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## EDITORIAL

*Central banks have been faced with many conceptual challenges in the course of ensuring financial system stability. The list of problems includes the ability to predict the likelihood and severity of financial crises, the optimum level of prudential capital requirements, and the early detection of the risk of individual bank failure. This issue of the Bulletin highlights the results of analyses of the Czech banking sector's ability to withstand various economic shocks (M. Čihák), the bank capital requirements generated by various approaches to risky debt evaluation (A. Derviz), and the extent and consequences of inefficient cost management in banks (A. Podpiera). This in-house economic research made a major contribution to the first Financial Stability Report published by the CNB in January 2005.*

**Vladislav Flek**,
Adviser to the Bank Board

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# Stress Testing the Czech Banking System[1)]

**Martin Čihák** *

Stress testing is a key method for measuring the resilience of financial institutions and financial systems to exceptional but plausible adverse events. Stress tests were originally developed for use at the portfolio level to understand how the value of a portfolio changes if there are adverse shocks to asset prices and other risk factors. They have become widely used as a risk measurement tool by financial institutions and are also increasingly used worldwide by financial sector supervisors interested in assessing the robustness of individual institutions to shocks ("microprudential stress tests").[2)]

In recent years, stress testing techniques have started to be applied in a broader context, with the aim of measuring the sensitivity of a group of banks or even an entire banking system to common shocks. These "system-focused" or "macroprudential" stress tests are the main subject of this article.

The literature on macroprudential stress testing is in a nascent state, but growing rapidly. The use of macroprudential stress tests as a method of measuring financial sector soundness has been promoted by the International Monetary Fund and the World Bank in their joint Financial Sector Assessment Program (FSAP), started in 1999. An FSAP report on the Czech Republic in 2001 was the first one to present stress testing results for the Czech banking system - see International Monetary Fund (2001). A number of central banks have started presenting results of stress tests in recent years as part of their financial stability reports - see Čihák and Heřmánek (2005) for a survey of the stress tests presented by various central banks.

The methodology of macroprudential stress tests is relatively less settled than that of microprudential stress tests. The prevalent view is that the process of stress testing needs to involve a number of steps, in particular (i) identification of macroeconomic and market risks; (ii) identification of major exposures; (iii) definition of coverage; (iv) identification of needed data; (v) calibration of shocks or scenarios; (vi) selection and implementation of methodology for individual risk factors; and (vii) interpretation of results - see Jones *et al.* (2004).

There is a wide range of possible methodologies that have been used for modeling individual risk factors. The choice of methodology depends largely on the availability of data. Ideally, system-focused stress tests should be carried out on institution-by-institution data. However, given the complexity of such calculations, macroprudential stress tests typically involve a combination of bottom-up approaches (using balance sheets, income statements, and other data for individual institutions) and top-down approaches (using aggregate data). For example, to stress test for credit risk, a sophisticated method would involve estimating an econometric model of probability of default as a function of a set of borrower-specific variables (e.g., debt-to-income ratios) and macroeconomic variables.[3)]

A set of shocks to the macroeconomic variables (derived from a macroeconomic model or from a historical scenario) can then be applied to this credit risk model and combined with data on financial institutions' exposures to different types of borrowers to estimate the impact on the profitability and net worth of individual financial institutions and the system as a whole. Such a

1) This short article is based on Čihák (2004a,b); Čihák and Heřmánek (2005); and CNB (2004). The relevant website references are provided at the end of this article.

2) See, e.g., Laubsch (2000) for an introduction to the literature on stress tests for individual institutions. See also Committee on the Global Financial System (2005).

3) The article by Alexis Derviz in this issue lists examples of credit risk models that can be used as part of this approach

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calculation requires detailed panel data on individual borrowers as well as institution-by-institution balance sheet data on credit exposures (a bottom-up approach).

If such detailed data are not available, alternative approaches include estimating the relationships between asset quality and a set of macroeconomic and other variables using time series of aggregate data (a top-down approach), and carrying out a simple, but illustrative "what-if" analysis, assuming that a percentage of loans in each classification category will be downgraded by one category. A range of methods, depending on data availability, also exists for market risks - see IMF and World Bank (2003) for a survey of the range of methodologies used in FSAP missions, and Čihák and Heřmánek (2005) for a similar survey on stress test methodologies in central banks' financial stability reports.

In our work, we first suggested improvements in the regression estimates that relate credit quality to macroeconomic shocks[4] and also identified data that would need to be compiled to improve stress tests, such as data on household credit (to improve credit risk analysis) and bank-to-bank credit exposures (to analyze interbank contagion). Also conducted at this stage was a survey of stress testing practices in Czech commercial banks, aimed at deepening the CNB's knowledge of the risk measurement methods used by banks.

The survey was based on questionnaire responses from 28 institutions, accounting for 92 percent of the banking system's total assets. A total of 19 of the 28 institutions used stress tests for risk management purposes; the remaining 9 did not use stress testing, but planned to do so in the near future. Overall, the results suggested that Czech banks are at a relatively early stage of developing their stress testing capacity. For market risks, banks had regular risk measurement exercises, but most of them used value-at-risk models rather than stress tests. For credit risk, banks did not use scenarios and shocks to risk factors. The stress tests done by banks do not allow for correlation between market risk and credit risk. Also, banks have so far not been using vector autoregression models, Monte Carlo simulations (except for two banks) or other more sophisticated methods.

