not provide its reports to UICE), Ukrainian banks with 100% foreign capital, large, average and small private banks. The sample could be viewed as representative because it includes 79 banks from 170 operating banks[3] and it covers 76% of the gross total assets of the whole banking system.[4]

A detailed description of the variables used for the estimations is reported in Table A3 in Appendix A. For the balance sheet items we used period averages. One of the main problems with the data was the non-financial information about the banks, in particular the number of employees. Official information about the number of employees was available only for 24 banks in the sample, for the remaining banks we used estimates from private sources. We used total assets to proxy the price of labor, given that total assets are highly correlated with the number of employees. Another problem in calculating the price of labor is that the reported figures of wage and salary expenses often does not represent actual expenses for labor, salaries and benefits are often paid in hidden or even illegal form.

3.3. Estimation of (in)efficiency of commercial banks

In this section we present the results of estimating Eq. (3) for cost efficiency and its equivalent for profit efficiency. The cost/profit functions include as outputs interbank loans (*ibc*), clients' loans (*loans*) and investment in securities and other investment (*sec*), as prices of inputs we use labor (*labor*) and deposits (*dep*), including clients' deposits and purchased funds (14 coefficients to be estimated in total). In other specifications different sets of inputs and bank-specific variables were included [bank specific and environmental variables could be included as additional parameters in the cost Eq. (5)], input variables are bank capital (*cap*) and fixed assets (*fix*), while a bank-specific variable is the share of non-performing loans in the total volume of loans (*bad*).

The estimates of cost and profit efficiency parameters for the whole sample and different groups of banks are reported in Table 2.[5] According to the stochastic frontier approach, approximately one-third of banks' cost are used inefficiently, and only one-fifth for the thick frontier approach. However, both methods show

[3] From 214 banks which were in the NBU register at the end of 1998 some banks do not perform operations because of insolvency or other problems.

[4] Note that the largest bank, Prominvest (not included in the sample because this bank did not provide its information to UICE), in 1998 had approximately 19% of the total assets of the Ukrainian banking system.

[5] The estimates reported in Table 2 are derived by estimating the cost and profit functions using the least-squares estimator. The full set of parameters of cost and profit functions are reported in Table A4 and Table A5, respectively.

Table 2
Cost and profit efficiency of Ukrainian banks[a]

Group of banks	Stochastic frontier approach	Thick frontier approach
Cost efficiency:		
All sample (79 banks)	0.672 (0.0218)	0.805 (.0165)
Large and medium banks (more than UAH 100 m of assets, 22 banks)	0.631 (0.0418)	0.775 (.0304)
Small banks (less than UAH 100 m of assets, 57 banks)	0.688 (0.0254)	0.816 (0.0195)
Very small banks (less than UAH 40 m of assets, 31 banks)	0.732 (0.0291)	0.845 (0.0242)
Profit efficiency:		
All sample (79 banks)	0.7199 (0.0081)	0.6577 (0.0305)
Large and medium banks (more than UAH 100 m of assets, 22 banks)	0.7316 (0.0194)	0.6719 (0.0602)
Small banks (less than UAH 100 m of assets, 57 banks)	0.7154 (0.0084)	0.6522 (0.0357)
Very small banks (less than UAH 40 m of assets, 31 banks)	0.7025 (0.0107)	0.5849 (0.0466)

[a]S.E. in parentheses.

that large banks are substantially less efficient in cost efficiency terms compared to small ones. There are many possible explanations for this result. The first is related to the possible differences between reported figures and actual cost if we assume that small banks have more possibilities for hiding some expenditures (e.g. for tax or regulatory purposes). Another possible explanation is the large amount of non-performing loans concentrated mainly in large (mainly state-owned) banks.

Furthermore, it is worth noticing that there is a substantial difference between the cost and profit efficiency estimates. Large banks are more efficient in profit terms than small banks. The possible explanation is monopoly power exercised by the large banks, which allows them to receive more profit despite having relatively high costs.

