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Cyprus: Financial Sector Assessment Program Update—Technical Note—Measuring Banking Stability in Cyprus

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FINANCIAL SECTOR ASSESSMENT PROGRAM UPDATE

REPUBLIC OF CYPRUS

TECHNICAL NOTE

MEASURING BANKING STABILITY IN CYPRUS

MAY 2009

INTERNATIONAL MONETARY FUND
MONETARY AND CAPITAL MARKETS DEPARTMENT

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GLOSSARY

CAR	Capital adequacy ratio
CBC	Central Bank of Cyprus
DD	Distance to default
ECB	European Central Bank
EMTN	Euro medium-term note
EU	European Union
EWS	Early warning system
FSAP	Financial Sector Assessment Program
FSI	Financial soundness indicators
FX	Foreign exchange
LTV	Loan-to-value
MoF	Ministry of finance
MoU	Memorandum of understanding
NPL	Nonperforming loan
ROA	Return on assets
ROE	Return on equity
RWCAR	Risk-weighted capital adequacy ratio

I. Introduction and Main Findings[1]

1. **This note examines financial sector stability in Cyprus, using a combination of accounting-based and market-based indicators, and stress tests.** Market-based indicators and stress tests provide useful dimensions to the analysis of financial stability in Cyprus. In its work on financial stability, the Central Bank of Cyprus (CBC) has mostly relied on a range of standard accounting-based financial soundness indicators (FSIs). Recently, it has started work on stress testing. The aim of this technical note is to illustrate how the existing analysis can be further enhanced by improving the stress tests and developing the more forward-looking market based indicators.

2. **Various indicators place Cyprus's banking system soundness ahead of emerging countries but behind advanced economies.** This is in line with the assessments by major rating agencies. Compared with the accounting ratios, market-based indicators paint a more mixed picture of recent financial stability developments in Cyprus, possibly reflecting markets' assessment of challenges and risks associated with the financial sector reforms.

3. **Cypriot commercial banks are weaker than their counterparts in Greece and also less stable than cooperative banks in Cyprus.** Both these findings are driven by the higher return volatility of Cypriot commercial banks. The analysis also finds that banks in Cyprus have lower margins than in Greece, which is consistent with the recent intensification of deposit competition in Cyprus. While Cypriot banks exhibit higher returns than their cooperative counterparts, the lower return volatility of cooperative banks implies that these are more able to smooth out income over the business cycle, consistent with their stated objective of maximization of consumer surplus instead of profits. The finding that cooperative banks in Cyprus tend to be more stable is based on aggregated data, and individual cooperative banks differ substantially. In addition, the cooperative sector has recently undergone some dramatic consolidation which will continue in the near future.

4. **Spillover analysis highlights the close ties between the Cypriot financial sector and the rest of the world.** Cyprus has been on the sidelines of the U.S.-originated financial crisis so far with Cypriot banks having limited exposure to mortgage-backed securities in the United States. However, we find that an equity index of the Cypriot banking sector exhibits strong co-movement with bond spreads in Russia and Ukraine during the recent financial market turmoil, while the correlation between the Cypriot and Greek bank equity index has almost doubled in the past three years. It is also found that shocks to individual Greek banks significantly impact on Cypriot banks' default probability while the opposite does not hold.

[1] Prepared by Martin Čihák and Heiko Hesse, with inputs from Kalin Tintchev and Srobona Mitra. The stress testing exercise has been carried out in cooperation with Joseph Theodorou and Marianna Charalambous (Central Bank of Cyprus). Bottom-up stress testing calculations have been done by individual commercial banks, based on assumptions and methodology by the FSAP team, in cooperation with CBC.

This suggests substantial vulnerabilities of Cypriot banks emanating from the Greek banking sector.

5. **Credit risk appears the main source of risk in the banking sector with demand for real estate slowing, declining property price growth as well as Cyprus' high household indebtedness.** According to the widely cited BuySell Index, Cypriot real estate prices have been stagnating in January–June 2008. In addition, at 140 percent, the level of household indebtedness is very high by European standards. This could severely impact the household debt serving capacity should there be a substantial decline in property prices. In such a scenario, banks' would be exposed to higher collateral and credit risk. The CBC has been prudent on this front and has reduced the maximum loan-to-value (LTV) ratio which will provide some buffer against adverse real estate price developments.

6. **Counterparty risk has been highlighted by the current crisis.** Since the onset of the financial crisis in the summer of 2007, interbanking markets both in the U.S. and Europe have been put under strains with severe dislocations at times. In Europe, the European Central Bank (ECB) injected liquidity both through their usual main refinancing operations as well as through long-term refinancing operations and dollar liquidity in coordination with the Fed. Besides liquidity risk, c*ounterparty risk* became the main reason why banks were reluctant to lend to each other and hoarded liquidity due to the uncertainty with regard to the mortgage exposure of counterparties and the inability to value their respective assets. Cypriot banks are currently net lenders to the European money market and have sizable exposures to European financial institutions (e.g. bond investments). In total, they have balances with other euro area EU banks of 12 billion Euro and almost 10 billion euro with the rest of the world (non-euro area EU banks and non-EU banks). Banks plan to reduce counterparty risks both in their interbanking activities and bond investments.

7. **Given the international business nature of Cyprus and the prominent role of foreign deposits, liquidity risk becomes important should foreign sentiment turn against Cyprus in the current turmoil.** Cypriot banks fund themselves by retail deposits and have substantial liquidity buffers. Russian short-term deposits form a sizable part of foreign deposits in Cyprus. Past experience has suggested a lack of deposit withdrawal when problems abroad occur, and there has so far been no evidence that stock markets in Russia and Ukraine move in tandem with deposit balances. Cyprus also benefited from its reputation of being considered a "safe heaven." However, past tends to provide at best only a limited guidance for the future, and the ongoing global financial crisis highlights that confidence in the banking system is crucial, and rumors can distort the actual state of the financial system. A related risk is Cyprus' dependence on double-tax treaties especially for foreign short-term deposits. The international business model of Cyprus might be significantly damaged should severe problems with the various double-tax treaties (e.g., with Russia) occur. Overall, the CBC's conservative liquidity ratio has served the banks well.

8. **Stress tests confirm that credit risk is the key source of risk, and the exposure has grown in recent years.** Banks are resilient to medium-size shocks, but under extreme shocks they would likely face solvency problems. An extreme but plausible scenario implies costs of 4 percent GDP. Compared to banking crises in the past with an average fiscal cost of 15–20 percent of GDP (Appendix IV), the estimated recapitalization costs for Cypriot banks are of a lower magnitude. In contrast to credit risk, stress testing results for foreign exchange, interest rate as well as equity price risks suggests a relatively small impact on the banks' capital adequacy.

9. **CBC's financial stability work could be further strengthened.** We suggest to build on the commendable work of CBC's financial stability section by adding resources to that section (so that it can devote relatively less time to data collection and relatively more time to in-depth analysis of the data) and to put on a firmer footing its cooperation with CBC's banking supervisors (to better integrate CBC's micro- and macro-prudential work). The note also contains a range of other specific recommendations to improve CBC's financial stability work.

10. **The structure of the remainder of the note is as follows.** Section II compares the banking stability in Cyprus to some international benchmarks. Section III analyzes spillover risks between Cyprus and the rest of the world. Section IV discusses banks' sensitivity to shocks, based on a stress testing exercise. Section V contains the recommendations for CBC's further financial stability work. Section VI concludes.

II. Banking Stability in Cyprus: Cross-Country Comparison

A. Financial Soundness Indicators

11. **The Cypriot banking sector has recovered from the bursting of the stock market bubble in 2000 to which it had a substantial exposure.** After a string of losses through 2003, profitability returned, with aggregate return on equity (ROE) and return on assets (ROA) of 37 percent and 2 percent, respectively as of end-2007 (Table 1), on the back of robust interest margins, growing loan portfolios and contained costs. Overall, banks have maintained stable capital ratios in the face of strong credit expansion, with Tier I capital to risk-weighted assets standing at 10 percent as of end-2007. The very high profitability ratios have been driven in part by decreasing NPL ratios in the past years.

12. **Based on the available aggregate FSIs, cooperative banking sector is roughly on par with commercial banks (Table 2).** Cooperative credit institutions feature capitalization ratios that are broadly similar to commercial banks (even though the latest aggregate data for cooperatives are available only for end-2006). Their return indicators (ROE, ROA) are relatively lower, reflecting their different business model. Their nonperforming loan (NPL) ratios are marginally lower than in commercial banks (but comparable NPL ratios for cooperatives are available only from 2008, which limit the scope for a rigorous comparison).

Table 1. Cyprus: Financial Soundness Indicators for Commercial Banks, 1999–2008

Indicator	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008 (March)
Core Set										
Regulatory capital to risk-weighted assets	12.7	13.5	14.0	12.7	11.7	11.4	12.4	12.4	12.2	11.19
Regulatory Tier I capital to risk-weighted assets	11.6	13.7	11.6	10.1	10.0	9.8	10.0	10.8	10.4	9.63
Nonperforming loans net of provisions to capital 2/	...	...	…	…	99.4	72.0	34.8	20.4	9.3	10.9
Nonperforming loans to total gross loans 2/	8.4	8.5	7.9	9.5	11.3	11.7	7.1	5.4	3.4	3.69
Sectoral distribution of loans to total loans (enterprises and households, domestic and foreign residents)										
Residents							47.9	42.6	39.4	38.6
Loans to Insurance corporations										
Loans to Domestic and foreign credit instituitions										
Loans to Non-financial corporations							19.4	17.4	17.4	20.0
Loans to Households										
Consumer credit (=all loans to households without mortgage on dwelling)										
Lending for house purchase										
Nonresidents							52.1	57.4	60.6	61.4
Return on assets	2.4	1.5	0.6	-0.7	-0.3	0.2	0.8	1.4	2.3	0.49
Return on equity	30.3	17.4	8.4	-11.1	-4.7	4.3	14.1	25.5	37.3	8.09
Interest margin to gross income	32.3	56.3	57.5	38.7	32.6	46.1	66.2	66.1	55.9	59.57
Noninterest expenses to gross income	45.2	61.9	68.2	68.6	66.6	62.7	59.1	49.0	42.6	41.6
Liquid assets to total assets							29.5	31.1	29.6	25.26
Liquid assets to short-term liabilities							34.9	37.1	35.9	34.3
Net open position in foreign exchange to capital	2.9	7.6	5.8	1.9	2.9	…	2.0	2.1	1.4	0.41
Optional Indicators										
Trading income to total income	29.0	-4.4	-0.8	3.9	4.8	3.9	5.7	7.5	9.2	12.8
Personnel expenses to noninterest expenses	61.3	59.2	60.6	63.4	63.0	64.0	62.2	62.9	57.6	60.84
Customer deposits to total (non-interbank) loans	131.9	133.1	137.0	132.0	127.6	140.9	134.7	132.2	122.8	109.79
Geographical distribution of loans to total loans										
Large exposures to capital										
Spread between reference lending and deposit rates										
Foreign currency-denominated loans to total loans										
Net open position in equities to capital										
Household debt to GDP										
Household debt service and principal payments to income										
Residential real estate loans to total loans										
Commercial real estate loans to total loans										

Source: Central Bank of Cyprus.

1/ Data for 2001-04 are for deposit-takers compiled on a domestic consolidation (DC) basis, while the ratio of regulatory capital to risk-weighted assets and the ratio of regulatory Tier 1 capital to risk-weighted assets are both compiled on a cross-border and cross-sector for all domestically-incorporated banks (CBCSDI) basis; do not include the cooperative credit institutions and the former International Banking Units. Data for 2005 onwards are for deposit-takers compiled on a domestically-controlled, cross-border consolidation basis (DCCB); do not include the cooperative credit institutions and foreign-controlled banks. The ratio of regulatory capital to risk-weighted assets compiled on a cross-border and cross-sector consolidation basis for all domestically-incorporated (CBCSDI) deposit-takers, which exclude the cooperative credit institutions but include the former International Banking Units, for 2005 works out at 13,4%, for 2006 is 13,2% and for 2007 12,5%. Similarly, on a cross-border and cross-sector basis, the ratio of regulatory Tier 1 capital to risk-weighted assets was for 2005 10,2%, for 2006 10,2% and for 2007 10,3%.

2/ The numbers are not fully comparable over time, because the threshold for classifying loans as non-performing was changed from 9 months in arrears to 6 months in 2005. The threshold was further reduced to 3 months in 2006. In addition, only data for 2005 onwards are compiled according to the methodology and specifications provided in the IMF "Compilation Guide on Financial Soundness Indicators." The decline in nonperforming loan (NPL) ratios since 2004 reflects stricter lending criteria, repayments and write-offs of NPLs as well as denominator effects (growth in capital/loans).

Table 2. Cyprus: Financial Soundness Indicators for Credit Cooperatives, 2003–08

	2003	2004	2005	2006	2007	2008 (June)
Core Set						
Regulatory capital to risk-weighted assets	11.1	11.3	12.1	13.8	…	…
Regulatory Tier I capital to risk-weighted assets	11.1	11.3	12.1	13.8	…	…
Nonperforming loans net of provisions to capital 1/	…	…	…	…	…	14.4
Nonperforming loans to total gross loans 1/	…	…	…	…	…	3.0
Sectoral distribution of loans (% of total loans)						
Residents	…	…	99.9	99.9	99.9	99.9
Insurance corporations	…	…	0.0	0.0	0.0	0.0
Domestic and foreign credit instituitions	…	…	27.3	30.8	28.7	23.8
Non-financial corporations	…	…	3.3	3.9	6.2	7.3
Households	…	…	67.4	63.6	63.8	67.6
Consumer credit 2/	…	…	22.7	20.9	20.1	20.9
House purchase	36.5	…	22.9	22.7	25.0	27.4
Nonresidents	…	…	0.1	0.1	0.1	0.1
Return on assets	-0.1	0.7	0.6	0.7	0.7	…
Return on equity	-1.9	10.4	8.4	9.4	9.4	…
Interest margin to gross income	162.5	157.3	158.5	151.1	149.9	…
Non-interest expenses to gross income	206.0	135.3	135.0	115.6	114.1	…
Liquid assets to total assets	29.8	27.2	26.8	29.5	28.5	…
Liquid assets to short-term liabilities	31.7	29.0	28.7	26.5	32.7	24.0
Net open position in foreign exchange to capital	…	…	0.0	0.1	-0.2	…
Encouraged Set						
Personnel expenses to non-interest expenses	…	…	…	40.2	40.5	…
Customer deposits to total (non-interbank) loans	135.2	129.3	129.2	133.9	131.4	123.6
Large exposures to capital	…	…	…	…	…	…
Spread btw reference lending and deposit rates	1.4	2.1	1.8	1.9	1.6	…
Residential real estate loans to total loans	36.5	35.0	32.0	32.0	33.3	…
Commercial real estate loans to total loans	18.4	18.1	17.5	17.3	16.5	…

Source: Authority for the Supervision and Development of Cooperative Societies.
1/ Non-performing loan data available only from 2008.
2/ All loans to households without mortgage on dwelling.

13. **There are no clear signs yet that the current global financial turmoil has directly affected banks in Cyprus, but some indirect effects are being increasingly felt.** End-of-year results for 2007 are strong with profits at record levels. In addition, liquidity of Cypriot banks has not suffered notably, with an aggregate ratio of customer deposits to (non-interbank) loans at 123 percent at end-2007. A portion of customer deposits are denominated in foreign currency, but banks are required to invest at least 70 percent of such deposits into liquid assets. This conservative liquidity requirement, though fairly unique across Europe, has served the banks well in light of the international financial crisis. However, not all indicators are rosy: equity prices of the main Cypriot banks have declined by over 60 percent from their peak in October 2007. In addition to the general stock market decline, this reflected the dwindling interest in the financial sector given the global economic outlook, growing concern of possible overheating in the property market, and continued regional expansion that have increased exposure to adverse shocks through foreign subsidiaries. The ongoing financial crisis and the freeze in the interbanking markets have led to an increase of funding costs for European banks across the board. While Cypriot banks are net lenders in the European money market, counterparty risk has become an important issue due to bond portfolios of Cypriot banks as well as possible credit risk since most loans have flexible interest rates linked to the Euribor.

14. **Overall, FSIs for Cyprus lag somewhat behind its advanced economy peers (Table 3).** It is therefore not surprising that Fitch (2008) rates systemic risk and macro prudential strength of the Cypriot banking system at C2, (on a scale from A1 to E3); this is the same rating given to Malta, San Marino, and Slovenia, but weaker than Czech Republic, Portugal, or Greece (all B2). The three largest banks have Fitch ratings BBB to A-, which is relatively weak compared to large banks in advanced economies, but comparable with large emerging market banks.[2] Similarly, as of November 2007, Cyprus' banking strength of C-ranked average in Moodys'(2007) global comparison, on par with Slovenia, Slovak Republic or Poland but behind Greece, Hungary (both C) and the other advanced EU countries. In terms of the long-term deposits in domestic as well as foreign currency, Cyprus (A3) ranked below average. Comparator countries for the domestic currency category include Romania and Turkey and for the foreign currency Malta. In contrast, Portugal ranked ahead with Aa3 in both categories.