In the second stage, our project focused on practical implementation of stress tests in the Czech context.[5] Key outcomes included designing stress test scenarios, carrying out stress testing calculations, and providing an input on stress testing for the CNB's first Financial Stability Report - see CNB (2004). The stress tests were built upon those from the 2001 FSAP, but the methodology was enhanced, for example by using scenarios involving combinations of shocks rather than the single-shock scenarios employed by the 2001 FSAP. We designed the scenarios based on the 1997-1999 experience in the Czech Republic, and taking into account international practice. The project also included work on some additional exercises, such as inter-bank contagion and sector-by-sector credit risk stress tests.

The stress tests were implemented using the "bottom-up" methodology, i.e. the assumed scenarios were applied to detailed balance sheets, income statements, and other relevant data for individual banks. The resulting direct impacts (e.g., the repricing impact of changes in interest rates on the market price of bonds in banks' portfolios) and indirect impacts (e.g., the impact of exchange rate changes on counterparty failures, and thereby on banks' asset quality) were aggregated by peer groups and expressed in terms of capital adequacy ratios.

The first stress testing results suggested that the Czech banking sector is generally stable and resilient to shocks. The sector would be able to withstand combinations of substantial adverse changes in interest rates, exchange rates, and loan quality. In particular, the main scenario involved a hypothetical increase in interest rates of 2 percentage points, an exchange rate depreciation of 20 percent, and an increase in the ratio of nonperforming loans to total loans of 3 percentage points.

The banking sector was able to withstand such shocks with an overall capital adequacy of more than 10 percent (Figure 1). Moreover, the results seem relatively robust with respect to changes in the assumed shocks. For example, if the

[4] A suggestion taken up by Babouček and Jančar (2005) using aggregate data on nonperforming loans, i.e. a top-down approach.

[5] The results are presented in Čihák and Heřmánek (2005).

assumed interest rate shock were 3 rather than 2 percentage points, the system's after-shock capital adequacy ratio would still be above 9 percent (Figure 2).

The preliminary results of the sector-by-sector credit risk stress tests (illustrated in a simplified way in Table 1) suggest that banks' exposures are quite dispersed across sectors, and, as a result, even relatively drastic shocks could mostly be absorbed by the system. For example, even if all loans to the manufacturing sector became nonperforming (an extreme shock), the banking sector would still have an overall capital adequacy ratio of about 10 percent, i.e., above the regulatory minimum of 8 percent.

To analyze interbank contagion, a matrix of net uncollateralized bank-to-bank exposures was compiled. The results of the tests based on this matrix suggest that the risk of a failure in an individual bank leading to a "domino" effect (i.e., failures in other banks) through interbank market exposures is low. Similarly, the risk that an adverse macroeconomic scenario would trigger a string of failures in banks, exacerbated by interbank exposures, is very low. The likelihood of direct liquidity contagion - problems in one bank leading to depositor runs on other banks - was not explicitly analyzed due to a lack of data. Such analysis, possibly based on past episodes of bank runs, remains one of the topics for further work.

## FIGURE 1

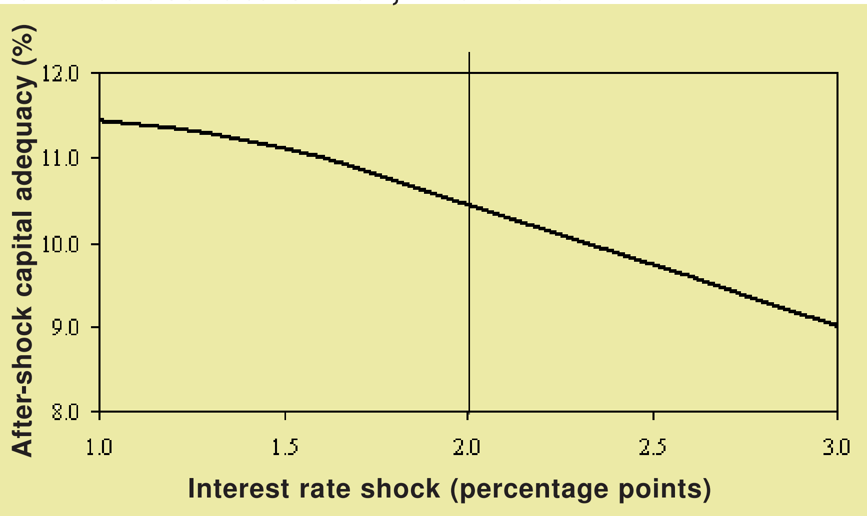
**Stress test results for the Czech banking sector**

(capital adequacy, in percent)


**Source:** Author's calculations. For assumptions, see Scenario II in Čihák and Heřmánek (2005).

## FIGURE 2

**Robustness of stress test results for interest rate shock, mid-2005**




Finally, the project recommended to improve credit risk modeling (especially in the rapidly growing area of household lending) and suggested to involve commercial banks more in future stress testing exercises.