In sum, the results above address an interesting and hot policy issue regarding the restructuring of Ukrainian banks concerning the necessity to accelerate the concentration of the industry. Small banks that do not meet capital requirements are supposed to be liquidated or taken over. Our results suggest that such a concentration, in the current economic environment, could produce undesirable consequences with greater inefficiency and greater monopoly power in the sector. It is absolutely true that most of the Ukrainian banks are extremely small from the point of view of international comparisons and one of the general long-term direction of changes in the industry structure is integration and mergers of banks. But in the current environment, the acceleration of such industrial concentration could produce only negative results for the economy.

3.4. Determinants of efficiency

The main conclusion from the previous paragraph is that the size of the bank does influence the efficiency of the banking system. Moreover, this does not exclude the possibility that other bank-specific factors may be important for efficiency. Thus, we performed further experiments. Table 3 reports the results from estimating alternative bank-specific variables such as total assets, bank capital, non-performing loans. Furthermore, following Berger and Mester (1997) we also tested the significance of raw data measures of efficiency, such as bank's cost to total assets, ROA and ROE.

The first interesting feature of the estimated regressions is the absence of inter-dependence between the size of a bank and efficiency parameters. Earlier we concluded that *on average* large banks are less efficient in cost terms and more efficient in profit terms, but for a particular bank there is no such correlation. There is also evidence of the importance of bad loans for cost efficiency, as expected, there is significant negative dependence of the cost efficiency term on the proportion of bad loans in the banks loan portfolio.

The significant correlation between cost and profit efficiency and raw efficiency parameters (costs to total assets, ROA, ROE) could be viewed as further evidence of the robustness of the estimated efficiency parameters.

3.5. Estimation of economies of scale and scope

Another dimension of efficiency is the evaluation of economies of scale and scope. Firms in an industry realize economies of scale when output rises proportionately faster than costs — *global economies of scale*. *Product-specific economies of scale* arise when an increase in production of a *specific* output rises proportionately faster than costs. Finally, we will also evaluate *economies of scope* arising when a firm produces two or more products jointly at a lower cost than if they are produced independently (in Appendix B we briefly present the definitions).

Table 3
Efficiency parameters of some bank-specific variables[a]

Variable	Cost efficiency (SFA)	Profit efficiency (SFA)
Total assets	−0.00003 (−0.775)	0.0000028 (0.203)
Bank capital	0.00001 (0.036)	0.00024 (1.846)
Non-performing loans (in% to total volume of loans)	−0.351 (−3.263)	−0.00784 (−0.183)
Bank's costs in% to total assets	−0.0231 (−0.083)	−0.288 (−2.921)
ROA	0.933 (3.126)	0.388 (3.542)
ROE	0.315 (2.499)	0.181 (4.091)

[a]Regression coefficients, *t*-statistics in parentheses.

Table 4
Global economy of scale estimates

	Estimate	S.D.	S.E. of estimate	*t*-stat. for Ho: scale = 0	*t*-stat for Ho: scale = 1
All sample (79 banks)	0.8856	0.3355	0.0377	23.46	−3.031
Large and medium (22 banks)	1.2331	0.2001	0.0427	28.88	5.465
Small (57 banks)	0.7515	0.2757	0.0365	20.59	−6.807

Table 4 represents statistically significant economy of scale[6] for the whole sample and small banks, but diseconomy of scale for the group of large banks.[7] The results for product-specific scale economy and scope economy are reported in Table 5, we observe diseconomies of scale for interbank loans (somewhat more significant for large banks). There is evidence of small, even though not statistically significant, economies of scale for investment in securities. In this case, the results are very different for small and large banks (large banks demonstrate significant economies of scope for this type of output). There are also significant economies of scale for loans that we like to interpret as evidence of the existence of potential for expanding this type of operations. Finally, Table 6 provides unequivocal evidence of significant scope economies. It is interesting to note that once more small banks as against large ones demonstrate substantial economies when combining different kinds of operations.