B. Cross-Country Financial Sector Comparison

15. **Given its role as an international financial center, the Cypriot financial sector is relatively deeper than many of its country peers; its banking sector is relatively concentrated, and its stock market exhibits a relatively low turnover (Figure 1).** The ratios of private credit to GDP and liquid liabilities to GDP both exceed 100 percent of GDP

[2] Bank of Cyprus was put on negative watch on June 30, 2008 after acquiring a Russian bank.

in Cyprus, illustrating the role played by the financial sector in the Cypriot economy.[3] The concentration ratio, measured as the percentage of banking assets held by the three largest commercial banks, indicates a concentrated banking sector. Despite having a relatively large cooperative banking sectors and facing international entrants, the Cypriot banking sector is dominated by a few large players. Compared to Greece and some other advanced European countries, the assets of the largest Cypriot bank stands at close to 300 percent of the country's GDP. Thus, the combination of high concentration and bank dominance in the Cypriot economy makes crisis prevention management more challenging than in other countries. In addition, the stock market turnover ratio (measured as the value of total shares traded to average real market capitalization) is very low in Cyprus, indicating relatively low trading in the Cypriot stock market. In 2008, on average only €7 Million was traded daily on the Cyprus Stock Exchange, down from €16 million in 2007. Only the larger stocks have liquid markets while a significant trading of Cyprus shares also occurs on the Hellenic Exchange after the common platform was established in 2006. Finally, for both the overhead costs and net interest rate margins (not shown here, but available upon request), Cyprus finds itself in the median range.

C. Analysis Based on Z-Scores

16. **One way of investigating the financial stability of Cypriot commercial banks, compared to commercial banks in Greece and Portugal, is the z-score methodology.** We used balance sheet and income statement data from BankScope as well as the z-score methodology (Hesse and Čihák, 2007).[4] A decomposition weighted by total assets for 1995–2007 as well as 2003–2007 shows that Cypriot banks are substantially weaker than their counterparts in Greece and Portugal. Table 4 presents the decomposition of the z-score into its components, i.e. equity/assets, ROA, and the standard deviation of ROA.

[3] This is supported by the peer comparison of Standard & Poor's (2008) where Cyprus had the highest intermediation capacity of its peers, ahead of Korea and Portugal. The comparative analysis also included Chile, Greece, Italy, Malta, Slovak Republic and Slovenia.

[4] The z-score measures the number of standard deviations a return realization has to fall in order to deplete equity, under the assumption of normality of banks' returns. A higher z-score implies a lower probability of insolvency risk.

Table 3. Cross-Country Comparison of Financial Soundness Indicators, 2002–07

(i) International Monetary Fund Statistics, 2002–07

2002-07 averages (%)	Cyprus	Europe		World
		Advanced	Emerging	
Capital to Risk-Weighted Assets	12.2	12.8	17.8	15.5
NPLs to Total Loans	8.1	2.3	6.5	6.9
Return on Assets	0.6	0.7	1.5	1.5
Return on Equity	10.9	15.4	14.7	15.6

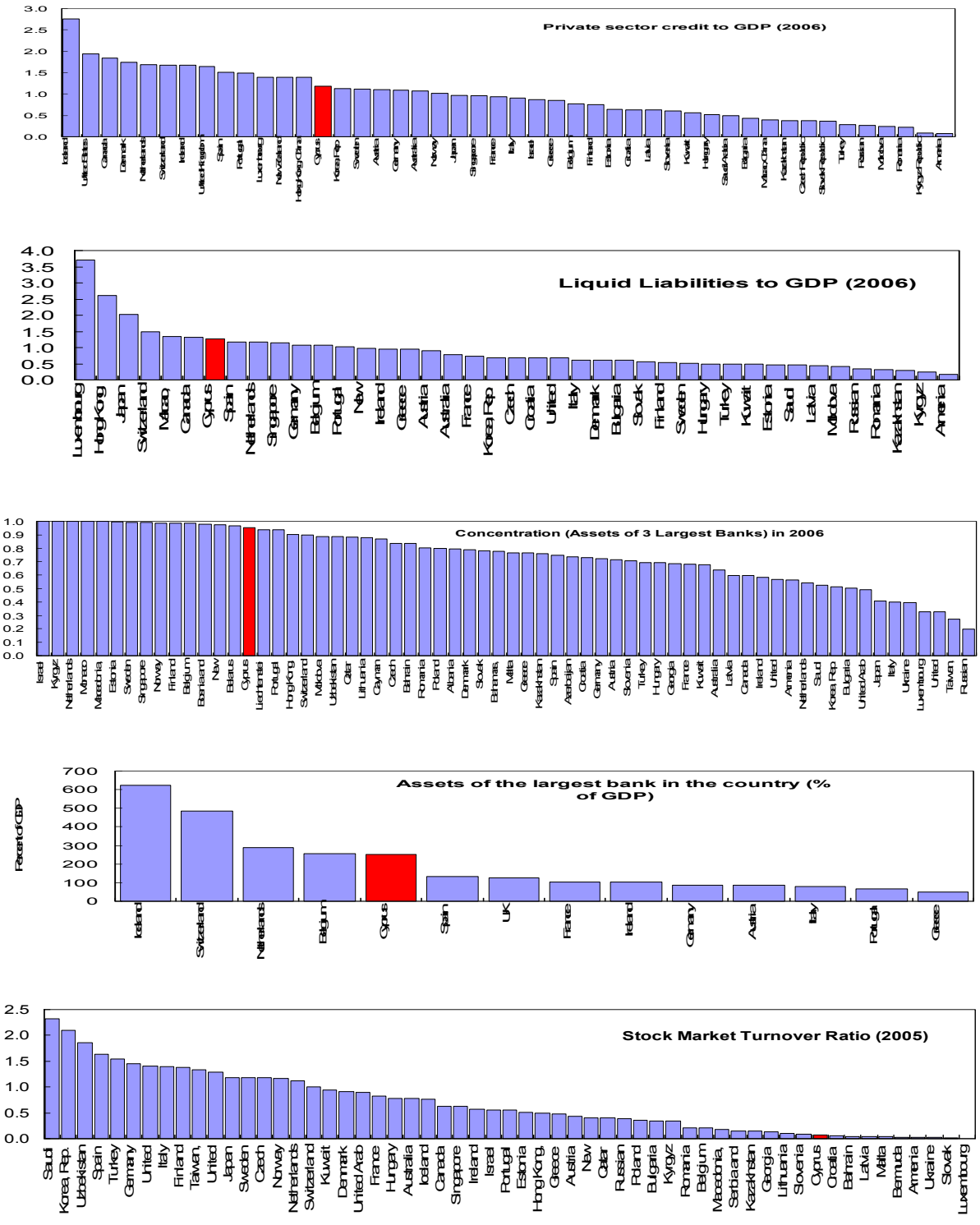
Source: International Monetary Fund, based on data from country authorities.

(ii) European Central Bank Statistics, 2006

	Cyprus	EU		
		Avg	Median	Stdev
Profitability (% of total assets, if not otherwise indicated)				
Net interest income	2.0	2.5	2.0	2.4
Net non-interest income	0.9	1.7	1.6	0.9
Total expenses	1.4	2.1	1.9	1.1
Profits (after tax) (ROA)	0.9	1.6	1.1	2.0
Profits (after tax) (% Tier 1) (ROE)	14.6	20.3	18.8	6.9
Net interest income (% of total income)	70.1	55.9	54.4	10.8
Net non-interest income (% of total income)	29.9	44.1	45.6	10.8
Cost-to-income ratio (% of total income)	48.7	52.7	53.5	11.4
Solvency				
Overall solvency ratio	13.6	14.3	12.3	5.3
Tier 1 ratio	10.7	12.0	10.4	6.0
Liquidity (% of amounts owed to credit institutions)				
Liquid asset ratio (cash and loans to credit institutions)	608.8	232.0	101.3	359.8
Balance sheet structure (% of total assets)				
Debt securities	18.6	19.2	18.4	11.4
Loans to customers	53.7	55.7	58.0	10.4
Amounts owed to credit institutions	3.8	14.0	11.9	7.3
Amounts owed to customers	80.4	52.3	49.6	19.2
Subordinated liabilities	2.1	1.8	1.9	1.3

Source: European Central Bank, calculations by IMF staff.

Figure 1. Cross-Country Comparison of Financial Sector Structures



Sources: Beck, Demirgüç-Kunt, and Levine (2000), IMF staff calculations.

Table 4. Z-Score Decomposition for Commercial Banks in Cyprus, Greece, and Portugal

Country	Cyprus	Greece	Portugal
1995-2007			
Z-score	12.1	45.7	33.1
ROA in %	0.8	1.0	0.7
Equity/ Assets (in %)	6.9	7.4	5.9
St. dev. of ROA (in % points)	0.7	0.4	0.2
2003-2007			
Z-score	11.7	46.9	37.7
ROA in %	0.8	1.0	0.9
Equity/ Assets (in %)	6.9	7.3	6.5
St. dev. of ROA (in % points)	0.7	0.4	0.2

Source: IMF staff calculation based on BankScope data

Note: All components for each type of bank have the same number of observations. The primary source for the decomposition is consolidated data and otherwise unconsolidated data. The variables in the z-score decomposition are weighted by total assets.

17. **The lower z-score of Cypriot banks is driven by their higher standard deviation of returns.** During the full sample period 1995–2007, both the ROA and capitalization in Cyprus is below Greece but marginally above Portugal. Looking only to the more recent period 2003–07 indicates that the picture has not changed much. While Cypriot banks have become slightly less volatile in their returns and their ROA has increased, they are still substantially weaker than their Greek and Portuguese counterparts, again driven by their higher return volatility. A panel regression analysis (Table 5) confirms these results. Both a robust estimation technique,[5] to avoid the influence of outliers, as well as a random effects model is used to test the impact of bank-specific variables, the Herfindahl index and macroeconomic variables (all variables in lags) on bank-specific stability, as approximated by the z-score. Dummy variables are used for banks in Cyprus and Portugal, implying the benchmark comparison is Greece. Indeed, both preliminary regressions indicate a significantly negative coefficient for Cyprus. In other words, Cypriot banks are weaker than Greek banks. There is also some evidence that higher loan/asset ratio negatively impacts bank stability while in the robust estimation technique, higher cost efficiency and income diversity leads to higher z-scores. These findings do not hold in the random effects panel model.

18. **Based on aggregate z-score data, cooperative banks appeared more stable than commercial banks in Cyprus during 2003–07 (Table 6).** While commercial banks exhibit a significantly higher ROA, capitalization, measured by regulatory capital to risk-weighted assets, is similar for both commercial and cooperative banks. The differences in z-scores is

[5] See Hesse and Cihak, 2007, for more details on applying the robust estimation technique.

driven by substantial differences in return volatility. The stated objective of cooperative banks is not to maximize profits but rather maximization of the consumer surplus. Cooperative banks pass on an important part of their returns to customers in the form of surplus and are able to smooth out income over the business cycle. This might explain why cooperative banks have a lower return volatility. For these reasons, some indicators of soundness indicate that cooperative banks appear somewhat more stable than commercial banks in Cyprus in 2003–07. These are, however, aggregate numbers. There are substantial differences among individual cooperative banks, and the sector has seen a considerable reduction in market players in recent years. Table 4 also shows that the z-scores based on BankScope and FSI data are comparable in magnitude, thus providing some support for the comparison.[6]

Table 5. Regression Results for Z-Score, 1995–2007

Z-Score	(1)	(2)
Assets (-1)	0.141	0.096
	(0.001)***	(0.180)
Loans/ Assets (-1)	-20.831	-8.162
	(0.000)***	(0.070)*
Liquid Assets/ Deposits (-1)	-1.143	-1.36
	(0.002)***	(0.003)***
Cost-Income Ratio (-1)	-0.077	0
	(0.000)***	(0.988)
Income Diversity (-1)	4.931	0.924
	(0.032)**	(0.331)
Herfindahl Index (-1)	0	-0.001
	(0.623)	(0.193)
Inflation (-1)	0.192	-0.434
	(0.840)	(0.399)
GDP Growth (-1)	-0.105	-0.14
	(0.733)	(0.201)
Cyprus Dummy	-8.535	-13.254
	(0.000)***	(0.074)*
Portugal Dummy	6.227	7.424
	(0.005)***	(0.342)
Constant	30.893	34.4
	(0.000)***	(0.000)***
Observations	199	199
R-squared	0.423	
Method	Robust	RE

Source: author's calculation based on BankScope data

Note: (1) is estimated using the Robust Estimation Technique, (2) is based on Random Effects with the residuals clustered by banks. * significant at 10%; ** significant at 5%; *** significant at 1%. P-values in parentheses.

[6] There are some differences in the z-score decomposition in BankScope and the FSI data. The former is based on bank-by-bank data, equity/ assets and weights the variables by total assets. Instead, the aggregate FSI data employs regulatory capital to risk-weighted assets as the measure for capitalization.

Table 6. Cyprus: Z-Score Decomposition—Commercial vs. Cooperative Banks, 2003–07

	BankScope Data Commercial Banks	FSI Data Commercial Banks	FSI Data Cooperative Banks
Z-score	11.72	12.64	36.92
ROA in %	0.8	0.9	0.5
Capital/ Assets (in %)	6.9	12.0	12.4
St. dev. of ROA (in % points)	0.7	1.0	0.3

Source: author's calculation based on BankScope and FSI Data
Note: For the FSI data, only regulatory capital/ risk-weighted assets was available. The variables in the z-score decomposition in the BankScope data are weighted by total assets.

D. Analysis Based on Margins

19. **Commercial banks in Cyprus face lower margins than Greece.** A cross-country analysis of interest margins indicates that net interest margins are on 1 percent higher in Greece than Cyprus (Table 7). These findings are not inconsistent with the current intensification of competition for deposits in Cyprus. Some international banks have recently entered the Cypriot market and are competing to attract deposits from commercial and cooperative banks, which overall has put pressure on the deposit rates. A panel data model of the margins in Cyprus, Greece and Portugal supports these descriptive results. The dependent variable was regressed on bank-specific and macroeconomic variables as well dummy variables for Cyprus and Portugal. The regression provides some evidence that margins are lower in Cyprus, compared to Greece. Overhead costs are the dominant driver of interest rate margins, consistent with the academic literature. Banks that face higher overhead costs will charge higher margins (Table 8).

Table 7. Cyprus: Net Interest Margin of Commercial Banks

	Cyprus	Greece	Portugal
2007	2.59	3.52	1.91
2006	2.36	3.46	1.96
2005	2.46	3.45	2.06
1995-2007	2.60	3.44	2.27

Source: IMF staff calculations based on BankScope data

Note: The net interest margins are defined as the net interest income expressed as a percentage of earning assets and are weighted by banks' assets.

E. Market Based Indicators

20. **A number of indicators can be used to gauge likelihood of default of financial institutions based on prices of financial instruments.** These indicators include distance to default (DD), bond prices, and credit default swaps.[7] Among their advantages is that they are available at high frequency, and incorporate market participants' forward-looking assessment of risks (unlike the more backward-looking accounting measures). Another practical advantage is that unlike supervisory data, they are widely available, and therefore can be scrutinized by independent analysts and researchers. The market-based indicators also have limitations. They may not work well if securities are not publicly traded or their trading is limited. Also, if little information is publicly disclosed but much is collected by supervisors, prudential data can be superior to market-based indicators in measuring financial sector soundness. Moreover, securities prices reflect potential losses to the security holders, which may be different from losses to depositors. Finally, the market based indicators incorporate assumptions that may not capture extreme events adequately (e.g., some basic measures assume that asset values follow a lognormal process).

Table 8. Cyprus: Regression Results for Margins, 1995–2007

Dependent Variable: Net Interest Margin	(1)	(2)	(3)	(4)
Overhead Costs	51.372	16.263	56.364	15.572
	(0.000)***	(0.009)***	(0.000)***	(0.023)**
Liquidity	-0.001	-0.022	-0.002	-0.026
	(0.932)	(0.053)*	(0.897)	(0.030)**
Capitalization	-1.366	0.681	-1.231	0.5
	(0.120)	(0.605)	(0.138)	(0.665)
Cyprus Dummy	-0.312	-0.553	-0.178	-0.615
	(0.060)*	(0.155)	(0.240)	(0.095)*
Portugal Dummy	-0.582	-0.28	-0.394	-0.315
	(0.000)***	(0.477)	(0.005)***	(0.403)
Inflation			0.162	0.073
			(0.005)***	(0.267)
GDP Growth			0.014	-0.034
			(0.423)	(0.112)
Constant	2.402	2.571	1.082	2.555
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Observations	218	218	218	218
R-squared	0.447		0.498	
Method	Robust	RE	Robust	RE

Source: author's calculation based on BankScope data

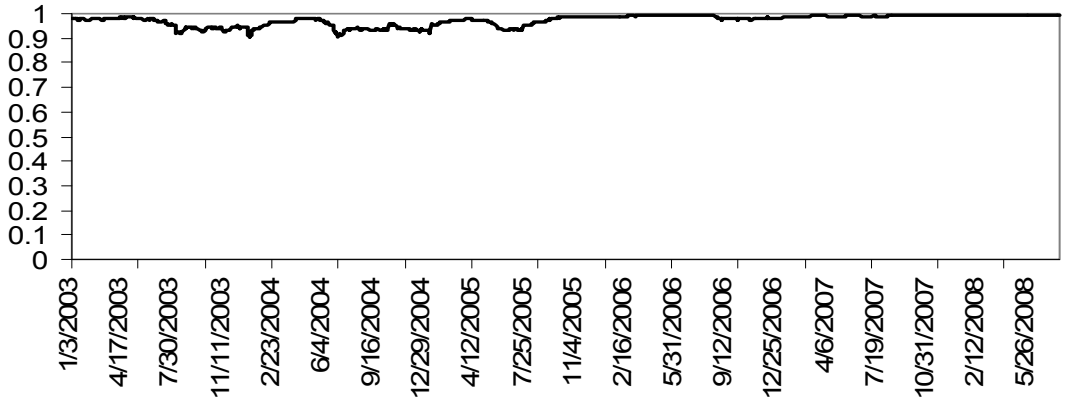
Note: (1) is estimated using the Robust Estimation Technique while (2) is based on Random Effects with the residuals clustered by banks. * significant at 10%; ** significant at 5%; *** significant at 1%. P-values in parentheses.