One of the key recommendations of the project was that the CNB follows up on the survey of stress testing practices in commercial banks and eventually moves towards an approach to stress testing whereby the central bank would send uniform scenarios to commercial banks, and each commercial bank would calculate the impacts of the scenarios and report back to the CNB, which would then aggregate the results. Such an arrangement could usefully complement and enhance the stress tests done in-house at the CNB. ■

# TABLE 1

## Basic Credit Risk Stress Tests for Selected Sectors, end-2004

(all data in percent)

| | Share of total credit | NPLs to total credit in sector | Shock I | | Shock II | |
|---|---|---|---|---|---|---|
| | | | CAR | Capital inject. | CAR | Capital inject. |
| Agriculture, hunting, fisching | 2.2 | 8.5 | 12.8 | 0.0 | 12.7 | 0.0 |
| Forestry and jogging | 0.1 | 12.8 | 12.8 | 0.0 | 12.8 | 0.0 |
| Mining of minerals | 0.6 | 1.9 | 12.8 | 0.0 | 12.8 | 0.0 |
| Manufacturing | 15.3 | 8.6 | 12.2 | 0.0 | 10.1 | 0.4 |
| Electricity, gas, and water | 3.1 | 0.0 | 12.6 | 0.0 | 12.5 | 0.0 |
| Construction | 1.6 | 10.8 | 12.8 | 0.0 | 12.8 | 0.0 |
| Trade and maintenance | 11.3 | 9.2 | 12.5 | 0.0 | 11.7 | 0.2 |
| Accommodation and hospitaly | 0.5 | 17.9 | 12.8 | 0.0 | 12.8 | 0.0 |
| Transport and storage | 2.1 | 5.1 | 12.8 | 0.0 | 12.8 | 0.0 |
| Communications | 0.9 | 1.4 | 12.8 | 0.0 | 12.8 | 0.0 |
| Financial intermediation except insurance | 10.6 | 1.2 | 12.5 | 0.0 | 11.0 | 0.4 |
| Insurance | 0.4 | 0.3 | 12.8 | 0.0 | 12.8 | 0.0 |
| Leasing of machines and appliances | 10.1 | 2.0 | 11.9 | 0.2 | 10.6 | 0.7 |
| Other business activities | 2.9 | 6.4 | 12.6 | 0.0 | 12.4 | 0.0 |

**Notes:** NPLs... nonperforming loans. CAR... capital adequacy ratio. Shock I ... 50% of performing loans in the sector become NPLs. Shock II ... All loans in the sector become NPLs. In both cases, a 50% provisioning rate is assumed for the additional NPLs. Capital inject. ... capital needed (in % of GDP) for each bank to have an after-shock CAR of at least 8%.

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# Estimating Credit Risk under Macroeconomic Fluctuations[1)]

**Alexis Derviz***

One of the biggest challenges faced by the financial industry and the regulatory authorities is the pro-cyclical nature of most prudential and economic capital schemes applied to banking sectors worldwide.[2)] In brief, it seems that the currently used rules encourage banks to be over-optimistic in evaluating credit risk during booms and under-optimistic during downturns. Bank behavior fosters increased fluctuations in economic activity over the cycle. In particular, it may cause credit crunches and otherwise aggravate the consequences of recessions.

Theoretical treatment of this problem has so far been fragmented: standard finance theory is not used to working with the macroeconomic concept of the business cycle, whilst the microeconomic theory of financial regulation is too stylized to offer quantitative implications with regard to the socially desirable level of bank capital provisions.

Asset pricing-based models of credit risk valuation attempt to cope with the above-noted fragmentation and therefore constitute a quickly developing strain of financial intermediation literature. These models borrow the formal techniques from the standard asset pricing theory originally developed to explain the behavior of publicly traded securities (such as stocks, fixed income instruments, currencies and their derivatives) and try to apply them to the specific problem of pricing an asset (a bank loan or a private corporate bond) whose only uncertainty lies in the issuing party's default risk.

The literature in the field of asset pricing-based models is traditionally divided into the so-called structural and reduced-form approaches to modeling credit events. In structural models, default happens when the debtor firm's asset value falls below a certain threshold level (the firm's outstanding debt). The main disadvantage of these models is that the exact measure of the company's assets that drives the default event is unobservable. In reduced-form models, default is an autonomous stochastic process that is not driven by any variable linked to the debtor firm's capital structure or asset value. The main limitation of this approach is that it cannot properly explain the credit event (either a default or a revision to the debtor's credit rating) but can only describe it more or less accurately.

The above-named limitations of the two approaches to credit risk modeling have provoked attempts at synthesis in terms of the categorization and treatment of the risks studied. The essence of this synthesis is that it attempts to link the credit event to other variables describing the firm and its surroundings, while recognizing the limited information available to the outside observer (including the creditor) on the debtor's internal decision processes.

In practice, regular assessments of the default risk of bank clients and estimations of credit risk at the portfolio level are becoming a necessity for banks in their daily operations. Lending contract design and the implementation of new regulatory norms constitute at least two reasons why banks apply quantitative methods to credit risk assessments of their clients.

Four major credit risk models had received most recognition in the banking industry by the end of the last decade.[3)] Outside commercial banks, credit risk models are now attracting the attention

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1) This short article is based on original research covered by Derviz et al. (2003), and Derviz and Kadlčáková, (2005). The full version of the BIS paper is available at: http//www.bis.org/publ/bispap22.htmnd and the Czech National Bank working paper at: http//www.cnb.cz/en/pdf/wp9-2003.pdf

2) This problem has been one of the main topics of discussion between the Basel Committee on Banking Supervision and commercial banks concerning potential changes to the New Basel Capital Accord (NBCA). See Basel Committee on Banking Supervision (2002) for more details.

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of several groups of economic professionals, including financial market supervisors.[4)]

Credit risk models have as their objective an estimation of the capital level that banks have to maintain to cover unexpected losses resulting from loans with different levels of default risk. The outcome is called prudential capital in regulatory terms and economic capital in terms of credit risk modeling.