4. Conclusions and policy implications

The main goal of this paper was the evaluation of the current development of the Ukrainian banking system. The research concentrated on cost and profit efficiency and scale and scope economies for 79 Ukrainian commercial banks.

One of the main findings of the research is that small banks operate more efficiently in terms of cost but less efficiently in terms of profit. This difference could suggest the existence of monopoly power in the Ukrainian financial sector where large banks can realize greater profits having at the same time greater costs.

Another important piece of evidence is the substantial difference in the scale economies between small and large banks. Large banks (large only for Ukraine but small when compared to international standard) present significant diseconomies of scale, while small ones show significant scale economies. This result could suggest that current technology in the financial sector (technology in the wide sense, including economic environmental factors) does not allow efficient growth

[6] The coefficient are statistically smaller than 1 (*t*-test = −3.031 and *t*-test = −6.807) for the whole sample of banks and small banks, respectively.

[7] The coefficient is statistically bigger than 1 (*t*-test = 5.465).

Table 5
Product-specific economy of scale estimates

	Estimate	S.D.	S.E. of estimate	*t*-stat. for H0: scale = 0
Interbank loans				
All sample (79 banks)	−1.618	5.545	0.628	−2.576
Large and medium (22 banks)	−5.651	9.018	1.968	−2.871
Small (57 banks)	−0.1318	2.212	0.293	−0.45
Securities				
All sample (80 banks)	0.5928	7.936	0.8985	0.660
Large and medium (22 banks)	1.705	0.2389	0.0509	33.47
Small (57 banks)	0.1561	9.352	1.250	0.125
Loans				
All sample (80 banks)	1.134	1.437	0.1627	6.97
Large and medium (22 banks)	1.173	0.0991	0.0211	55.51
Small (57 banks)	1.119	1.699	0.227	4.93

and concentration of the financial sector in the Ukraine (except maybe, the possible efficiency of concentration for small banks). This result is even more interesting if we compare it with estimations of scale economies for Russian banks (see Ogluzdin and Urga, 1999), where no significant differences between small and large banks are found.

Although statistically robust and economically interesting, the results reported in this paper cannot be considered conclusive for policy purposes, given that they are based on data for 1998 only. It is necessary to extend the data set in terms of both number of banks in the sample and time periods. This will allow us to formulate more precise and reliable policy implications. Unfortunately, at the moment it is extremely difficult to update the current sample due to the lack of disclosure of available data. However, we remain confident to expand this study in a future work.

Table 6
Estimate of scope economies

	Estimate	S.D.	S.E. of estimate	*t*-stat. for H0: scope = 0
All sample (80 banks)	2.0964	3.380	0.2677	7.831
Large and medium (22 banks)	0.2626	0.9001	0.1919	1.368
Small (57 banks)	2.8042	2.398	0.3177	8.828

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Appendix A: Tables

Table A1. Ukrainian Banking System in 1998 (UAH bn)

	Q1	Q2	Q3	Q4
Reserves (cash and deposits in NBU)	0.805	0.857	1.168	1.454
Foreign assets	1.649	1.953	2.808	3.107
Claims to general government	2.106	2.274	1.923	1.528
Claims to non-financial government institutions	1.441	1.372	1.563	1.447
Claims to private sector	6.004	6.425	7.892	7.731
Claims to non-banking financial institutions	0.111	0.117	0.128	0.129
Demand deposits	2.842	2.827	2.744	3.143
Term deposits	3.666	4.103	5.165	5.209
Foreign liabilities	1.578	1.706	2.140	1.738
Deposits on general government	0.820	0.807	0.898	0.544
NBU credits	0.653	0.645	0.829	0.809
Deposits of non-banking financial institutions	0.051	0.51	0.51	0.59
Capital accounts	4.195	4.428	4.825	4.843
Other items net	−1.686	−1.565	−1.167	−.948

Source, NBU.