[7] See for instance Čihák (2007a) for definitions and a survey of the various market-based indicators.

21. **Empirical studies show that market-based indicators can outperform traditional measures of soundness when forecasting distress in individual financial institutions**. Market-based indicators have been shown to predict supervisory ratings, bond spreads, and rating agencies' downgrades in both developed and developing economies, performing generally better than "reduced form" statistical models of default or measures relying on financial statements. For example, literature on U.S. banks finds that supervisory assessments are worse than market indicators in predicting bank performance, but supervisors may be more accurate when inspections are recent (Berger, Davies, and Flannery, 2000). Similarly, literature on European banks finds that market-based indicators improve performance of models based on banking ratios (Tudela and Young, 2003; Gropp, Vesala, and Vulpes, 2006).

22. **Bank stock prices in Cyprus are likely to contain useful information.** The stock market turnover in Cyprus is relatively low, as mentioned earlier. The low liquidity in the market may create "noise" in the information extracted from stock prices for the less traded stocks. However, trading in bank stocks is rather active and in fact dominates the market, as illustrates by the almost perfect correlation between the stock market index and bank stock index in Cyprus (Figure 2).[8] Moreover, the bank stocks are also actively traded abroad, on the Athens Stock Exchange, and the prices at the two stock exchanges are almost perfectly correlated. This gives some confidence that these stock prices may contain useful information.

Figure 2. Cyprus: Correlation of the Stock Market Index and Bank Stock Index, 2003–08



Source: IMF staff calculations, based on stock exchange data.

23. **Cypriot bank stocks have shown higher volatility than EU bank stocks.** Compared to an average of EU banks, Cypriot bank stocks have grown much faster between late 2004 and October 2007. In October 2007, about two months after the EU bank stocks

[8] The correlation of the bank and stock index is based on the dynamic conditional correlation GARCH model.

started falling, the Cypriot bank stocks begin to fall as well, at a much higher rate than the average EU bank stocks. At present, both the Cypriot bank stocks and the EU bank stocks are some the 30 percent below the 2004–08 average. An analysis of the co-movement between the two indices confirms this by suggesting a relatively high "beta," about 2.5, i.e., Cypriot bank stocks are relatively sensitive to a general downturn affecting bank stocks (Figure 3).

24. **In a cross-country comparison, the market based indicators for Cyprus depict a banking system with average levels of soundness.** The DD[9] for Cypriot banks are broadly in line with those for other advanced economy banks (Figure 4). This is broadly in line with ratings agencies' ratings.

25. **Market-based indicators and accounting indicators tell a slightly different story of performance in recent years.** Accounting indicators, such as NPL ratios, capital adequacy ratios (CARs), and liquidity ratios, suggest an improvement in banking sector soundness since 2003 (See Table 1). In 2007, the three largest Cypriot commercial banks continued to report marked improvements in their operating profitability and cost efficiency on the back of a remaining good economic environment, strong loan growth and improved cost management. The banks' strong operating profitability also benefited from continued restructuring and improving asset quality, which resulted in reduced impairment charges, allowing the banks to generate good internal capital. The banks' asset quality also continued to progress in 2007, strengthening their loan impairment coverage to more than 75 percent of impaired loans, which rating agencies consider satisfactory given that the banks hold a high level of collateral and guarantees against performing and impaired loans (Fitch Research, 2008b). Despite fast-growing loan books, at end-2007 the banks' core capital to total assets ratio remained at 7.3 percent (2006: 7.1 percent), mainly due to strong internal capital generation. Despite the crisis in the financial markets, the banks' liquidity remained satisfactory. At end-2007, their loans represented 73 percent of their deposits on aggregate. In addition, since 2005 some banks have diversified their sources of funding by issuing senior long-term debt under Euro medium-term note (EMTN) programs to improve their funding position further.

26. **Market indicators suggest that bank soundness, after a substantial improvement since 2003, has deteriorated in 2007 and 2008 (See Figure 4).** Stock market indicators have recently dramatically weakened as a result of the latest turbulence in equity markets. The reaction has been very muted thus far, reflecting little apparent exposure to subprime mortgages, and continuing good return performance of Cypriot commercial banks. Nonetheless, the somewhat lower DD values in recent periods may reflect worries among market players that continued rapid loan growth may put capital ratios under pressure if the banks cannot maintain high levels of internal capital generation. The continuing market

[9] The use of market-based indicators is illustrated here on the DD, a measure derived from banks' stock prices. Results derived from bond prices are similar. There are no CDS data on the Cypriot banks.

turmoil may make it challenging for them to replicate strong operating results in the future. Ratings agencies consider the prospects for the main Cypriot commercial banks to be substantially positive for 2008, but also note that maintaining the current level of income generation is an important challenge, given to the changed economic conditions (Fitch Research, 2008b).

Figure 3. Banking Sector Stocks in Cyprus vs. EU Bank Average

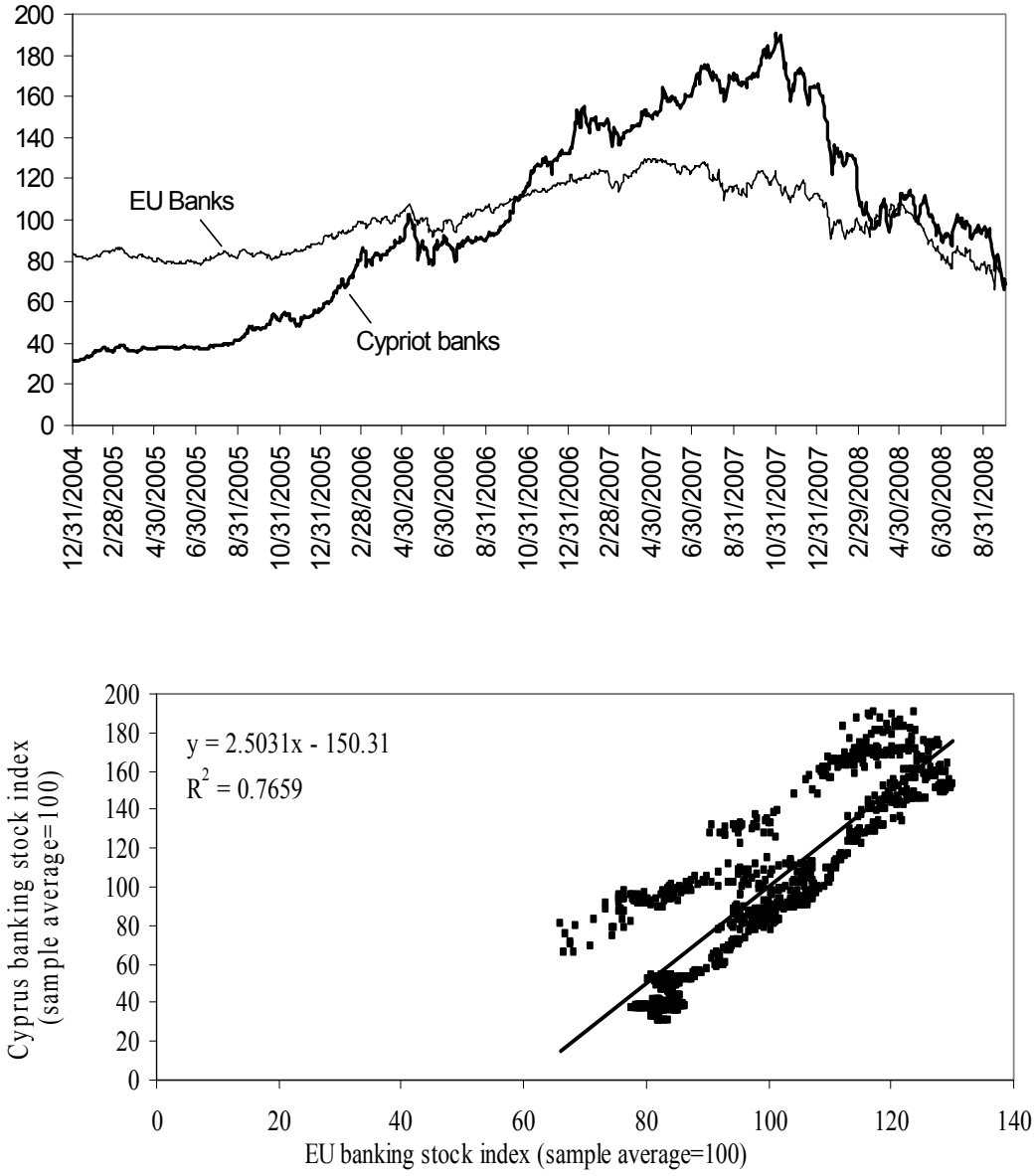
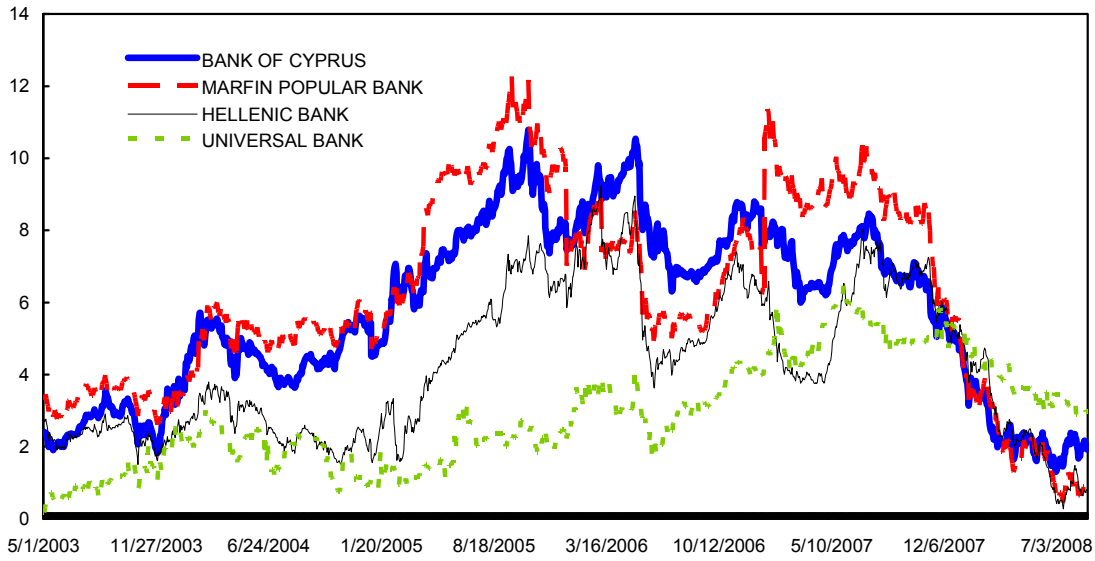
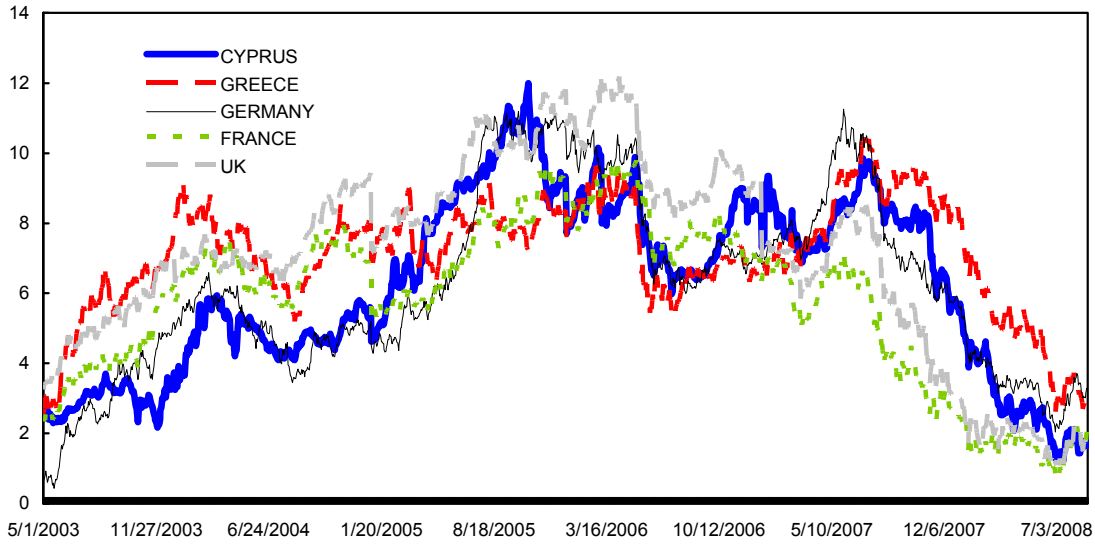


Figure 4. Cyprus: Bank Distance to Default Indicators

Individual Bank Distances to Default



Aggregate Bank Distances to Default 2/



Source: Datastream, and Bankscope; own calculations.
1/ Distance-to-default indicators measure the number of standard deviations from the default point.
2/ The DDs are computed on a portfolio of large banks in each country.

III. Analyzing Spillover Risks

A. GARCH Model

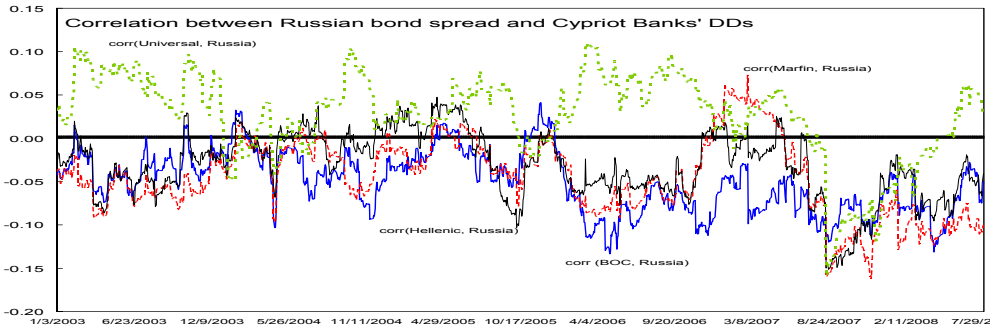
27. **Various dynamic conditional correlation GARCH models are adopted in order to investigate possible spillovers from other countries to Cyprus.** In one model, we have taken the DD measures of the four banks: the CBC, Marfin, Hellenic and Universal, and related them to the Russian bond spreads (Figure 5). The intuition was that the banks with a higher Russian exposure should be more sensitive to developments in Russia.

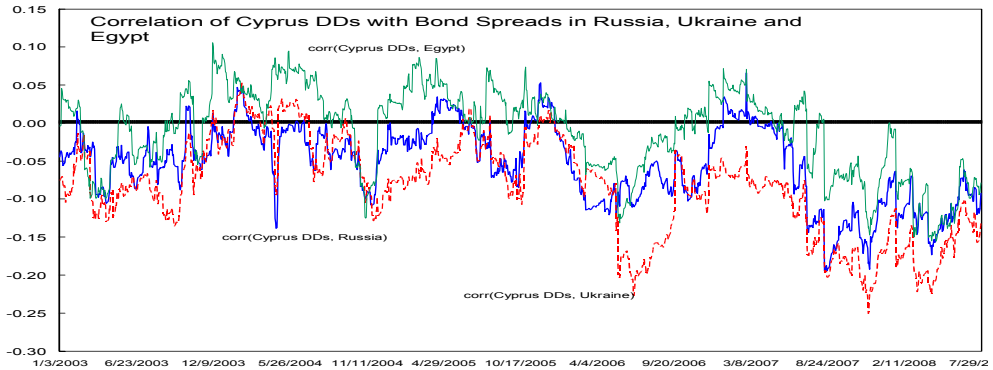
28. **Co-movements between the Cypriot banks' DDs, and the Russian bond spread increased during the onset of the financial turbulences last summer, even though overall correlation magnitudes are not very large.** Cypriot banks have large exposures to the Russian market, both in form of stakes in Russian banks and serving a large number of Russian corporate clients. Cyprus is also the largest intermediary for brokerage on the Russian stock exchange, with over 60 percent of volume going through Cyprus. During the summer of 2008, the implied correlations from the GARCH model were highest for the DDs of Marfin and the Russian bond spreads, followed by CBC and Hellenic. This is not surprising given Marfin's large engagement in Russia with a recent takeover of a Russian bank, which would make their DDs more sensitive to developments in Russia. In another similar GARCH model, the overall DDs of the Cypriot banks are related to bond spreads in Russia, Ukraine and Egypt (See Figure 5). As expected, co-movements with Russia and Ukraine are higher than with Egypt with correlation magnitudes hitting -0.20 to -0.25 at times during the financial crisis.