Holding economic capital is the banks' own choice, on condition that its level reaches at least the level of regulatory capital. In recognition of the superior - compared to the regulator - expertise of large creditors in the area of credit risk assessment, an increasing number of banks are being allowed to develop their own models for determining the regulatory capital level. These models are not made public. According to the available informal information they synthesize many features of the credit risk models already in use, which makes them somehow mutually comparable in the regulator's eyes. This is one reason why comparing regulatory and economic capital today is becoming an insightful exercise for regulatory decisions in the future.

In the Czech banking sector, which is almost completely dominated by foreign bank branches and subsidiaries, credit risk management procedures are usually imported from parent banks. Information on the approaches and methods in use is very imprecise. In our work, we have developed a technique for analyzing the impact of various existing credit risk-based capital determination methods on the capital requirements in the Czech banking sector.

Among other things, we wanted to identify those features of the capital requirements which may be seen differently from the credit risk modeling and regulatory perspectives. For this purpose, we have applied several capital requirement calculation methods for an artificially constructed risky loan portfolio. This portfolio contains 30 loans designed to reflect a number of prominent features of Czech non-financial borrowers. The portfolio mirrored the rating structure of a real loan portfolio obtained on the basis of a pool of corporate customers of six Czech banks.[5)] For the said loan portfolio, the capital requirements were determined using the NBCA, the two widespread commercial risk measurement models, CreditMetrics,[6)] CreditRisk+ and ,finally, our own model, which shares many features with the KMV approach.

The original KMV model, similarly to CreditMetrics, used the obligor's equity price statistics to derive the value distribution of a given loan, based upon the assumption of complete markets and tradability of both the obligors' equities and their debt. The KMV distributors promise in-built remedies in their product for the cases where one of these preconditions is not satisfied, but the publicly available literature, be it from the KMV authors or others, offers no general solution to this problem. To find a way around the mentioned difficulties in the KMV approach, we have resorted to the so-called pricing-kernel method of asset market modeling.[7)]

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3) We refer to JP Morgan's Credit Metrics/Credit Manager model, Credit Suisse Financial Products' CreditRisk+, KMV Corporation's KMV model, and McKinsey's CreditPortfolioView. Following our categorization, CreditMetrics and KMV can be put into the structural model, whereas CreditRisk+ and CreditPortfolioView form the reduced-form model group. Of the named products, only CreditPortfolioView allows for direct incorporation of macrovariables and is, therefore, able to reflect the business cycle. However, being a highly ad hoc model, CreditPortfolioView is unable either to deal with the creditworthiness of individual borrowers or to perform market-based valuation of individual credit exposures, making it difficult to incorporate into standard bank balance sheet analysis.

4) The creditworthiness of domestic firms also has implications for monetary policy transmission. Not surprisingly, several central banks in Europe have developed their own models for monitoring the financial situation of domestic firms and the lending performance of domestic banks. Rating systems and creditworthiness-assessment models for firms have been developed, among others, by the central banks of France, Germany, Italy, Austria and the UK.

5) Since ratings are the key input in many credit risk approaches, a simplified version of Moody's rating methodology for private firms has been applied to obtain ratings in our real sample of bank clients. Estimates of other inputs which were not available in the real bank data set were obtained using aggregate data from the CNB databases.

6) For CreditMetrics, we also conducted stress testing to gauge the impact of interest rate uncertainty (e.g. caused by changes in monetary policy and different reactions of the yield curve to these changes) on the economic capital calculations.

7) See, for instance, Campbell et al. (1997). Numerical approaches to calculating pricing-kernel-based asset values have been developed in, e.g., Ait-Sahalia and Lo (2000) and Rosenberg and Engle (2002).

Our model (called PK in the sequel) incorporates a number of reduced-form features allowing the default probability to be linked to macro-fundamentals, including the business cycle and monetary policy.

Financial and real uncertainties are modeled analogously to Ang and Piazzesi (2003), although instead of fitting the observed yield curve we conduct state-space estimation of the pricing kernel parameters that fit the returns of basic infinite maturity assets. Asset tradability and market completeness are not assumed, and default events that depend on systemic and idiosyncratic risk factors can be modeled. Thus, we are able to analyze non-traded debt in incomplete markets as a separate factor of financial (in)stability.[8)]

The prudential capital requirements for the artificial loan portfolio generated by various regulatory approaches are given in Table 1.[9)] Table 2 summarizes the estimated statistics of the same portfolio value treated as a random variable, at the estimation horizon of one year in accordance with several modeling approaches. The portfolio starting value (CZK 774.6 bn) is equal to the actual total face value of the underlying real loan sample. Columns 1-5 are reserved for the relevant descriptive statistics needed to determine the economic capital measure. For instance, the CreditMetrics line features the 1%, 5%, 50% (i.e. the median, equal to the mean in the case of symmetric distributions such as the ones utilized by CreditMetrics), 99% and 95% quantiles, the last

## TABLE 1

### Regulatory capital requirements
(in CZK bn)

| | |
|---|---|
| NBCA Standardized approach (Jan. 2001) | 51.84 |
| NBCA-IRB approach (Jan. 2001) | 165.46 |
| NBCA Standardized approach (Oct. 2002) | 46.9 |
| NBCA-IRB approach (Oct. 2002) | 44.79 |