Table A2. Ukraine: some macroeconomic indicators

	Q1	Q2	Q3	**End of 1998**
GDP, UAH bn				**104**
Inflation (CPI),% p.a.				**20**
M3, UAH bn	12.960	13.458	14.325	**15.718**
M0 (cash outside banks), UAH bn	6.364	6.39	6.31	**7.158**
M1, UAH bn	9.23	9.226	9.066	**10.331**
Reserve rate,%	15	15	16.5	**16.5**
NBU refinancing rate,% p.a.	40	45	82	**74.2**
Com. Banks credit rates,% p.a.	48.9	48.0	63.8	**60.4**
Private sector deposits in commercial banks, UAH bn	6.495	6.897	7.867	**8.278**
Commercial banks credits to private sector (UAH bn, end of period)	7.343	7.634	9.182	**8.855**
Exchange rate UAH/USD, end of period	2.0383	2.0573	3.4	**3.427**

Source: NBU, Ministry of Statistics.

Table A3. Data used for estimation

Variable	Description	Sample mean	S.D.
C	Variable cost plus expenses for bank's premises, furniture and equipment, and other administrative expenses, UAH m	39.607	111.136
P	Bank's profit: revenues from loans, securities, fees and charges, trading operations minus total cost, UAH m	15.110	30.434
Output variables (period averages)			
y_{ibc}	Inter-bank loans, UAH m	16.249	39.088
y_{loan}	Consumer loans, UAH m	53.912	123.237
y_{sec}	Other investment, including government and risky securities, and investment in other enterprises, UAH m	21.261	49.536
Input prices			
p_{lab}	Price of labor; here, total sum of expenses for labor divided by period average total assets (see text for explanation), %	2.86	1.94
p_{dep}	Price of deposits: total interest expenses divided by period average total sum of deposits (including clients' deposits and purchased funds), %	18.2	16.1
p_{cap}	Expenses for furniture and premises plus other administrative expenses divided by period average fixed assets (for scale efficiency estimation only), %	78.5	78.6
Output prices			
p_{ibc}	Price of inter-bank credits: interest revenues from interbank loans divided by period average sum of interbank loans, %	12.48	20.71
p_{loan}	Price of consumer loans: interest revenues from consumer loans divided by period average sum of consumer loans, %	39.03	20.77
p_{sec}	Price of securities: revenues from securities and other investments divided by period average sum of securities and other investment, %	39.35	28.33
Bank's capital, UAH m		35.097	61.618
Share of non-performing loans in total volume of loans, %		26.7	19.23
Number of observations = 79			

Table A4. Cost function estimation

	Coefficients	S.E.	*t*	Sig.
Constant	9.3274	0.301	31.015	0.000
sec	0.3644	0.188	1.943	0.056
sec − sec	0.0081	0.098	0.083	0.934
ibc	0.2848	0.135	2.113	0.039
ibc − ibc	0.2006	0.075	2.666	0.010
ibc − bond	−0.0558	0.053	−1.053	0.297
loan	0.4377	0.173	2.537	0.014
loan − loan	0.1718	0.070	2.470	0.016
loan − bond	−0.0146	0.057	−0.258	0.797
loan − ibc	−0.0993	0.066	−1.497	0.139
dep	0.2324	0.148	1.569	0.122
dep − dep	0.1611	0.057	2.849	0.006
dep − bond	0.0505	0.054	0.937	0.352
dep − ibc	−0.0505	0.054	−0.941	0.350
dep − loan	−0.0272	0.060	−0.457	0.649

R-sq., 0.939; Adj. R-sq., 0.926; D.-W., 1.901; *F*-stat., 70.76; and Mean of dep.var., 12.94.