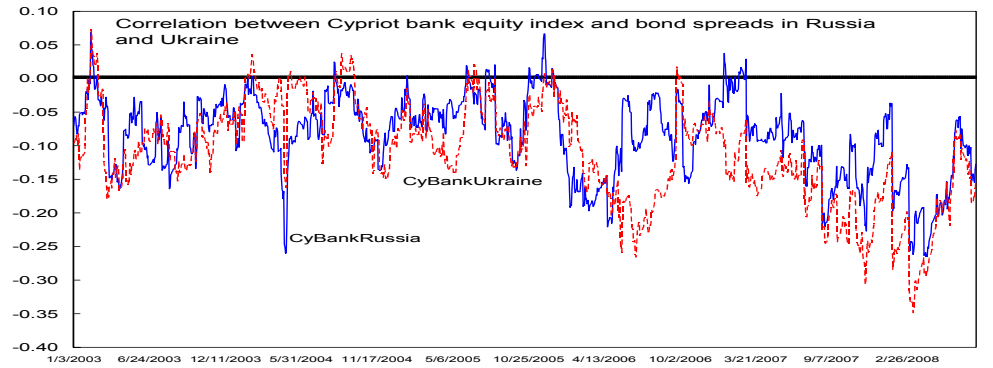
29. **As discussed above, Cyprus has been on the sidelines of the US-originated financial crisis with Cypriot banks having limited exposure to mortgage-backed securities in the U.S.** A GARCH model of the possible spillovers from the U.S. does not show any clear correlation break or increase between the Cypriot stock markets (overall and bank-specific) and proxies for US funding liquidity (U.S. Libor-OIS spread) and market liquidity (spread between 5-year on-the-run versus off-the-run spread).[10] This supports the fact that the funding liquidity capacity of Cypriot banks has not been sizably affected by problems in the wholesale funding market segments. Cypriot banks mainly rely on retail funding, and as net liquidity providers to the money markets have partially benefited from elevated interbanking rates. As cautionary measures, a few banks have also issued covered bonds in order to secure longer-term funding.

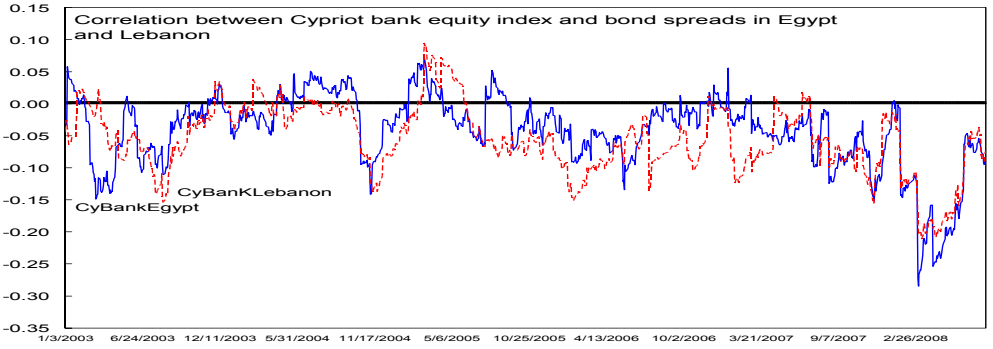
[10] The "on-the-run" treasury note is usually the most recently issued of a particularly liquid maturity and is used for pricing other assets. An on-the-run treasury bill becomes "off-the-run" when a new note is issued in that maturity bracket.

Figure 5. GARCH Model Results





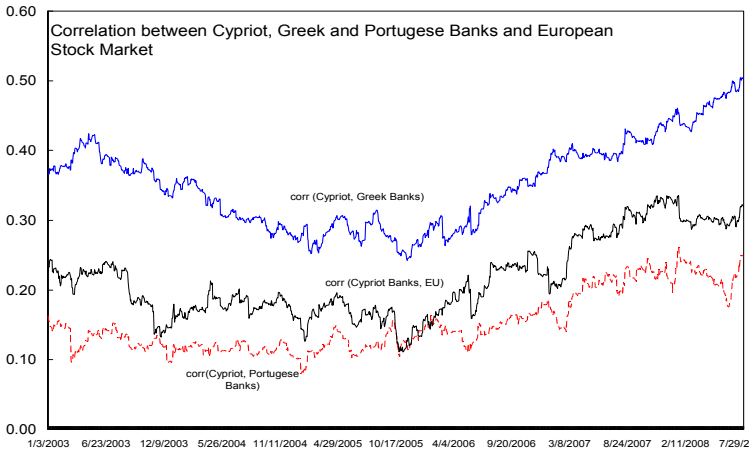




30. **An equity index of the Cypriot banking sector exhibits some increased co-movement with bond spreads in Russia and Ukraine during the recent financial market turbulences**, **which supports the above results on the Cypriot banks' DDs.**[11] In addition, correlations between the Cypriot banking index and the Egypt and Lebanon bond spreads increase significantly in the beginning of 2008. Within two months, the correlation between Cyprus and Egypt drops from zero to -0.30 and to -0.20 for Lebanon. Similar for Russia and Ukraine, higher co-movements are observed in this time period whereby the correlation decline for Ukraine is slightly more pronounced than for Russia. Comparing Russia/Ukraine with Egypt/ Lebanon indicates that co-movements tend to be higher for the former during the whole sample period from January 2003.

31. **The Cypriot stock market exhibits a higher co-movement with the European and U.K. stock markets than the corresponding U.S. market, as approximated by returns of the S&P 500.** There appears to be some overall increase of equity co-movement with Europe, proxied by the Eurofirst300 and U.K., approximated by the FTSE, in the past two years (graphs not shown). In other words, Cyprus is more affected by developments in Europe than the U.S. In addition, Figure 6 shows the co-movement between markets in Cyprus, Greece, Portugal and Europe. As expected, bank indices in Cyprus and Greece exhibit higher correlation, exceeding the one of Cyprus with the European index and Portuguese banks.

Figure 6. Bank Stock Correlations

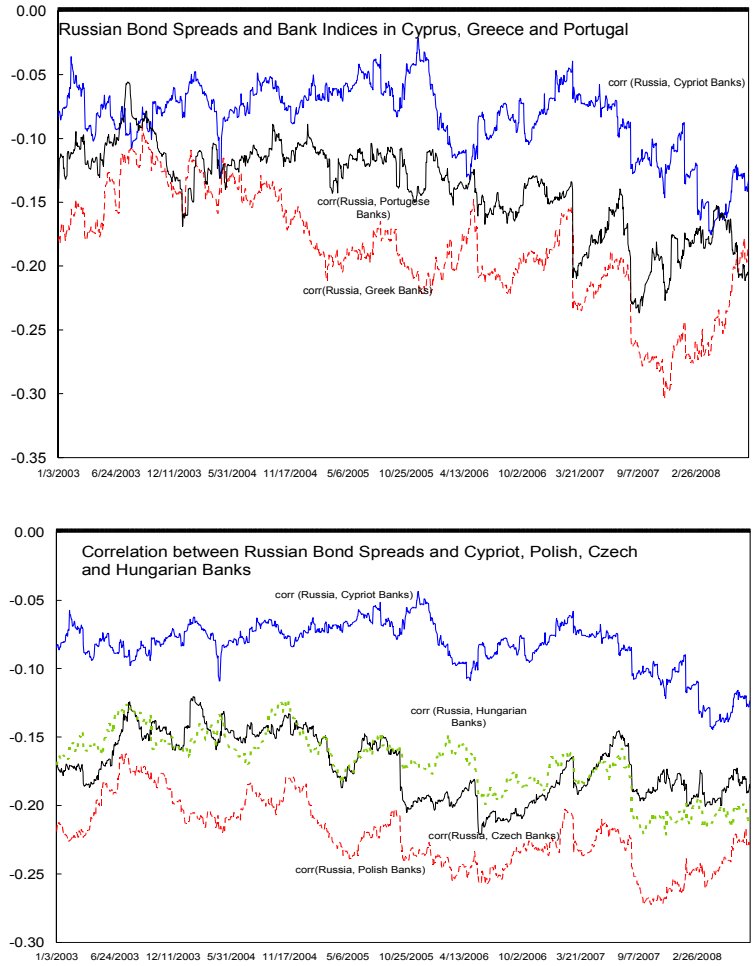


32. **A GARCH analysis of the possible spillovers from Russia to Cyprus and other Eastern European countries suggests that the impact on Cyprus has been relatively smaller.** Figure 7 presents the time-varying correlations between the Russian bond spread on

[11] In the analysis, we employ the Cypriot bank index instead of the overall stock market index. Given that the largest Cypriot banks dominate the stock exchange, the time-varying correlation between both are very high, almost close to 1 at times.

one hand and the bank indices in Cyprus, Greece, Portugal, Poland, Czech Republic, and Hungary on the other hand. It implies that the Cypriot bank index does not have as strong a co-movement with the Russian bond spread, as the other countries, as indicated in a lower negative correlation magnitude. It is not too surprising that some of the Eastern European countries such as Poland, Czech Republic and Hungary show more significant co-movements with the Russian bond spreads than Cyprus. One reason is that 90 percent of equity ownership is domestic with Russian investors not holding sizable stakes in domestic banks or companies, compared to other Eastern European countries. It is also possible that Cyprus as an international business center has been more isolated from the recent fallout during the subprime crisis.

Figure 7. Bank Stocks and Russian Bond Spreads

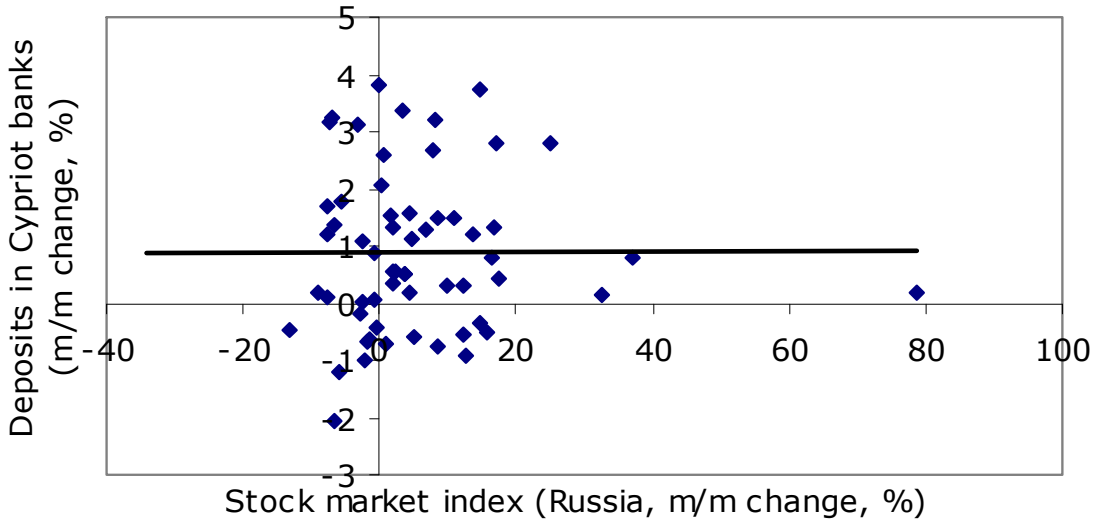


33. **To summarize the GARCH findings, Cyprus is not completely immune to spillovers emanating from the protracted fallout of the financial crisis.** The Cypriot stock market moves with markets in Greece and Europe while there is some negative co-movement with Russian spreads during times of stress, albeit smaller than of other Eastern European countries. A distance-to-default measure of the Cypriot banking sector also exhibits some

spillover potentials with bond spreads in Russia and Ukraine. Direct repercussions from the U.S. illiquidity spirals in the form of impaired funding and market liquidity were not found for Cypriot banks.

34. **Past experience suggests a lack of deposit withdrawal when problems abroad occur, even though that does not necessarily have to hold in the future.** Cyprus benefited from its reputation of being considered a "safe heaven," and based on past observations (Figure 8), there is little evidence that stock markets in Russia and Ukraine move in tandem with deposit balances. However, as highlighted by the ongoing global financial crisis, confidence in the banking system is crucial, and rumors can distort the state of the financial system. Also, the relationship between financial conditions and deposit withdrawals may be highly nonlinear, which can be highlighted by a crisis. In this context, the CBC's conservative liquidity ratio has served the banks well.

Figure 8. Russian Stock Market vs. Deposits in Cypriot Banks



B. Spillover Risks Among Individual Banks: Co-Exceedance Analysis

35. **Market-based indicators can also be used to examine the spillover risks among financial institutions, a topic of practical relevance for financial stability analysis and supervision.** To illustrate this, two questions were analyzed: (i) to what extent are large Cypriot banks exposed to market-wide shocks, affecting all of them simultaneously; and (ii) what is the scope for spillover of idiosyncratic shocks from one bank to other banks. The scope for spillovers among the Cypriot banks was examined using the Extreme Value Theory framework. The methodology is characterized as follows:[12]

[12] The approach is similar to that of Čihák and Ong (2007), which provides the methodology in detail.

- The data sample comprised the five large Cypriot banks, accounting for 95 percent of total Cyprus banking system assets. The sample period was 1999–2007.

- To determine the spillover risk, a binomial logit model is applied to the DD data. The method examines the likelihood that a sizeable negative idiosyncratic shock experienced by a large Cypriot bank would be followed by a similarly sizeable shock experienced by another large Cypriot bank. Following the literature, such an event is called "co-exceedance," and "sizeable" is defined as the bottom 10 percent tail of the distribution of all five trading-day changes in DDs .

- Four control variables were used to account for common shocks affecting the local real economy, and domestic, global, and European markets. The calculations incorporate changes in the slope of the local term structure to represent developments in the domestic real economy; the stock price return volatility in the domestic stock market index to capture local market influences; the price return volatility in the Morgan Stanley Capital International All-Country World Index and European Index returns to account for global and European market shocks, respectively.

- The objective is to identify potential risk concentrations among Cyprus's systemically important banks, by distinguishing between the impact of common and idiosyncratic shocks. These calculations do not explore the exact nature of the links among financial institutions. Those may reflect direct financial links through the interbank market, but there may be spillovers even in the absence of explicit financial links between banks. In the presence of asymmetric information, difficulties in one bank may be perceived as a signal of possible difficulties in others, especially if market participants perceive opacity in banks' balance sheets, and other publicly available data may be uninformative (Morgan, 2002).

36. **The results suggest that the spillover risks are spread far from evenly among the large Cypriot banks and the largest spillovers occur from Greek banks (Table 9).** Cypriot bank DDs respond strongly to large movements in DDs for Greek banks. Cypriot banks are also exposed to some banks from other EU countries, but to a much lesser degree. The results also indicate that shocks emanating from Cypriot banks do not materially impact the Greek banks. This suggests that vulnerabilities for Cypriot banks from any Greek banking problems could be substantial especially since some Greek subsidiaries operate in Cyprus. As shown in the GARCH modeling, bank equity prices in Cyprus and Greece exhibit very high co-movements so the equity market could act as a possible financial channel of transmission. Other channels could come from a loss of confidence that could suddenly spillover to Cyprus, even if Cypriot fundamentals are considered sound.

IV. Assessing Sensitivity to Shocks: Stress Testing

37. **A set of basic stress tests was performed to assess the resilience of the banking sector to a variety of potential shocks.** The purpose of these tests was to examine the potential effects on banks' financial condition of a set of changes in risk factors, corresponding to a range of adverse events. The shocks can be considered extreme but with a positive, albeit small, probability of occurrence. The tests are based solely on publicly available data, which limited the extent of possible stress tests, and required a number of simplifying assumptions. Moreover, past data may capture only partly the type of extreme events that might happen in the future. The stress testing analysis therefore had to rely on a combination of experience from other countries, expert judgment, and sensitivity analysis. Therefore, the results should only be treated as approximations.

Table 9. Co-Excedance Analysis, 1999–2007

("1" indicates that the bank in the column experienced significant "co-excedances" in response to shocks originating from to the bank in the row)

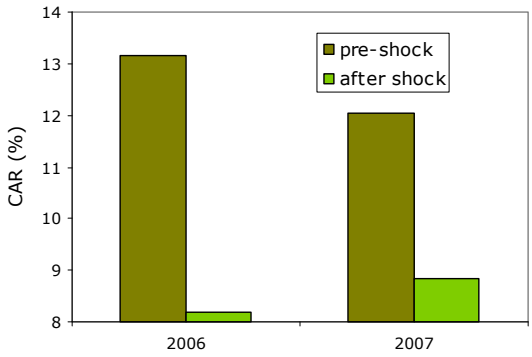
		BOC	Marfin	Hellenic	Universa	SYSTEM
CYPRUS	BANK OF CYPRUS		1			1
	MARFIN POPULAR BANK	1				1
	HELLENIC BANK					
	UNIVERSAL BANK					
	CYPRUS SYSTEM	1	1			
BELGIUM	DEXIA					
	FORTIS (BRU)					
	KBC BKVS.HDG.					
	BELGIUM SYSTEM					
FRANCE	BNP PARIBAS	1				
	CREDIT AGRICOLE	1				
	SOCIETE GENERALE					
	FRANCE SYSTEM					
GERMAN	BANKGESELLSCHAFT					
	BAYER.HYPO-UND-V					
	COMMERZBANK	1				
	DEUTSCHE BANK					
	GERMANY SYSTEM					
GREECE	ALPHA BANK					
	BANK OF GREECE	1	1			
	BANK OF PIRAEUS	1		1		
	EFG EUROBANK ERG					
	EMPORIKI BK.OF G					
	NAT.BK.OF GREECE	1		1		1
	GREECE SYSTEM	1	1	1		1
ITALY	UNICREDITO ITALIANO					
	BANCA INTESA					
	BANCA MONTE DEI PASCH					
	ITALY SYSTEM			1		
NETHERL	ABN AMRO HOLDING					
	FORTIS (AMS)					
	NETHERLANDS SYST					
	NETHERLANDS SYSTEM					

38. **The tests combined single-factor sensitivity calculations and scenario analysis.** The single-factor scenarios are useful since they are simple and allow analysis of the partial impacts of the various shocks over time. The macroeconomic scenarios allow to reflect better the interplay of the numerous risk factors, all influenced by macroeconomic developments.