## TABLE 2

### Economic capital estimations (in CZK bn)

| | 1% percentile | 5% percentile | Mean | 99% econ. capital | 95% econ. capital | Non-VaR economic capital |
|---|---|---|---|---|---|---|
| **CreditMetrics** | 767.90 | 796.62 | 845.78 | 77.89 | 49.16 | |
| **CreditRisk+** (Loss) | 133 | 101 | 42.18 | 90.82 | 58.82 | |
| **Pricing Kernel Model** | | | | | | |
| **baseline** | | | 768.30 | | | 64.56 |
| CZ-0.03 | | | 723.00 | | | 109.86 |
| CZ-0.02 | | | 737.94 | | | 94.93 |
| CZ-0.01 | | | 754.27 | | | 78.59 |
| CZ+0.01 | | | 775.68 | | | 57.19 |
| CZ+0.02 | | | 783.32 | | | 49.54 |
| CZ+0.03 | | | 790.24 | | | 42.63 |
| DE-0.03 | | | 673.73 | | | 163.14 |
| DE-0.02 | | | 704.80 | | | 132.06 |
| DE-0.01 | | | 738.20 | | | 99.66 |
| DE+0.01 | | | 770.62 | | | 68.24 |
| DE+0.02 | | | 766.15 | | | 72.71 |
| DE+0.03 | | | 774.14 | | | 65.72 |

8) Since we take into account the random nature of interest rates and other economic fundamentals, the uncertainty factors in the loan characteristics usually treated in the market risk context (interest rates and exchange rates) are an integral part of the capital calculations as far as each of the tested approaches allow. In this respect, we advance towards a promising end of an integrated financial risk assessment methodology (Barnhill and Maxwell, 2002, or Hou, 2002).

9) IRB stands for "Internal Rating-Based".

two of which give rise to the corresponding capital requirement figures.

For our own PK model, although derived from the conventional 5%-quantile measure for the portfolio value, the calculated economic capital does not rely on the standard correlation assumptions of the Value-at-Risk method, and is, therefore, featured in a separate column 6.

The PK model is able to deliver capital measures under different scenarios of macroeconomic development that are different from the baseline. At the bottom of Table 2, we give results for six scenarios corresponding to the Czech GDP growth rate deviating by 1, 2 and 3% from the baseline GDP growth value, and the same exercise was conducted for the GDP growth rates in Germany.

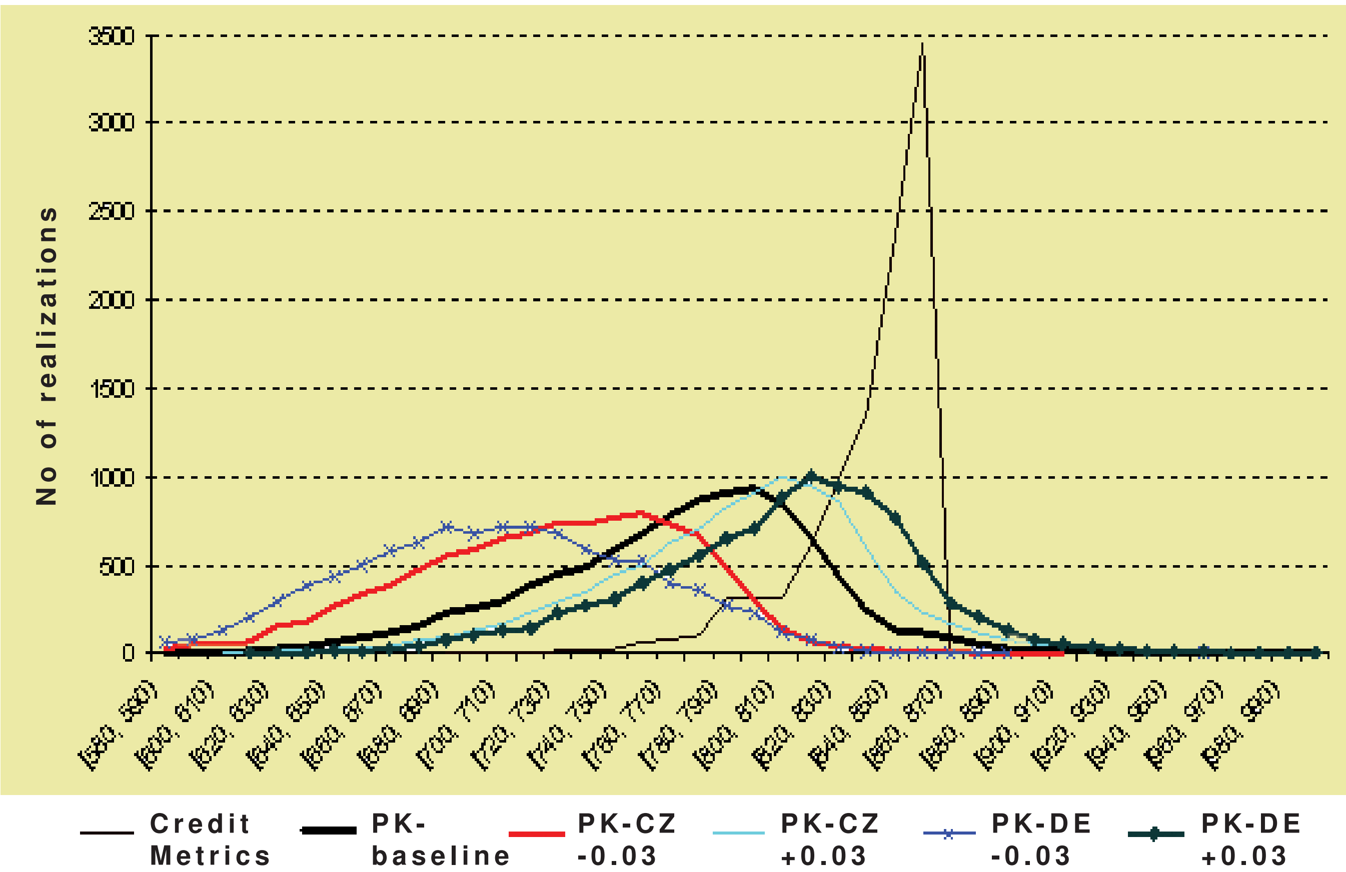
In our particular example, the standardized approach of the NBCA predicted approximately the same level of capital as the credit risk models at the 95% confidence level (i.e., around CZK 50 bn). At the 99% confidence level, the internal credit risk models predicted a higher level of economic capital than the NBCA standardized approach, but these estimates were still lower than the estimates of the NBCA-IRB approach.