Table A5. Profit function estimation

	Coefficients	S.E.	*t*	Sig.
Constant	3.5384	1.520	2.328	0.023
ibc	0.1716	0.362	0.474	0.638
ibc − 2	0.2463	0.102	2.406	0.019
loan	0.0398	0.555	0.072	0.943
loan − 2	0.1157	0.107	1.083	0.283
pcap	−0.3042	0.728	−0.418	0.677
pcap − 2	0.3161	0.215	1.468	0.147
pcap − ibc	−0.0952	0.101	−0.945	0.348
pcap − loan	0.0783	0.141	0.554	0.582
pcap − sec	−0.0294	0.132	−0.223	0.824
pdep	0.5464	0.411	1.329	0.189
pdep − 2	0.3281	0.164	2.004	0.049
pdep − ibc	0.0529	0.106	0.497	0.621
pdep − loan	−0.2958	0.157	−1.886	0.064
pdep − pcap	−0.1972	0.153	−1.285	0.204
pdep − sec	0.1686	0.131	1.283	0.204
sec	0.2629	0.502	0.524	0.602
sec − 2	−0.1208	0.140	−0.860	0.393

R-sq., 0.756; Adj. R-sq., 0.688; D.-W., 1.740; *F*-stat., 11.139; and Mean of dep.var., 5.8285.

Table A6. Cost function estimation (modified specification, three types of inputs, model includes share equations)

	Coefficients	S.E.	*t*	Sig.
sec	−0.5438	0.195	−2.79	0.006
sec − *sec*	0.0514	0.017	3.07	0.002
sec − *loan*	0.0405	0.012	3.28	0.001
Constant	10.6116	1.345	7.89	0.000
ibc	0.1736	0.111	1.57	0.118
ibc − *ibc*	0.0248	0.011	2.36	0.019
ibc − *sec*	−0.0030	0.012	−0.258	0.797
inc − *loan*	−0.0255	0.016	−1.600	0.111
loan	−0.4823	0.192	−2.513	0.013
loan − *loan*	0.0913	0.015	6.089	0.000
dep	0.1136	0.070	1.615	0.108
dep − *dep*	0.1904	0.012	15.854	0.000
dep − *sec*	0.0141	0.007	1.905	0.058
dep − *ibc*	0.0031	0.004	0.825	0.410
dep − *loan*	0.0141	0.007	2.077	0.039
capital	0.4419	0.067	6.628	0.000
capital − *capital*	0.0243	0.011	2.139	0.034
capital − *sec*	−0.0100	0.007	−1.521	0.130
capital − *ibc*	−0.0027	0.003	−0.807	0.421
capital − *loan*	−0.0067	0.006	−1.125	0.262
capital − *dep*	−0.0592	0.009	−6.804	0.000

R-sq., 0.997; Adj. R-sq., 0.997; D.-W., 2.041; *F*-stat., 3685.14; and Mean of dep. var., 12.835.

Appendix B: Scale and scope economies

Measures for scale and scope economies

Global economy of scale could be measured from the cost function as a sum of output cost elasticities:

$$\sum_i \varepsilon_i = \sum_i \frac{\partial \ln C}{\partial \ln y_i}, \tag{A1}$$

where ε_i is output cost elasticity for i-th product. If in the Eq. (A1) is less then 1, we have global economy on scale, otherwise we have diseconomy on scale.

Product-specific economies arise if increasing in production of particular product lower costs, or if the value of:

$$\frac{1}{\varepsilon_i} \cdot \frac{C(y_1,\ldots,y_n) - C(y_1,\ldots,y_{i-1},0,y_{i+1},\ldots,y_n)}{C(y_1,\ldots,y_n)} \tag{A2}$$

is positive (negative number indicates product-specific diseconomies on scale).

The measure of global economy on scope could be calculated from the cost function as follows,

$$\frac{C(y_1,0,\ldots,0) + C(0,y_2,0,\ldots,0)\ldots + C(0,\ldots,0,y_n)}{C(y_1,\ldots,y_n)}. \tag{A3}$$

Positive values indicate existence of the overall scope economy, while negative tells us about diseconomy on scale.

Scale and scope economies estimation

For the estimation of scale and scope economies modified specification of the cost function was used, one additional input (capital) was added. Price of capital is defined as expenditures on bank premises, furniture and fixtures divided by bank's fixed asset. Share equations specified according to Shephard's lemma was added into the model. Iterative feasible least squares procedure (IFLS) was used for estimation of parameters.

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