39. **The tests also combined top-down and bottom-up approaches.** Two sets of top-down stress tests have been carried: one by the CBC staff, based on supervisory data, and one by the FSAP team, using publicly available financial data. In addition, a bottom-up stress testing exercise performed by individual banks' risk managers has been organized. The results of the two top-down exercises and the bottom-up exercise have been cross-checked for consistency, and discrepancies were discussed in meetings between the FSAP team, the authorities, and individual bank representatives.

A. Sensitivity Analysis

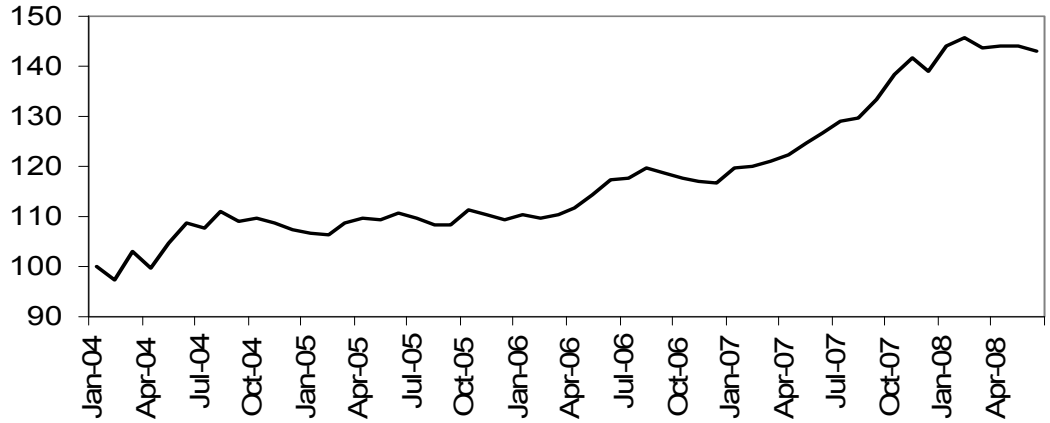
40. **Sensitivity analysis confirms that credit shocks had a large and more widespread potential impact on banks than any other single-factor shock, and that the impact of credit risk has declined.** Analyses of the impact of a range of single-factor shocks to credit risk (i.e., general deterioration in credit quality) were carried out by the FSAP team, by the CBC, and by a subgroup of large banks. The results of the tests suggest that credit shocks had a large and more widespread potential impact on banks than other single-factor shock; the impact of credit risk has declined, but only marginally. The text chart shows the results of one of the tests, namely one based on CBC's calculations, and assuming that NPLs double and that loss-given-default equals 75 percent.



41. **Property prices have seen a recent leveling off according to the widely used BuySell index.** Since the inception of the index in January 2004, it has sharply risen until January 2008 after which a stagnation set in (Figure 9). Given its focus on vacation homes in the tourism sector, the BuySell index does not fully reflect real estate developments in Cyprus. Nonetheless, with the U.S. originated financial crisis fully hitting the European banking system and also spilling over into a reduction in growth rates in Europe, Cyprus will not be fully immune to these developments. For instance, a lower vacation home demand from the U.K. is likely given their domestic housing problems. A slowing in the rate of property price increases might be a healthy development to avert any possible overheating but will also impact the credit risk of domestic banks going forward.

Figure 9. Cyprus: Real Estate Prices, 2004–08

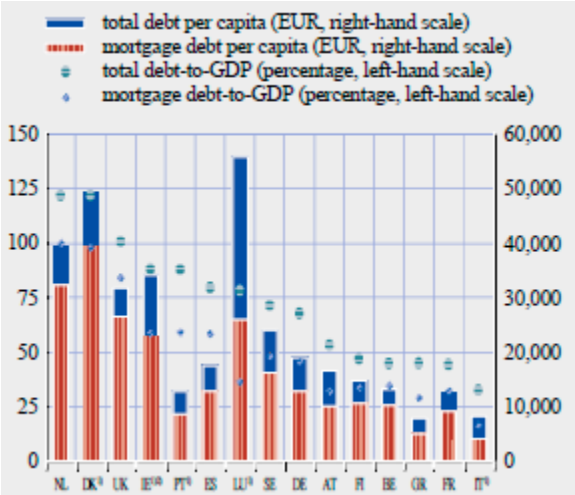
(Index, January 2004=100)



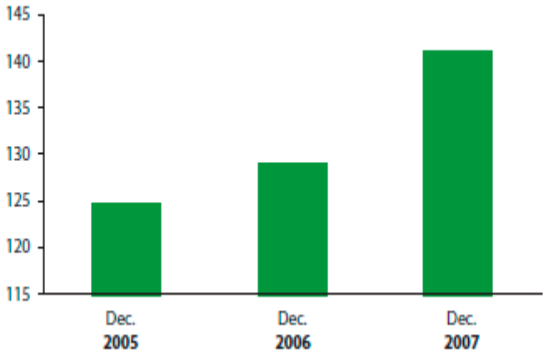
Source: BuySell.

42. **A cross-country comparison within Europe shows that Cyprus has one of the highest household debt-GDP ratio which could potentially impact on credit risk of banks (Figure 10).** The household indebtedness of Cyprus stood at 140 percent to GDP by the end of December 2007 compared to 129 percent in 2006. This ranks Cyprus among the most household indebted countries in Europe where the average ratio was 60 percent in 2006. Countries such as Ireland, Portugal and Spain had household debt-to-GDP ratios of between 80-90 percent while Greece was around 50 percent in 2006. Only Netherlands and Denmark came close to Cyprus with ratios over 120 percent in 2006. Cyprus's high level of household indebtedness significantly exposes it to adverse real estate shocks and could impact its household debt serving capacity should real estate prices substantially decline. In such a scenario household net worth as well as the collateral value would suffer which in turn exposes banks to higher credit and collateral risk. Regulation on mortgage lending has been tightened in recent time with the maximum LTV ratio changed to 80 percent for first-home buyers and 70 percent for vacation home. This provides some buffer against property price declines.

Figure 10. Household Debt-to-GDP Ratios

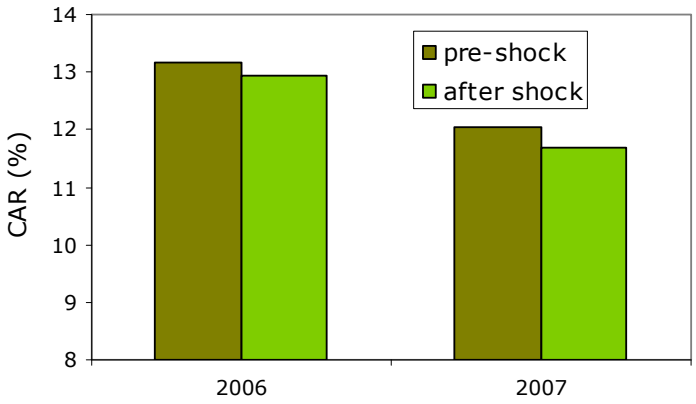


Source: ECB (2007); data for 2006.



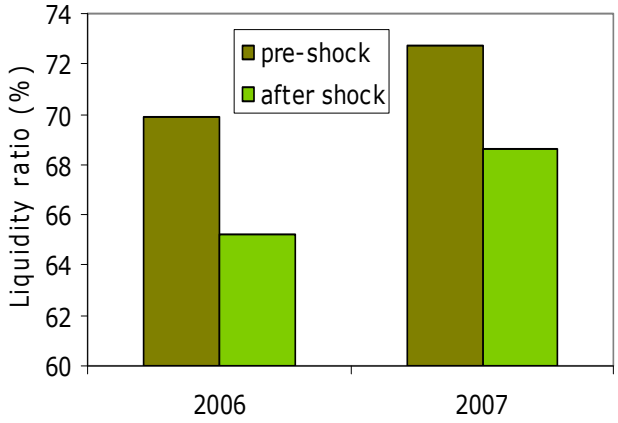
Source: Central Bank of Cyprus (2008)

43. **For market risks, a range of sensitivity tests were carried out.** For exchange rate risk the tests evaluated the direct (i.e., market price) effects on Cypriot banks of a 15 percent and 30 percent depreciation and appreciation of the euro against all other currencies. Direct losses arising from exchange rate shocks are negligible for most banks, reflecting their very small net open positions in foreign exchange. Even the indirect exchange rate risk (i.e., the impact of exchange rate changes onto credit risk) appears manageable. This is illustrated by the text chart, which illustrates the indirect exchange rate risk stress test, based on the assumption that the exchange rate depreciates by 50 percent against all other currencies, 5 percent of foreign exchange loans become nonperforming, and require 50 percent provisioning. The impact of interest rate changes on banks' soundness is also relatively small. Generally, an increase in interest rates improves banks' situation as their asset size reprices more quickly than their liabilities.[13] Banks' exposure to stock prices is very small, reflecting the reduction in their exposures after the stock price bubble of the early 2000s.



[13] For example, most of the mortgage loans are flexible and linked to the Euribor rates.

44. **Stress tests for liquidity risk confirm that the banks would be able to withstand substantial liquidity drain before requiring emergency liquidity support.** The mechanism of the test was a deposit outflow; the question being asked was how long a bank can survive without borrowing from the central bank or from other banks in the system on an uncollateralized basis. The results of the deposit liquidity stress tests suggest that liquidity buffers are reasonably high in banks. The text chart (based on CBC's calculations) illustrates the liquidity ratio impact of an extreme scenario assuming that 30 percent of all demand deposits are being withdrawn, the banks can use only their liquid assets, and have no recourse to other banks or to the lender of last resort. These sensitivity tests only looked at liquidity shocks from the liability side. During times of stress, as currently observed, the liquidity of even "safe" assets can suddenly evaporate and would magnify the impact from any severe deposit outflow scenario.



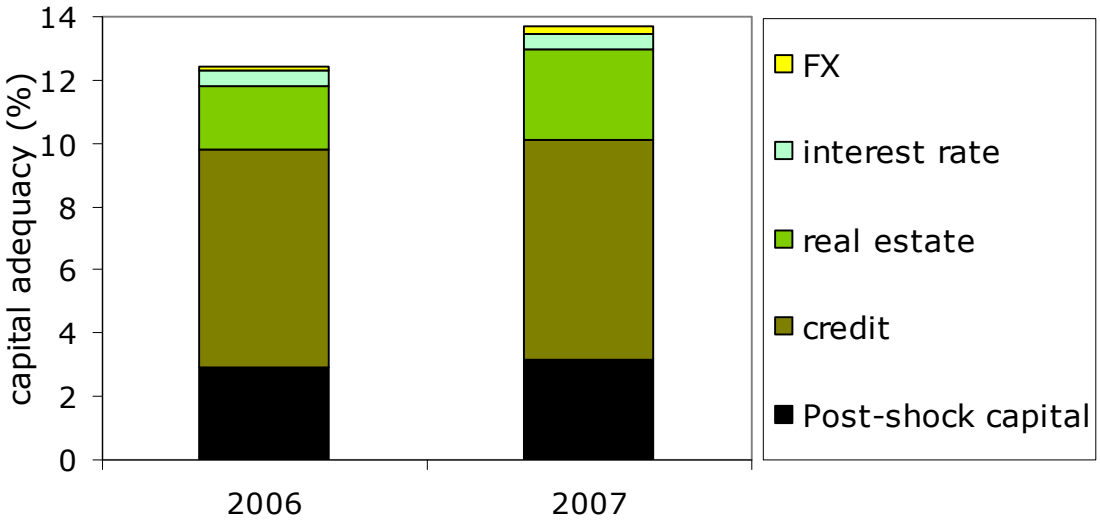
45. **Counterparty risk to financial institutions.** Since the onset of the financial crisis in the summer of 2007, interbanking markets both in the U.S. and Europe have been put under strains with severe dislocations at times. In Europe, the ECB injected liquidity both through their usual main refinancing operations as well as through long-term refinancing operations and dollar liquidity in coordination with the Fed. Besides liquidity risk, *counterparty risk* became the main reason why banks were reluctant to lend to each other and hoarded liquidity due to the uncertainty with regard to the mortgage exposure of counterparties and the inability to value their respective assets. The main Cypriot banks have been on the sidelines of the financial turmoil given their limited exposure to asset-backed securities and their reliance on retail deposits for funding instead of the wholesale interbank market or the securitization market. They have been net lenders to the European interbank market and during the most severe dislocations only lent overnight and at short maturities (e.g., one week). Some of the banks currently view counterparty risk as a main risk given their exposures to European financial institutions (e.g., bond investments). According to data from the CBC, 12 billion euros are invested in European banks and 9.8 billion euros are in the rest of the world. Lending to counterparties in the money market mainly occurs to larger financial institutions that are deemed safe. There are also some plans to migrate matured bond investments to these larger financial institutions in the future in order to reduce counterparty risk.

B. Scenario Analysis

46. **Scenario analysis focused on several combinations of shocks.** The single-factor sensitivity calculations summarized above are only approximate, as individual shocks would most likely be accompanied by a broader macroeconomic stress that would impact banks also through channels other than just their direct exposures to market risks. This is addressed in scenario analysis, which considers how capital account shocks would affect the economy against a background of rising macro-financial linkages. While the scenarios have been informed by Cyprus's recent experience, relationships that worked in the past generally break down during times of dislocation. Accordingly, these scenarios draw on the experience of a wide number of countries that have undergone similar exceptional scenarios.

47. **The scenario analysis indicates that banks' exposures remained broadly unchanged between 2006 and 2007, and that a combination of shocks could have substantial impact on banks' capitalization.** Figure 11 shows the results of one extreme scenario, which combines an increase in NPLs by 100 percent, a real estate price decline by 30 percent, a decline in interest rates by 200 basis points, and an exchange rate depreciation by 30 percent. The results, aggregated from the results reported by the four large banks, show that under such a scenario, the aggregate capital adequacy would decline to about 3 percent both in 2006 and 2007, and capital injections equivalent to about 4 percent of GDP would be needed to ensure that all banks satisfy the minimum CAR of 8 percent.

Figure 11. Cyprus: Scenario Stress Test Results, 2006–07



V. Recommendations for Further Work on Financial Stability

48. **The CBC has created a dedicated Section that covers financial stability issues.** The Financial Stability Section at the CBC covers an impressive range of issues, from the

collection of statistical, market and banking sector data, the compilation of macro-prudential indicators, FSIs and other indicators to writing a regular analysis of financial stability in the semi-annual CBC Economic Bulletin. The Financial Stability Section also carries out secretariat duties for the National Financial Stability Committee as well as the Management Committee of the Deposit Protection Scheme. Recognizing the importance of stress testing for the financial sector stability framework, the unit has also started carrying out top-down stress tests of the banking system (focusing on sensitivity analysis of credit risk, basic market risks and liquidity risk), and, as part of preparations for the FSAP, coordinated a bottom-up stress testing exercise with major banks..

49. **We recommend to build on this work by further strengthening capacity in the Financial Stability Section, and formalizing its cooperation with banking supervisors.** Given the mandate and tasks involved, the current number of staff is insufficient to effectively carry out all the planned activities. The Financial Stability Section should be strengthened with additional suitably qualified graduate staff who will contribute towards the analysis of financial stability. In addition, additional staff that deal with data collection on various fronts would enable existing staff to focus on more analytical tasks such as stress testing and financial stability policy work. Also, to better integrate CBC's micro- and macro-prudential work, cooperation between the Financial Stability Section and the Banking Supervision and Regulation Division could be formalized.

50. **Including sensitivity tests on counterparty risk into the stress testing exercise (both top-down and bottom-up) would help to provide information about the resilience of Cypriot banks on this particular shock.** As mentioned above, Cypriot banks have sizable exposures to other European banks and elsewhere (e.g., bond investments). European banks are highly connected through, for instance, the money market, payment system and bond investments so counterparty risk becomes especially important during the current financial turmoil. In light of the turmoil in financial markets, the CBC should monitor developments in banks' liquidity (both assets and liabilities) with extra care and high frequency. Not only is depositor confidence at this point volatile, but previously liquid assets see their markets drying up rapidly, not least because counterparty risk is currently at all-time highs. Also, foreign subsidiaries may need to transfer liquid assets to their parent bank because of liquidity pressures at the group level. Related, the CBC should conduct an exercise how much of balance sheets of local banks could in principle be refinanced by the ECB under normal circumstances and appropriate haircuts. In other words, what is the degree of comfort under an extreme scenario that Cypriot banks should become net borrowers instead of currently being net lenders to the European money market.

51. **Further improvements in the stress testing framework and data collection would help CBC's perform its financial stability function better.** The following is a list of specific recommendations:

- Issue specific guidelines to banks on stress testing, with a view to monitoring stress test results in major banks on a systematic basis.(medium term). Based on discussions between the CBC and the FSAP team, banks have been already informed via a circular at the beginning of the bottom-up stress testing exercise that hereafter they would have to perform the stress tests on a quarterly basis and the results would have to be submitted to the CBC. The regular stress testing will follow the assumptions of the exercise while shocks and scenarios will be reviewed and modified in the future according to the prevailing economic and market conditions.