We obtained different results when applying the NBCA guidelines as formulated by the third Quantitative Impact Survey, QIS 3 (October 2002). Here, the outcomes of the two NBCA approaches (standardized and IRB) were more similar to each other, with the IRB requirement being slightly lower than the requirement of the standardized approach. The requirements of both regulatory approaches were even lower than the level of capital required by the various credit risk models. This means that banks themselves would have behaved more cautiously than required by the regulatory norm. However, as the PK results show, there is no reason to praise the banks for this over-prudential behavior, given that it is based on severely biased models that ignore the business cycle. (Figure 1)

The risky debt valuation based on the PK technique has allowed us to investigate the consequences of economic upturns and downturns both inside and outside the Czech economy. The

## FIGURE 1

**Portfolio Value Distrubutions According to the CreditMetrics and PK**
Model (Different GDP Growth Scenarios)



latter case was analyzed by means of simulated real shocks in the euro area. Figure 1 shows the debt portfolio value distribution for the PK-baseline and the most extreme positive/negative real shock cases in comparison with the CreditMetrics-generated distribution. The Monte Carlo simulation results (10,000 runs) in Figure 1 graph adjacent elementary intervals for the portfolio value realizations against the number of simulated scenarios for which the value fell into the given interval. Figure 1 visualizes the extent to which a business cycle-sensitive model of the PK-type can improve on the rigid and inaccurate outcome generated by CreditMetrics.

Although giving similar capital requirement outcomes under stable macroeconomic conditions of moderate growth, the PK-based and the ready-made credit risk measurement approaches currently employed by the banking industry differ under major economic upturns and downturns. Specifically, under the rational optimizing behavior implied by our model, as opposed to the existing ones, banks would take into account the current position in the business cycle to adjust their estimations of credit losses. Although still acting pro-cyclically in recessions (higher economic capital values obtained under both the Czech and the German downturns, see Column 6 of Table 2), the PK model users would not be so over-confident during booms as are the users of both CreditMetrics and CreditRisk+ (Column 5).

At the same time, a simple change of the confidence level from 1% to 5% would turn the behavior of these models (as well as the other two industry-sponsored models mentioned earlier) to over-cautious (Column 4). Where these models originally economized on capital, they are now overpaying for it.

This suggests that the rigid operation of one selected prudential capital scheme cannot serve the interests of financial stability. Rather, in the course of the New Basel Capital Accord implementation, the banking sector should be allowed to support rational behavior through diversity of risk evaluation procedures. In addition, banking regulators, in order to get a realistic picture of sector-wide risks in the right macroeconomic context, may need even more sophisticated credit risk measurement models than individual financial institutions. As the example of our application of PK techniques demonstrates, modeling the interplay of systemic and idiosyncratic default risk factors by advanced incomplete market asset pricing methods is not just a matter of academic curiosity, but an approach that can save money in both the public and private sector. ■

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# Bank Failures and Inefficient Cost Management[1)]

**Anca Podpiera***

During the course of the economic transition, banks operating in the Central and Eastern European countries have experienced tumultuous changes, often culminating in failures. In the Czech case, 21 banks failed in the period 1994-2003, which represents almost one half of the total number of banks. Except for 2001 and 2002, no year passed without at least one bank failure. Significant financial participation by government authorities (billions of euro) has been required to deal with the consequences of these failures. The issue of preventing such adverse developments is therefore of primary importance.

Our study brings into attention the potential relevance of advanced measures of the managerial performance of commercial banks. Although the early warning system employed by the Czech regulatory authorities to detect problematic banks (CAMELS ratings)[2)] acknowledges the importance of banks' management quality, this component appears underrepresented (no more than 5% of the rating) and is based on ad hoc information available to the regulator.

As Derviz and Podpiera (2004) show on a peer group of Czech banks, the CAMELS rating used by the banking supervisory authority can be almost entirely explained by just a few financial ratios. However, the standard financial ratios targeted, such as ROA, ROE and capital adequacy, are able to signal the bank's mismanagement only shortly prior to an occurrence of bank failure.

That is why we employ more advanced measures of managerial performance, such as cost efficiency analysis, for the early detection of problems in banks. Cost efficiency analysis implies that banks are ranked according to their performance relative to the best-practice bank in terms of managing the operating costs of producing the same output under the same conditions, such as output quality, production function and market conditions - see Berger and Humphrey (1997) for a literature survey.

We address the correlation between cost inefficient management and bank failure by carrying out successively a cost efficiency analysis and a hazard model estimation. We use a quarterly panel of all the banks operating in the Czech banking sector over its consolidation period (1994-2002). The relative efficiency scores are estimated for each year separately.

As far the methodology of the cost efficiency analysis is concerned, we favour parametric over nonparametric methods for the reason that parametric methods study economic efficiency, i.e., allocative as well as technological efficiency, whereas the nonparametric techniques focus on analysing technological efficiency only. The core principle of the parametric methods is based on introducing a composite error term and disentangling the inefficiency component from it. More specifically, the random shock is considered as a composite error term, consisting of an inefficiency factor, which brings the costs above those of the best-performing bank, and a random error to account for measurement error or other exogenous factors which can temporarily either increase or decrease the costs.

Given the relatively small number of banks operating in the Czech banking sector, we chose to employ three different parametric methods: the Stochastic Frontier Approach (SFA), the Random Effects Model (REM) and the Distribution Free Approach (in the form of the Fixed Effects Model - FEM). The use of alternative estimation methods, differing in their embedded distributional assumptions, is a compelling means to validate the results and strengthen their policy impact.

The estimated specification of the cost frontier function takes the translog form, where the dependent variable is the banks' total costs and the translog function's factors are represented by a vector of input prices (of labour, physical capital and borrowed funds) and a vector of output (including demand deposits and total loans net of bad loans). The translog function is the most commonly estimated one in the literature due to its sufficiently flexible functional form (Taylor expansion around the mean), which has proven an effective tool for empirical assessment of efficiency. The results of estimating the cost efficiency frontier by the three parametric methods for yearly panels are presented in Table 1. The mean cost efficiency, which is the percentage of the resources of the average bank sufficient to produce the same output if it were on the efficiency frontier, exhibits a decline in 1995-1998 and

1) This short article is based on Podpiera and Podpiera (2005).

2) C-capital; A-asset quality; M-management; E-earnings; L-liquidity; S-market risk.

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an increase in 1999-2002. Taking the SFA results, for instance, the score of 0.46 in 1994 indicates that the average bank was in that year wasting 54% of its resources relative to the best-practice bank. By 2002, however, the figure was only 18%.[3] The stronger mean efficiency performance in the period following 1999 seems intuitive, as many of the least efficient banks had already exited the market by that time and the restructuring and privatization had an efficiency enhancing effect.

We also estimate the cost efficiency on pooled data for different samples of banks - the full sample and the sample excluding entries and exists. We assume a constant ranking of banks during the investigated period to analyse the differences in mean efficiency between the different samples of banks. The mean efficiency for the full sample is by 20 percentage points lower than that for the alternative sample. This finding shows that the mean efficiency is crucially dependent on the choice of the sample of banks.

In addition, estimating the efficiency scores on three sub-periods for the full sample and the sample excluding entries and exits, the derived mean efficiencies for the different samples differ even in their trend (see Table 2). Whereas the results for the full sample show a decline in 1997-1999 and an upswing in 2000-2002, the results for the alternative sample suggest an increase in 1997-1999 and a decline in 2000-2002. Given our findings, we stress the need to use the whole sample of banks in order to derive conclusive results.

Finally, we conducted an analysis of the relationship between the relative efficiency scores and the likelihood of bank failure. We use (i) a simple assessment of the rank-order placement of failing banks prior to their failure, and (ii) also estimation of the Cox proportional-hazards model.

The former approach is based on systematic recording of the position of failed banks in the cost efficiency quartiles of the banks' rank-order for each year prior to their failure. Five years prior to failure, the failing banks were found around the second quartile. Within three to four years prior to failure, the banks tended to descend towards the third quartile. Two years prior to failure, 56% of these banks were in the bottom cost efficiency quartile and 23% of them were in the third quartile. Finally, one year prior to failure, 83% of the banks were in the fourth quartile and 6% in the third quartile. Besides the tendency of failing banks to be located in the bottom efficiency quartile prior to their failure, they tend to descend even to the lowest places within the bottom quartile.

In order to formally test whether the cost efficiency score is a valid predictor of bank failure, we estimate Cox's proportional hazards model. We perform the hazard rate estimations for both a single-factor model (the efficiency scores derived by the SFA, FEM and REM) and a two-factor model (also including bad loans/total assets in order to control for the effect of bad loans).

After controlling for the effect of bad loans (the coefficient on the ratio is positive and significant in all regressions (Table 3), that is, the higher the ratio, the higher the risk of bank failure), the efficiency score significantly explains the risk of failure regardless of the method used for the efficiency evaluation. ■

# TABLE 1

**Descriptive statistics of estimated efficiency scores** (full sample of banks)

| | | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Stochastic frontier approach | Mean | 0.46 | 0.82 | 0.41 | 0.57 | 0.28 | 0.53 | 0.52 | 0.62 | 0.82 |
| | S.D. | 0.15 | 0.17 | 0.13 | 0.18 | 0.17 | 0.18 | 0.20 | 0.17 | 0.18 |
| | Min | 0.18 | 0.17 | 0.19 | 0.23 | 0.12 | 0.25 | 0.23 | 0.26 | 0.33 |
| Random effects model | Mean | 0.55 | 0.72 | 0.43 | 0.53 | 0.33 | 0.55 | 0.54 | 0.60 | 0.62 |
| | S.D. | 0.13 | 0.24 | 0.12 | 0.16 | 0.17 | 0.17 | 0.17 | 0.16 | 0.13 |
| | Min | 0.29 | 0.29 | 0.21 | 0.24 | 0.15 | 0.27 | 0.28 | 0.28 | 0.31 |
| Fixed effects model | Mean | 0.41 | 0.36 | 0.36 | 0.45 | 0.18 | 0.29 | 0.36 | 0.49 | 0.52 |
| | S.D. | 0.18 | 0.18 | 0.22 | 0.20 | 0.19 | 0.26 | 0.25 | 0.24 | 0.22 |
| | Min | 0.06 | 0.05 | 0.07 | 0.03 | 0.05 | 0.13 | 0.16 | 0.17 | 0.12 |
| Number of banks | | 42 | 45 | 43 | 37 | 36 | 34 | 32 | 30 | 30 |

3) In the spirit of the consistency conditions formulated by Bauer et al. (1998), we compare the outcomes of the SFA, REM and FEM in terms of rank-order correlation and correspondence between the ten best (worst) performing banks as independently identified by each method. We find a high rank-order correlation and percentage of jointly identified banks among the top (bottom) ten banks, which validates the results for further policy decisions.