- Develop an off-site early warning system model for banks that could be compared with stress testing results (short term)

- Develop tests for financial contagion of banks, non-banks, insurance companies (medium term)

- Collect more comprehensive data on real estate prices (short term). The CBC is already compiling its own residential property valuation index which will be revised and enhanced in the short-term. A commercial property valuation index will also be compiled by the CBC soon. The Statistical Service of the Republic is in the final stages of compiling its own residential property price index based on a methodology approved by Eurostat.

- Conduct regular scenario analysis top-down stress tests, in addition to the existing sensitivity analysis (medium term)

- Work with the Statistical Service of the Republic to compile (in a cost-efficient manner) reliable data on household debt service to income ratios (short term). Also, for financial stability purposes, collecting disaggregated data on household assets, liabilities and income through a household survey would be useful (medium term). Contrary to macro data, such micro data would allow for more detailed distributional analyses that better capture tail risks.

- Consider an implementation of the suggestions for improvements in credit risk modeling detailed in Appendix V. In particular, implement a simplified credit risk VaR to better assess credit risk at the system-wide level (medium term)

VI. CONCLUSIONS

52. **Market-based indicators provide a useful additional dimension to the analysis of financial stability in Cyprus.** The indicators paint a more mixed picture of recent financial stability developments than the accounting ratios, which is most likely a reflection of the market assessment of challenges and risks associated with the recent reforms. In a cross-country comparison, the indicators place Cyprus's banking system close to the average of

advanced and emerging countries, which is in line with the assessment based on accounting ratios and rating agencies' ratings. The market-based indicators also allow to identify spillover risks among major Cypriot banks; the key finding from this calculation is that the spillover risks are far from evenly distributed among the banks.

53. **The basic stress tests suggest that resilience of the Cypriot banking system has improved in recent years.** A comparison over time shows that the capital injections needed to bring all banks in compliance with the minimum capital adequacy requirements have been declining appreciably over time. This reflected a combination of increasing buffers (improving capitalization and profitability) with generally decreasing stock market exposures.

54. **The spillover analysis highlights the close ties between the Cypriot financial sector and the rest of the world.** Cyprus has been on the sidelines of the US-originated financial crisis with Cypriot banks having limited exposure to mortgage-backed securities in the US. However, we find that the key financial market correlations sharply increase during the onset of the financial turbulence since summer 2007, and an equity index of the Cypriot banking sector exhibits strong co-movement with bond spreads in Russia and Ukraine during the recent financial market turbulences.

55. **The stress tests confirm credit risk as the main source of risk.** Banks' exposures to direct interest rate risk are limited, as most of banks' loan book is in floating rates, and the duration of banks' trading portfolios is relatively short. Banks also have low direct exchange rate risk, reflecting their relatively low foreign exchange positions, and their exposures to equity risk are moderate. Banks are liquid at present, which was reflected in positive results of tests of the impact of sudden withdrawals.

56. **We suggests further strengthening of the Financial Stability Section at the CBC**. The Section carries out very important work. Strengthening it includes both allocating more resources (so that it can carry out in-depth analysis of the financial sector data) as well as putting on a firmer footing its cooperation with bank supervision.

APPENDIX I: Z-SCORE AND MARGIN ANALYSIS

Z-Score Analysis

1. **The primary dependent variable is the z-score as a measure of individual bank risk. The z-score has become a popular measure of bank soundness (see Hesse and Cihak, 2007).** Its popularity stems from the fact that it is directly related to the probability of a bank's insolvency, i.e., the probability that the value of its assets becomes lower than the value of the debt. The z-score can be summarized as $z \equiv (k+\mu)/\sigma$, where k is equity capital as percent of assets, μ is average after-tax return as percent on assets, and σ is standard deviation of the after-tax return on assets, as a proxy for return volatility. The z-score measures the number of standard deviations a return realization has to fall in order to deplete equity, under the assumption of normality of banks' returns. A higher z-score corresponds to a lower upper bound of insolvency risk—a higher z-score therefore implies a lower probability of insolvency risk.[14]

2. **First, a decomposition of observed differences in z-scores into the underlying factors (capitalization, returns, and volatility of returns) is undertaken followed by regressions of z-scores on a number of explanatory variables.** We estimate a general class of panel models of the form

$$z_{i,j,t} = \alpha + \beta B_{i,j,t-1} + \gamma I_{j,t-1} + \sum \delta_s T_s + \sum \phi_s T_s I_{j,t-1} + \sum \varphi_s T_s B_{i,j,t-1} + \varpi M_{j,t-1} + \sum \lambda_j C_j + \sum \pi_t D_t + \varepsilon_{i,j,t}$$

where the dependent variable is the z-score $z_{i,j,t}$ for bank i in country j and at time t; $B_{i,j,t-1}$ is a vector of bank-specific variables; I_{jt-1} are time-varying banking industry-specific variables in country j; T_s, $T_s I_{j,t-1}$ and $T_s B_{i,j,t-1}$ are the type of banks and the interaction between the type and some of the industry-specific variables as well as bank-specific variables, respectively; $M_{j,t}$, C_j, and D_t are vectors of macroeconomic variables, country, and yearly dummy variables, respectively; and $\varepsilon_{i,j,t}$ is the residual.

3. **To distinguish the impact of country on the z-score, we include country dummy variables.** For example, the Cyprus dummy variable takes the value of 1 if the country in question is Cyprus, and 0 otherwise; The other country dummy variable is Portugal. If banks in Cyprus are relatively weaker than banks in the benchmark country Greece, the sign of the Cyprus dummy variable would be negative.

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[14] For banks listed in liquid equity markets, a popular version of the z-score is distance-to-default, which uses stock price data to estimate the volatility in the economic capital of the bank (Denmark National Bank, 2004). For most cooperative banks, however, market price data are not available. This paper therefore relies on the specification of the z-score that relies only on accounting data.

4. T**he regression also includes a number of other control variables, both on individual bank level and on country level.** To control for bank-level differences in bank size, asset composition, and cost efficiency, we include the bank's asset size in billions of U.S. dollars, loans over assets, and the cost-income ratio. Also, to control for differences in structure of banks' income, we calculate a measure of income diversity which implies the degree to which banks diversify from traditional lending activities (those generating net interest income) to other activities. Controlling for these variables is important because there are differences in these variables between cooperative banks and the other groups.

5. **On the country level, we also adjust for the impact of the macroeconomic cycle by including GDP growth and inflation.** To account for cross-country variation in z-scores caused by differences in market concentration, we include the Herfindahl index, defined as the sum of squared market shares (in terms of total assets) of all banks in the country.

Margin Analysis

6. **We investigate which bank-specific and macroeconomic characteristics are the main drivers for the margins in Cyprus, Greece and Portugal.** A simple panel data model for the margins is estimated (see also Beck and Hesse, 2008):

$$M\arg in_{i,t} = \alpha + \beta B_{i,t} + \gamma M_t + \varepsilon_{i,t}$$

where i indexes bank i and t indexes time t; $B_{i,t}$ is a vector of bank-specific variables for bank i and time t; M_t is a vector of time-variant macroeconomic variables, and $\varepsilon_{i,t}$ is the residual. Finally, we control for year effects by including yearly dummy variables except when incorporating macroeconomic variables into the model.

7. **The dependent variable is the net interest margin in a percentage of earning assets.** As bank-specific variables we use *overhead* as the ratio of overhead costs to total assets and anticipate that a higher overhead leads to higher spreads since banks usually pass on these costs to the borrowers. In addition, *liquidity* is defined as liquid assets over deposits, and the equity/ assets ratio is also employed. Finally, we account for potential effects of macroeconomic developments by including GDP growth and inflation.

APPENDIX II: GARCH METHODOLOGY

8. **The estimation presented below is conducted within a multivariate GARCH framework, which takes the heteroskedasticity exhibited by the data into account, in addition to providing the natural interpretation of the conditional variance as a time-varying risk measure.** In this context, the Dynamic Conditional Correlation (DCC) specification by Engle (2002) is adopted, which provides a generalization of the Constant Conditional Correlation (CCC) model by Bollerslev (1990). These econometric techniques allow us to analyze the co-movement of markets by inferring the correlations of the changes in the interested variables. Frank, Gonzalez-Hermosillo and Hesse (2008) apply this methodology to the subprime crisis.

9. **The DCC model is estimated in a three-stage procedure.** Let r_t denote an *n x 1* vector of asset returns, exhibiting a mean of zero and the following time-varying covariance:

$$\begin{aligned} & r_t \mid \Im_{t-1} \sim N\left(0, D_t R_t D_t\right) \\ & \text{where } D_t = diag\left\{\sqrt{h_{it}}\right\} \end{aligned} \tag{1}$$

Here, R_t is made up from the time dependent correlations and D_t is defined as a diagonal matrix comprised of the standard deviations implied by the estimation of univariate GARCH models, which are computed separately, whereby the i^{th} element is denoted as $\sqrt{h_{it}}$. In other words in this first stage of the DCC estimation, we fit univariate GARCH models for each of the five variables in the specification. In the second stage, the intercept parameters are obtained from the transformed asset returns and finally in the third stage, the coefficients governing the dynamics of the conditional correlations are estimated. Overall, the DCC model is characterized by the following set of equations (see Engle, 2002, for details):

$$\begin{aligned} D_t^2 &= diag\left\{\omega_i\right\} + diag\left\{\kappa_i\right\} \circ r_{t-1} r_{t-1}' + diag\left\{\lambda_i\right\} \circ D_{t-1}^2 \\ \varepsilon_t &= D_t^{-1} r_t \\ Q_t &= S \circ (\iota\iota' - A - B) + A \circ \varepsilon_{t-1}\varepsilon_{t-1}' + B \circ Q_{t-1} \\ R_t &= diag\left\{Q_t\right\}^{-1} Q_t diag\left\{Q_t\right\}^{-1} \\ S &= E\left[\varepsilon_t \varepsilon_t'\right] \end{aligned} \tag{2}$$

Here, S is defined as the unconditional correlation matrix of the residuals ε_t of the asset returns r_t. As defined above, R_t is the time varying correlation matrix and is a function of Q_t, which is the covariance matrix. In the matrix Q_t, ι denotes a vector of ones, A and B are square, symmetric and ∘ is the Hadamard product. Finally, λ_i is a weight parameter with the contributions of D_{t-1}^2 declining over time, while κ_i is the parameter associated with the squared lagged asset returns.

10. **For the analysis, daily data from January 2003 until the end of July, 2008, were used.** In addition, the variables are first-differenced.

APPENDIX III: CALCULATING CO-EXCEEDANCES

11. **We begin by calculating the DD measure for individual banks, which is based on the structural valuation model of Black and Scholes (1973) and Merton (1974).** An exposition of the method is detailed in Čihák and Ong (2007). We find that the DDs across banks exhibit some common trends over time, which suggests that they are also likely to be exposed to common shocks, in addition to idiosyncratic ones. Next, we derive the changes in DD (we denote the percentage change in the DD as "ΔDD") from the generated series of DDs. We calculate the weekly (5 trading-day) ΔDDs, on a daily basis, for the following reasons: (i) extreme events are more significant if they are prolonged; events that last for only a day are of little concern; (ii) the use of weekly changes reduces "noise" in the data.[15] The ΔDDs are derived as follows:

$$\Delta DD_{it} = \frac{DD_{it} - DD_{it-5}}{| DD_{it-5} |}. \quad (1)$$

We then rank all ΔDD_{it} observations across all banks in our sample, and calculate the threshold, T_{10}, for the bottom 10 percent tail of the common distribution, which we define as "exceedances" or "extreme values". The threshold for the 10th percentile left tail is calculated at −0.016 (Figure 2). The 10 percent tail is a value commonly used in the literature.

Co-Exceedances

12. **A "co-exceedance" is defined as the probability that a particular bank will experience a large negative shock as a result of shock to another bank in the sample, after controlling for common shocks.** The exceedances for each bank *i* at time *t* are defined as binary variables, y_{it}, such that:

$$y_{it} = 1 \text{ if } \Delta DD_{it} < T_{10}, \text{ and 0 otherwise,} \quad (2)$$

where T_{10} is the 10th percentile threshold in the left tail of the distribution (Figure 4). As mentioned earlier, this threshold is commonly used in the existing literature. The co-exceedances reflect all potential spillover channels, without defining explicit links between banks or specifying a particular channel of contagion.

[15] Stock price returns exhibit day-of the-week effects (Chang, Pinegar, and Ravichandran, 1993; French, 1980; Jaffe and Westerfield, 1985; and Lakonishok and Smidt, 1988), while non-synchronous trading effects related to the overnight or weekend non-trading periods impact the calculation of daily close-to-close returns (Rogalski, 1984), effects of which could be "smoothed" using weekly data.

13. **We estimate the conditional probability that bank *i* will be in distress at time *t* conditional on bank *j* ($j \neq i$) being in distress, after controlling for other country-specific and global factors,**

$$\Pr(y_{it} = 1 \mid x, \beta) = \frac{e^{\alpha_i F_{it} + \sum_{s=1}^{5} \rho_{si} C_{it-s} + \gamma_j \sum_{j=1}^{B} C_{jt-1}}}{1 + e^{\alpha_i F_{it} + \sum_{s=1}^{5} \rho_{si} C_{it-s} + \gamma_j \sum_{j=1}^{B} C_{jt-1}}}, \quad (3)$$

which is based on the cumulative distribution function for the logistic distribution. On the left hand side, *x* represents the explanatory variables *F* and *C*, and β represents the slope coefficients α, ρ, γ. The parameter α represents the sensitivity of bank *i* to "common shocks," i.e., real and financial developments in its own country as well as in the European and global markets (F_{it}); ρ represents the sensitivity of bank *i* to extreme shocks it has experienced itself in the previous periods of up to *s* lags (C_{it-s});[16] and γ represents the sensitivity of bank *i* to extreme shocks experienced by the rest of the banks in the sample during the previous period (C_{jt-1}, where $j \neq i$), or in other words, the "co-exceedance" of bank *i* with other banks in the sample. All the *C* variables are lagged by one period to capture the impact on bank *i* from developments in the other banks.[17] The goodness of fit is given by the McFadden R^2.

Common Shocks

14. **This sub-section describes how we have calculated the "common shocks" (F_{it}), introduced in equation (3).** These shocks reflect the real and financial developments in each bank's country as well as in the European and global markets, which are denoted $F_{it} = f(\sigma_C, \Delta yc, \sigma_E, \sigma_W)$, as defined below.

Country-Specific Market Shocks (σ_C)

15. **We calculate the weekly (5 trading-day) returns on each country-specific stock index by taking the weekly log-difference of the stock index in the local currency.** The

[16] This operation adjusts for any serial correlation in the residuals, which may be induced by our use of overlapping weekly □*DD*s.

[17] The issue of non-synchronicity is not a major concern in this case, given that the stocks of the majority of banks in our sample largely trade in the same time zone (continental banks also have operations in London and some are listed on the London Stock Exchange).

volatility of returns is approximated by the conditional variance estimated from a GARCH(1,1) model of the weekly returns, such that,

$$X_t = c + \varepsilon_t, \text{ and} \tag{5}$$

$$\sigma_t^2 = w + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \tag{6}$$

where X_t is the weekly local currency return in the country's stock price index and σ_t^2 is the GARCH volatility, both at time *t*.[18] The ARCH effect is captured by the lagged square residual, ε_{t-1}^2. We predict this period's variance by forming the weighted average of a long term average (the constant, *w*), the forecast variance from the previous period (σ_{t-1}^2), and information about volatility observed in the last period (ε_{t-1}^2). This model is consistent with the volatility clustering associated with financial returns data, where large changes in returns are likely to be followed by further large changes.[19] Lagrange multiplier tests show significant ARCH(1) effects for all the stock market returns used in this paper.

Developments in the Local Real Economy (Δyc)

16. **We use weekly (5 trading-day) changes in term structure spreads to represent expectations of changes in the business cycle in a bank's home country.** The term structure spread is calculated as the difference between a long-term interest rate (the 10-year government bond yield) and a short term rate (the 1-year government bond yield) in any one country. Thus, the *change* in yield curve slope is defined as

$$\Delta yc_t = \frac{yc_t - yc_{t-5}}{| yc_{t-5} |}, \tag{7}$$

where yc_t is the term structure spread at time *t*.

Regional Market Shocks (σ_E)

17. **We apply a regional (European) stock market return volatility variable to control for common shocks affecting European markets, in this case, the MSCI ACEI index.**[20] We denominate the index in the currency of the country in which the dependent

[18] It should be noted that the use of GARCH volatility may induce errors-in-variables in the modeling process.

[19] This method was developed by Ding and Engle (1994).

[20] This is a free-float-adjusted market capitalization index, which consisted of the following 16 developed market country indices as at June 2006: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

variable bank is located. We use the same method as that for the local stock markets, and estimate the GARCH(1,1) volatility for the MSCI ACEI.

Global Market Shocks (σ_W)

18. **We apply a global stock market return volatility variable to control for common shocks affecting global markets, in this case, the MSCI ACWI.** We denominate the index in the currency of the country in which the dependent variable bank is located, and estimate the GARCH(1,1) volatility for the MSCI ACWI, as for the other indices.

APPENDIX IV: DESIGNING MACROECONOMIC SCENARIOS

19. **Single-factor sensitivity analysis needs to be complemented by multi-factor scenarios. Sensitivity analysis is useful for a basic understanding of how individual shocks influence banking sector soundness.** However, in real episodes of stress, multiple shocks tend to take place at the same.

A number of scenarios would be interesting to examine. These include:

- *A (continuing) disorderly global adjustment.* Several recent FSAPs had a scenario along the following lines: there is a sharp correction of global imbalances, with a decline in global economic growth, a significant depreciation of the U.S. dollar and an abrupt decline in equity prices; the euro-wide monetary policy response to these events implies a reduction in short-term interest rates (see, e.g., the FSAP stress test for Portugal (IMF, 2007).

- *Real estate shock.* A decline in real estate prices is a plausible scenario, given the existing situation in a number of advanced markets.

20. **Both of these scenarios should take into account the open nature of the Cypriot banking system, and the substantial share of business with nonresidents.**

Other scenarios can be envisaged, but their implementation is problematic. These include:

- *Contagion from other countries in the region.* The Cypriot banking system is exposed to the risk of cross-border contagion arising from the fact that parent companies of foreign-owned Cypriot banks have substantial exposures elsewhere in the region. These are important issues, but the risk is not trivial to assess in a single-country assessment; it can be analyzed more efficiently in a regional financial sector exercise. To a limited extent, the cross-border contagion was modeled as part of the liquidity risk, when we tested for the impact of large funding withdrawals by foreign banks.

- *Shocks to tourism.* This is an interesting scenario. However, the available loan data are not amenable to the relevant analysis (e.g., there is no separate loan category on "tourism").

- *Cyclical asynchrony.* In principle, one could also model a "cyclical asynchrony scenario. Such a scenario was used in the FSAP for Portugal (IMF, 2007), in which the Portuguese economy was assumed to fail to follow a strong recovery of economic activity in the euro area. This was accompanied by a steep rise in short-term interest rates. Fiscal consolidation consistent with the Stability and Growth Pact was imposed in the scenario. A similar scenario could be arguably envisaged in the case of Cyprus, but it does not appear timely at the current juncture. Moreover, the basic features of the scenario would most likely not be too different from other scenarios considered

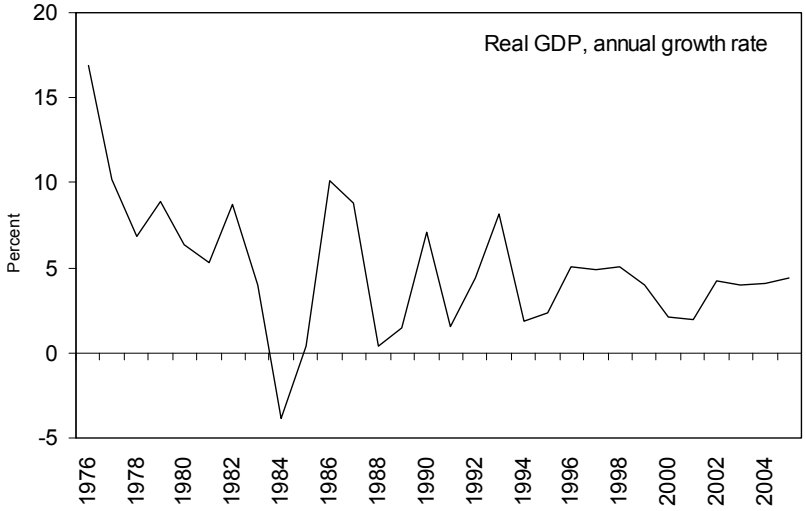
here (and indeed, in the case of Portugal, this scenario was found to have smaller impacts than the "disorderly global adjustment" scenario).

Calibrating the Scenarios

21. **How to best calibrate these combinations of shocks for the case of Cyprus?** The basic underlying principle for FSAP stress testing is that the shocks should be "extreme but plausible" (e.g., IMF and World Bank, 2005). The options are (i) past experience from Cyprus; (ii) estimating an explicit model for Cyprus; (iii) using data from actual banking crises that occurred in other countries; (iv) taking into account scenarios used by FSAP missions (and other stress testers) in other countries.

Past experience from Cyprus

22. **Past data for Cyprus provide only a limited guidance of what a response to a major macroeconomic shock would look like.** The only period of negative GDP growth rates in modern Cypriot history was in mid-1980s. The usefulness of data from that period for calibration is limited due to the important changes which the Cypriot economy and financial sector has undergone since then, as well as the availability of key data. In particular, comparable data on NPLs in the banking sector are available only since early 2000s.



Perhaps the most substantial stressful period in recent period was the bursting of the stock price bubble in the early 2000s. However, as shown above, the impact on GDP has been relatively modest.

Estimating a model

23. **Even in the absence of large shocks, it would be possible to estimate/calibrate a macroeconomic model.** However, the usefulness of such an approach for modeling extreme scenarios would be limited. Standard dynamic stochastic general equilibrium (DSGE) models, which are used by many Eurosystem central banks, are useful when focusing on small movements around equilibrium. However, such models are of relatively little use for large shocks such as those considered in the stress testing exercise. This is primarily because such models have strong equilibrating properties, which means that the growth rates and

other variables in the model tend to revert back to the long-term trend very rapidly after the shock. This leads to some unrealistic results for large shocks.

24. **To map macroeconomic scenarios into credit risk, econometric estimates based on Cypriot data were attempted, but yielded no robust results that could be used for such large shocks.** To model such a link, work was attempted on estimating a "satellite model" that would provide such a link by estimating a relationship between NPLs (or loan loss provisions) and macroeconomic variables (and bank-specific variables if bank-specific data are used for loan performance). Various specifications have been tried, from basic single equation models to dynamic estimates (such as vector autoregression and vector error correction models); however, the estimates did not yield robust results that could be used with confidence for stress testing.[21]

Past FSAPs

25. **Given the limited usefulness of past data for Cyprus for modeling how major shocks would look like, an alternative approach to calibration is to look at what shocks were used in previous FSAPs.** It should be noted that FSAP stress tests are always tailored to country-specific circumstances, both as to the different types of potential vulnerabilities to be subjected to stress testing, and the exact nature, coverage, and size of the shocks applied to the various risk factors. In combination with the ongoing evolution of stress testing methodologies, this has therefore resulted in quite a wide range of approaches. Nonetheless, it is especially useful to look at recent FSAPs in other advanced European economies.

26. **Cihak (2007) provides an overview of stress tests in European FSAPs.** Tables 11–15 toward the end of this document provide an updated version of the overview (this update was done by Stephanie Stolz).

Past experience from other countries

27. **Another approach to parameterizing the shocks and scenarios is to analyze data from other countries.** One option analyze countries that have gone through crises or situations of extreme financial stress (of course, with the caveat that no two crises are completely alike, and the past is not a "guarantee" for the future). For this purpose, we have done an extensive analysis of 17 capital account crises in the 1990s–2000s. Specifically, the following crises were included in the sample: Indonesia, Korea (1997), Philippines, Thailand (June 1997), Argentina (December 2001), Brazil (December 1998), Mexico (December 1994), Uruguay (June 2002), Bulgaria, Czech Republic (May 1997), Russia

[21] This leaves aside the Lucas (1976) critique that even if we had estimates that appear robust based on past data, those estimates may change in a stressful event that departs from past experiences. In this case, the past data did not even yield significant and robust relationships between financial sector variables (such as NPLs) and macroeconomic variables to start with.

(August 1998), Slovak Republic (August 1998), Turkey, Finland (October 1991), Sweden (November 1992), Italy, Spain, and United Kingdom. In terms of the level of economic development, Cyprus would be slightly above the middle of the sample, and it is characterized by a much higher degree of economic openness than the rest of the sample. Also, compared to the emerging market average, it is characterized on one hand by better governance and transparency standards, but on the other hand by a higher credit to GDP ratio.

28. **The experience from these 17 crises (summarized in Table 10 and Figure 12) suggested the following for the parameterization of the stress tests:**

- In the event of such a crisis, it is realistic to assume a *steep initial depreciation***,** reflecting the loss of confidence, but some appreciation thereafter. This "overshooting" phenomenon occurs in most of the case studies we considered. The average depreciation of the exchange rate in the sample a year after the crisis was 33 percent, and many countries have experienced considerably larger depreciations. It is unclear how to translate this to the case of Cyprus, given that it is part of the euro area. Nonetheless, given the past movements in the euro vis-à-vis other currencies, it is not implausible to assume a 30 percent depreciation of the currency (which is already assumed for the purpose of sensitivity calculations)

- The average *increase in the NPL ratio* in the crisis countries was 9.6 percentage points a year after the crisis, with a substantial variation from country to country (the cross-country standard deviation of the increase was 9.1).[22] The characteristic of this approach is that it captures the whole credit risk impact conditional on the event of a crisis. It does not identify what part of the NPL increase is due to exchange rate, which part is due to interest rate, which part reflects real estate price decline, and so on. It is a more comprehensive approach of measuring the overall credit impact.

- The *recovery rates on bank assets* in crises vary widely (see Figure 12). For a sub-sample of 10 systemic banking crises for which the relevant data are available, the average recovery rate was 59 percent, with a standard deviation of 33 percent. The bulk of the country observations is in the 10–40 percent recovery rate range, which would imply a 60–90 percent "loss given default" range. Thus, to capture a range of the crises experience, is reasonable to use a 60 percent provisioning rate as a starting parameterization, and to test how results would change if the average provisioning rate were 90 percent.

[22] Analyzing the average percentage increase in terms of NPLs rather than the NPL ratio would give a smaller absolute increase in the case of Cyprus, because the starting level of NPLs in Cyprus as of end-2006 is low. However, that would be a misleading approach. Performing loans or total loans are a better proxy for exposure to credit risk, especially after such a massive structural change in the credit portfolio as in the case of Cyprus.

29. **To calculate the overall impacts of the scenario on banks, the credit risk impact would be combined with direct impacts of the interest rate and exchange rate changes.** The overall impacts are likely to be dominated by the credit risk (including indirect interest rate and exchange rate risk).

Proposed Scenarios

30. **With the above considerations in mind, the stress tests include several downside scenarios.** While the downside scenarios have been informed by the recent experience of Cyprus, relationships that worked precisely in the past generally break down during times of dislocation. Accordingly, these scenarios draw judgmentally on the experience of a wide number of countries that have undergone similar exceptional scenarios.

Appendix Table 10. Calibrating a Banking Crisis Scenario

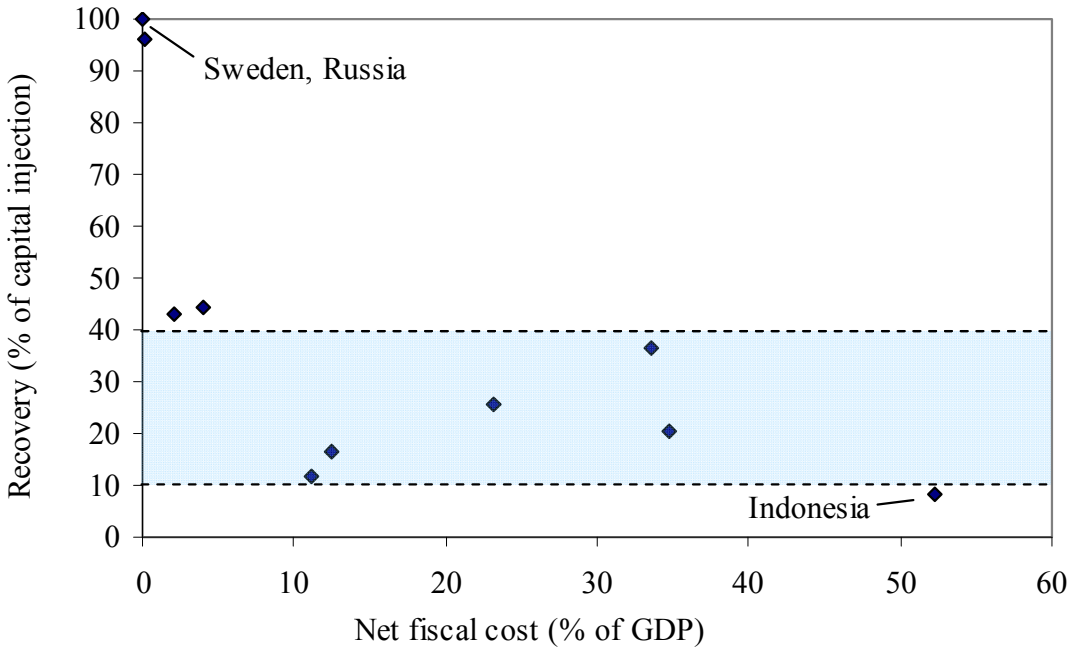
(In percent; unless noted otherwise)

	Output 2/		Change in	Change in NPL ratio	GDP per capita 4/
	T+1	T+2	NEER (T+1)	(% points, T+1)	(% of US GDP at PPP)
Averages					
Emerging (12)	-4.9	-0.1	-39.2	12.7	27.3
Asia (4)	-7.8	-3.6	-40.5	16.4	23.2
Europe (4)	-0.1	5.2	-29.7	8.7	30.8
Latin America (4)	-6.8	-2.1	-47.3	11.8	27.8
Advanced (5)	-0.8	1.5	-18.4	3.1	74.6
All (17)	-3.7	0.4	-33.1	9.6	41.2
Medians					
Emerging (12)	-6.5	0.2	-35.9	7.6	24.0
Asia (4)	-8.7	-2.3	-29.1	16.3	17.3
Europe (4)	0.4	2.0	-25.4	7.6	27.0
Latin America (4)	-8.5	-2.2	-44.3	10.2	26.8
Advanced (5)	-0.9	1.2	-19.7	3.3	76.0
All (17)	-1.3	1.0	-28.9	4.7	33.8
Standard deviations					
Emerging (12)	6.2	7.6	24.9	9.6	12.4
Asia (4)	5.4	7.3	26.2	13.5	17.0
Europe (4)	5.8	8.0	33.7	6.2	14.2
Latin America (4)	5.6	5.9	15.5	8.9	5.9
Advanced (5)	2.1	4.1	4.2	0.7	7.2
All (17)	5.6	6.7	22.9	9.1	24.8
Average+1st dev.					
Emerging (12)	-11.1	-7.7	-64.0	22.3	39.7
Asia (4)	-13.2	-10.8	-66.7	29.8	40.2
Europe (4)	-5.9	-2.8	-63.4	14.9	45.0
Latin America (4)	-12.4	-7.9	-62.7	20.7	33.7
Advanced (5)	-3.0	-2.6	-22.7	3.8	81.8
All (17)	-9.3	-6.3	-56.0	18.6	65.9
Average-1st dev.					
Emerging (12)	1.3	7.5	-14.3	3.1	14.8
Asia (4)	-2.3	3.7	-14.4	2.9	6.2
Europe (4)	5.7	13.3	3.9	2.5	16.5
Latin America (4)	-1.3	3.8	-31.8	2.9	21.9
Advanced (5)	1.3	5.7	-14.2	2.4	67.4
All (17)	1.9	7.0	-10.2	0.5	16.4

Source: IMF calculations, based on *International Financial Statistics* and data collected in other missions.

1/ Country samples are defined as follows: "Advanced" includes Finland, Italy, Spain, Sweden, and the United Kingdom. "Emerging" includes Indonesia, Korea, Thailand, Philippines (all Asia), Czech Republic, Russia, Slovak Republic, Turkey (all Europe), Argentina, Brazil, Mexico, and Uruguay (all Latin America).
2/ Cumulative loss of output 1 year (T+2) and 2 years (T+2) since the onset of crisis (in percent of pre-crisis GDP).
3/ Nominal effective exchange rate, percentage change over 12 months after the onset of the crisis.
4/ In the year prior to the crisis.

Figure 12. Recovery Rates in Systemic Banking Crises



Note: Includes 10 crises for which relevant data on recoveries are available. Capital injection is approximated by "gross outlay" reported by Hoelscher and Quintyn (2003).

Source: FSAP team calculations, based on data in Hoelscher and Quintyn (2003).