# TABLE 2

## Descriptive statistics of estimated efficiency scores; three-year periods

| | | full sample | | | w/o entries and exits* | | |
|---|---|---|---|---|---|---|---|
| | | 1994-96 | 1997-99 | 2000-02 | 1994-96 | 1997-99 | 2000-02 |
| Stochastic | Mean | 0.47 | 0.43 | 0.56 | 0.70 | 0.75 | 0.73 |
| frontier | S.D. | 0.14 | 0.18 | 0.14 | 0.11 | 0.18 | 0.13 |
| approach | Min | 0.18 | 0.21 | 0.32 | 0.47 | 0.28 | 0.5 |
| Random | Mean | 0.61 | 0.47 | 0.57 | 0.86 | 0.73 | 0.94 |
| effects | S.D. | 0.13 | 0.17 | 0.14 | 0.06 | 0.16 | 0.02 |
| model | Min | 0.29 | 0.24 | 0.34 | 0.68 | 0.33 | 0.89 |
| Fixed effects | Mean | 0.39 | 0.37 | 0.44 | 0.61 | 0.64 | 0.48 |
| model | S.D. | 0.15 | 0.19 | 0.18 | 0.14 | 0.24 | 0.17 |
| | Min | 0.15 | 0.09 | 0.19 | 0.38 | 0.13 | 0.29 |
| Number of banks | | 45 | 37 | 32 | 22 | 22 | 22 |

**Notes:** The efficiency scores derived using the stochastic frontier approach were rescaled to the maximum outcome to achieve consistency among the results of the different methods.

* Excluding exits and entries, i.e., banks continuously operating throughout 1994-2002: Komerční banka, Československá obchodní banka, Živnostenská banka, GE Capital Bank, Česká spořitelna, Českomoravská hypoteční banka, eBanka, Interbanka, Citibank, HVB Bank Czech Republic, ING Bank, Dresdner Bank CZ, Českomoravská záruční a rozvojová banka, Credit Lyonnais Bank Praha, J & T Banka, ABN AMRO Bank, Raiffeisenbank, IC banka, Commerzbank, Všeobecná úvěrová banka, Volksbank and Deutsche Bank.

# TABLE 3

## Cox proportional hazards model (coefficients)

| | BL/TA | EFF(scores) | Log-likelihood | ps-R2 |
|---|---|---|---|---|
| HR=f(SFA,...) | 0.044(0.008)*** | -3.34(1.51)** | -69.02 | 0.20 |
| HR=f(REM,...) | 0.041(0.009)*** | -5.43(2.04)*** | -67.75 | 0.22 |
| HR=f(FEM,...) | 0.05(0.008)*** | -3.46(1.78)** | -69.35 | 0.20 |
| HR=f(SFA,...) | | -4.96(1.42)*** | -78.79 | 0.10 |
| HR=f(REM,...) | | -7.71(1.88)*** | -75.91 | 0.14 |
| HR=f(FEM,...) | | -3.97(1.58)** | -82.27 | 0.06 |

**Notes:** HR stands for hazard rate; BL/TA represents the ratio of bad loans to total assets; EFF stands for efficiency scores; standard errors are in parentheses; number of observations: 326; failures: 19; asterisks denote significance level: *10%, **5%, and ***1%.

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# This Year's News from the CNB Economic Research Department

This year's major intellectual challenge at the CNB Economic Research Department (ERD) was the process of defining the CNB's economic research priorities for 2007-2012. The forthcoming preparations for the euro and the increased role of the CNB in supervising the Czech financial sector added to the challenge. The outcome of this process, in which the Board and the Research Advisory Committee played a crucial role, is a set of priorities that will guide the forthcoming three Research Programmes. They will be published next year prior to the announcement of the Call for Projects 2007-2008.

I hope that the Call will attract at least as much attention as the Interim Call 2005-2006 organised this year. The Board approved nine projects in the Interim Call, which means that 24 projects, involving 40 researchers, are now being supervised by the ERD. The number of on-going projects has increased in comparison to previous years, and the volume of CNB research outputs produced by the ERD is also rising.

In April, the ERD's publications were registered with the RePEc database (http://repec.org/). They now rank among the top tenth downloaded series there. In September, the CNB's first-ever Research Open Day (ROD) showcased the ERD's main activities and the best research papers published so far. The CNB is to hold its second ROD on May 16, 2006. We hope that the open days become a well-established tradition, just as the ERD seminars jointly organised with the Czech Economic Society and CERGE-EI have become.

Finally, I would like to mention several personnel changes inside the ERD. Aleš Čapek decided to move to Eurostat. His position of deputy director was taken over by Vladimír Bezděk, who managed to finish the Czech pension reform strategy just in time to do so. Juraj Antal and Michal Hlaváček are the new research co-ordinators for modelling and financial stability respectively. Carsten Detken (ECB) has joined our Research Advisory Committee, replacing Ignazio Angeloni, who resigned due to a change in his professional career.

**Kateřina Šmídková**, Executive Director
CNB Economic Research Department

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