Appendix Table 11. Approaches to Credit Risk Modeling in European FSAPs

Approach to Credit Risk Modeling	FSAP
NPLs, provisions: historical or macro-regressions	Austria (2003), Czech Republic (2000), France (2004), Iceland (2000), Ireland (2006), Israel (2000), Romania (2003), Russia (2002), Sweden (2001)
NPLs, provisions: ad hoc approaches	Belarus (2004), Bosnia and Herzegovina (2005), Bulgaria (2001), Croatia (2001, 2007), France (2004), Hungary (2000, 2005), Ireland (2000), Israel (2000), Latvia (2001, 2007), Lithuania (2001), Macedonia (2003), Malta (2002), Moldova (2004, 2007), Montenegro (2006), Poland (2000, 2006), Russia (2007), Serbia (2005), Slovakia (2002, 2007), Slovenia (2000, 2003), Switzerland (2001), Ukraine (2002)
Shocks to probabilities of default based on historical observations or regressions	Austria (2003, 2007), Belgium (2004), Denmark (2005), Greece (2005), Lithuania (2007), Luxembourg (2001), Russia (2002), Spain (2005)
Shocks to probabilities of default (ad hoc)	Germany (2003), Italy (2004), Netherlands (2003), Norway (2004), United Kingdom (2002)
Shocks to profits based on regressions	Switzerland (2006)
Explicit analysis of cross-border lending	Austria (2003, 2007), Spain (2005)
Explicit analysis of foreign exchange lending	Austria (2003, 2007), Croatia (2001, 2007)
Explicit analysis of loan concentration	Greece (2005), Latvia (2007), Malta (2002), Moldova (2007), Montenegro (2006), Netherlands (2003), Poland (2006), Russia (2002, 2007), Serbia (2005)
Explicit analysis of sectoral shocks	Belarus (2004), Finland (2001), Greece (2005), Latvia (2007), Moldova (2007)
Analysis of LTV ratios, mortgage PDs	Croatia (2001), Sweden (2001)

Appendix Table 12. Approaches to Interest Rate Risk Modeling in European FSAPs

Approach to Interest Rate Risk Modeling	FSAP
Repricing or maturity gap analysis	Austria (2003, 2007), Belarus (2004), Belgium (2004), Croatia (2001, 2007), Czech Republic (2000), Greece (2005), Hungary (2000, 2005), Ireland (2006), Italy (2004), Latvia (2007), Lithuania (2001, 2007), Macedonia (2003), Malta (2002), Moldova (2004, 2007), Montenegro (2006), Poland (2000, 2006), Romania (2003), Russia (2002, 2007), Serbia (2005), Ukraine (2002)
Duration	Belgium (2004), Greece (2005), Iceland (2000), Ireland (2006), Israel (2000), Italy (2004), Latvia (2001, 2007), Norway (2004), Poland (2006), Slovakia (2002, 2007), Switzerland (2001)
Value at Risk	Denmark (2005), Finland (2004), Germany (2003), Israel (2000), Italy (2004), Netherlands (2003), Switzerland (2006), United Kingdom (2002)
Others (e.g., Δ NPV of balance sheet, Δ market value of bank capital, regressions, simulations)	Austria (2007), Norway (2004), Sweden (2001)

Appendix Table 13. Approaches to Exchange Rate Risk Modeling in European FSAPs

Approach to Exchange Rate Risk Modeling	FSAP
Sensitivity analysis on the net open position	Austria (2003, 2007), Belarus (2004), Belgium (2004), Bulgaria (2001), Croatia (2001, 2007), Czech Republic (2000), Hungary (2000, 2005), Iceland (2000), Ireland (2006), Latvia (2001, 2007), Lithuania (2001, 2007), Macedonia (2003), Malta (2002), Moldova (2004, 2007), Montenegro (2006), Norway (2004), Poland (2000, 2006), Romania (2003), Russia (2002, 2007), Serbia (2005), Slovakia (2002, 2007), Slovenia (2000, 2003), Sweden (2001), Switzerland (2001), Ukraine (2002)
Value at Risk	France (2004), Germany (2003), Israel (2000), Netherlands (2003), Switzerland (2006), United Kingdom (2002)

Appendix Table 14. Interest Rate Shocks in European FSAPs

Interest Rate Scenarios Used	Examples of Shock Sizes
• Ad hoc or hypothetical interest rate increase • Parallel shift in yield curve • Flattening/steepening of yield curve • Historical interest rate increase • Basel Committee Amendment to Capital Accord to incorporate market risk	• 3 standard deviations of 3-month changes • 50%-100% increase • three-fold increase in nominal rate • 100 basis point shock to interest rates • 100 basis point shock to dollar interest rates and a concomitant 300 basis point shock to local currency interest rates • 300 basis point increase • +500, +200, +0 (+0, +200, +500) basis point increase in interest rates for 3 month, 3 month to 1 year, and over 1 year

Appendix Table 15. Exchange Rate Shocks in European FSAPs

Exchange Rate Scenarios Used	Examples of Shock Sizes
•Ad hoc or hypothetical devaluation •Historical large exchange rate changes	• 20%-50% devaluation • 30% devaluation • 10% depreciation • 20% depreciation/appreciation • 40% depreciation/appreciation of Euro/Dollar exchange rate

APPENDIX V. IMPROVEMENTS IN CREDIT RISK MODELING

31. **In terms of further improvements in methodology, we suggest to focus on further improvements in credit risk modeling.** Credit risk is the most important source of risk, as identified by the FSAP. At the same time, it is the part of stress tests where methodology could be strengthened most.

32. **Some of the methodological improvements are hampered by the lack of data; others can be done with the existing data**. As regards new data needed, it would be particularly useful to extend backward the existing NPL data broken down by credit segment. However, it is practically impossible to extend backward the existing NPL data broken down by credit segment. The data limitations in Cyprus are considerable; nonetheless, more work can be done using methods for data-constrained environments (Gasha and Morales, 2004; Segoviano, 2006, and Chan-Lau and Santos, 2006). For example, even with the existing data, using bank-level estimates on NPLs may potentially give better estimates than the aggregate estimates used by CBC so far. The data are more noisy, and bank-specific variables need to be included, but still the number of degrees of freedom is much higher, and based on the FSAP staff's preliminary calculations, the estimates are stronger.

33. **The CBC could consider further analyzing the link between credit growth and individual bank weakness.** Rapid credit growth has been an important phenomenon across the region, and especially in Cyprus. To analyze the relationship between credit growth and bank weakness, the CBC could run a bank-by-bank regression on the relationship between financial soundness of individual banks (e.g., measured by their post-shock CAR in the downside scenarios) and credit growth. The results of such a calculation could be useful both for micro and macroprudential purposes, as the implications of credit growth for stability are very different depending on whether the most rapidly growing banks are weak or strong.

34. **For corporate credit, the existing exercise can be improved by using the methodology proposed in this appendix, if CBC can put together basic data on financial soundness of banks' corporate counterparts.** The data requirements of the methodology are reasonable given the potential payoff (in terms of better modeling of credit risk). The method requires an identification of largest bank corporate borrowers, detailed financial statements for each of these borrowers, a breakdown of GDP and exports by sector (and ideally, of export by size of firms), a breakdown of bank loans by currency and by borrower, average interest rates on debt in foreign and in domestic currency, amount of debt maturing within a year, or average maturity of debt, and data on use of foreign currency derivatives by firm. Additionally, past earnings before interest, taxes, depreciation, and amortization (EBITDA) values of companies, distinguishing those in problems and not in problems, would be useful, but are not necessary.

35. **To implement the scenario analysis, it is important to analyze the links between macroeconomic and other factors and loan losses (or probabilities of default).** We

suggest that this analysis is started in the first phase, and completed in the second phase. The key feature of is to make credit risk (default probabilities) conditional on the projected behavior of the explanatory economic variables.[23] Given the data limitations, the technique may require using methods designed for credit risk measurement in data-constrained environments (see in particular Segoviano, 2006, and Gasha and Morales, 2004; and Chan-Lau and Santos, 2006), or using estimates from other countries or cross-country studies, if warranted. Depending on data availability, the analysis could be based on panel data on the main sectors or aggregate data. The impact on loan losses could then be fed into individual bank balance sheets and compared with banks' profits or capital.

36. **In the next phase, we suggest to model in more detail the "credit risk VaR."** The advantage of the credit risk VaR is that it allows to calculate the loan loss distribution on banks' portfolios, both under the baseline and under the stressed scenarios. It is a very useful exercise for bank supervisors that allows to highlight the risks associated with credit risk concentration in bank portfolios. For estimating the loan loss distribution, it is proposed to use the Credit Risk + technology (Avesani and others, 2006).

37. **The adaptation of Credit Risk + provides a coherent framework to assess and stress test the risks embedded in a bank's credit portfolio.** The model is one of the several market standards, originally developed by Credit Suisse First Boston to manage a loan portfolio. The IMF/MCM version has been adapted to handle aggregated supervisory data, while preserving information on the key risk drivers—portfolio concentration and correlations. Its main feature is the ability to compute economic "capital at risk" for a given loan portfolio. It does so by generating the portfolio loss distribution, whereby we can estimate economic capital (i.e., unexpected losses) at different confidence levels (Figure 13).

38. **The model can run with either detailed portfolio information (bottom up) or with aggregated supervisory data (top down).** The first four columns in Appendix Table 16 below show the inputs needed to run the model for a typical commercial bank. The loan portfolio has been segmented into eight main sub-portfolios: (i) the largest five corporate borrowers, which account for about one-third of the loan book; (ii) loans to small and medium enterprises; (iii) mortgage loans; and (iv) consumer loans. For each segment, the model requires the PD, the size of the exposure, number of loans, and the recovery rate. A limitation in the case of Cyprus is that so far, the Cypriot banks have implemented the standardized approach for credit risk under the CRD (Basel II), and have not yet calculated

[23] There are of course some caveats that need to be considered when interpreting the macroeconomic-based models. First, it is necessary that the data series span at least one business cycle; otherwise, the model would not capture completely the impact of the business cycle on default probabilities. Second, the estimated model is a reduced form model of default probabilities, which summarizes the complex interaction between the state of the economy and individual/sectoral default risk. These models are subject to the Lucas critique (Lucas, 1976) since their parameters and/or functional forms are unlikely to remain stable. Finally, aggregate economic data is usually reported at substantial lags and subject to revision rendering macroeconomic-based models unsuitable for tracking rapidly deteriorating conditions of a firm or sector.

historical PDs. Although full-fledged modeling work would require calculation of the PDs, in the meantime NPL ratios can be used as proxies.

39. **The model also offers a more advanced version with two additional features, namely, stochastic default probabilities and sectoral exposures.** For the advanced version, the standard deviation of the PDs is required (i.e., a measure of the precision with which PDs are estimated) and the sectoral exposures to manufacturing, services, etc. These extra features enhance the model by adding sectoral concentrations and correlations to the portfolio, as well as by providing a potential link between macroeconomic factors and the PDs. Figure 2 shows the output of the model, i.e. the estimated portfolio loss distribution corresponding to "Bank X," as described in Table 10, as well as the estimated capital at risk based on a 99 percent credit VaR.[24] The main building blocks of the model are probabilities of default by portfolio categories (public, corporate, and household), the number of accounts/obligors in each category, and estimated loss given default by category (see Table 10 for an example of input data).[25] Probabilities of default and loss given default can be estimated based on bank by bank data for Cyprus. Box 1 provides a brief summary and discussion of the methodology.

40. **The proposed framework for credit risk analysis is of interest to supervisory authorities and financial stability units alike.**[26] In the context of risk-based supervision, the model is well suited for bank supervisors to assess the sufficiency of economic capital relative to actual bank capital (the inputs required by the model are similar to those of Basel II). In the context of financial stability analysis, the model is also suitable to assess bank solvency under stressed macroeconomic scenarios (for example, to analyze the impact on bank capital of a sudden deterioration in the quality of credit). So far the model has been successfully applied in the Greece and Turkey FSAPs, and various institutions have shown interest in the model for supervisory and financial stability analysis, including the ECB and the Bank of Portugal.

[24] The model is based on an analytical closed-form solution (no simulations are needed to generate the loss distribution), thus, the program only takes a few seconds to run on a standard laptop.

[25] If feasible it would be desirable to obtain separate probabilities of default and other information along the lines of Table 2 for related party exposures.

[26] For an implementation of Credit Risk + by the Swedish central bank, see Sveriges Riksbank (2006).

Figure 13. The Portfolio Loss Distribution

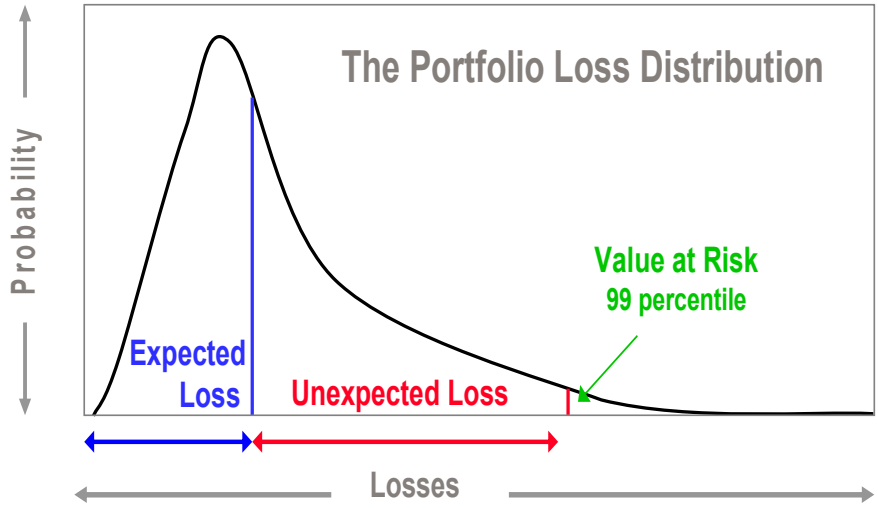
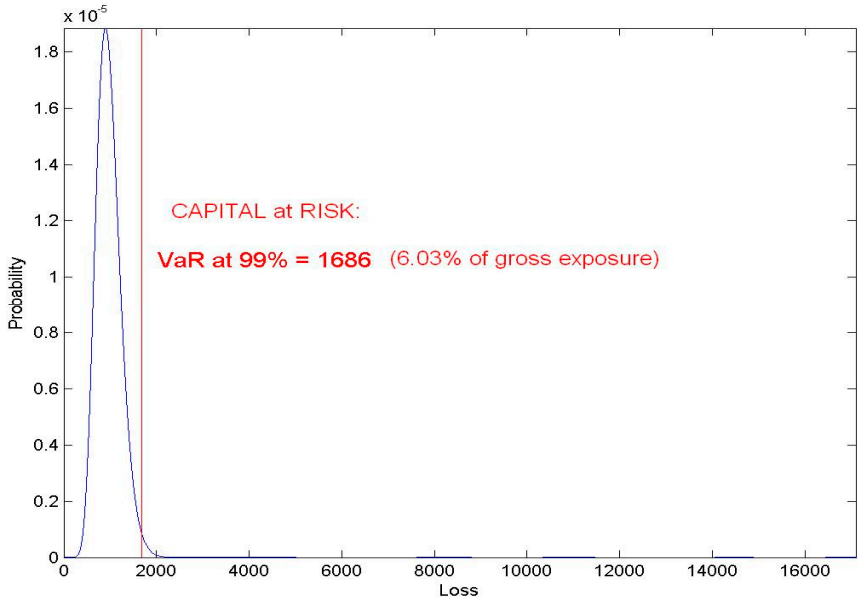


Figure 14. Estimated Loss Distribution for Bank X Loan Portfolio



Appendix Table 16. Example of Input Data for the Credit VaR Model

a) Standard Presentation: "Bank X" Loan Portfolio

	PD	Exposure (local currency)	Number of Loans	Recovery Rate	Standard Deviation of the PDs	Sectoral Exposures			
Corporate 1	0.0407	1,766	23	0.40	0.020	0.00	0.30	0.70	0.00
Corporate 2	0.0207	1,688	5	0.40	0.010	1.00	0.00	0.00	0.00
Corporate 3	0.0360	3,455	659	0.30	0.018	0.10	0.00	0.10	0.80
Corporate 4	0.0400	1,420	9	0.50	0.020	0.00	1.00	0.00	0.00
Corporate 5	0.0237	2,082	233	0.60	0.012	0.00	0.00	0.00	1.00
SMEs	0.0907	6,563	25,876	0.30	0.045	0.35	0.25	0.15	0.25
Mortgages	0.0186	9,881	56,872	0.75	0.009	0.35	0.25	0.15	0.25
Consumer lending	0.1078	3,908	195,400	0.25	0.054	0.35	0.25	0.15	0.25

(b) Alternative Presentation: "Bank Y" Credit Portfolio

					Sectoral Exposures (in percent) 1/		
	Proba-bility of Default (PD)	Loss given default (LGD)	Value	Number of accounts (obligors)	Agri-culture	Trade	Etc.
Total							
Corporate 1/							
Total loans to obligors of the public sector							
o/w five largest public sector customers							
Total loans to obligors of the private sector							
o/w five largest private sector customers							
Loans to SMEs							
o/w five largest SME customers							
Mortgage							
Consumer lending							

*Please provide a breakdown by economic sectors as well, if available.

Source: IMF staff.

Box 1. Credit Value-at-Risk

The IMF toolbox for Credit Risk+ model can be used to estimate credit VaR and determine economic capital needed to meet unexpected credit losses. Originally developed by Credit Suisse Financial Products, the model has quickly become one of the market benchmarks for credit risk modeling due to its simplicity of use, straightforward and limited assumptions and data requirements. While simple spreadsheet stress testing and sensitivity analysis focus on an increase in NPLs and provisioning, credit VAR allows analyze how dynamics in probabilities of default of individual borrowers could affect bank sustainability even before such loans are classified as nonperforming. IMF staff has developed a software toolbox that implements the Credit Risk+ model as part of Excel (see Avesani and others, 2006, for a description of the methodology). The toolbox is available for use by country authorities and has been shared with the Bank of Cyprus staff working on stress tests.

The set of necessary assumptions in the basic model presented here is very limited. An obligor characterized by a given default probability could be either in default or still performing at the end of a certain time period (e.g., the period to which the default probability refers to, which could be one month, one quarter, one year, etc). Furthermore, it is assumed the default probabilities in each time period are constant, and that the number of defaults that occur in any given period is independent of the number of default that occurs in any other period. Finally, we assume that each obligor's default probabilities are small in order to obtain a closed form solution for the loss curve and to integrate the analysis with default probabilities uncertainty and correlations.

From the bank supervision and financial stability perspective, the main purpose of the CreditRisk+ framework is to build the loan portfolio loss distribution that can be used to monitor credit risk at the level of each financial institution. In addition, this tool is well suited for macroeconomic scenario analysis once it is integrated with a model for the PDs, where the PD is linked to macroeconomic indicators. For example, stress testing of the resilience of an institution's credit portfolio to an exchange rate shock can be analyzed through its impact on the default probability. The stressed PDs is then used to built the new loss distribution and the new level of economic capital can be computed.

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