National University of Kyiv-Mohyla Academy
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Modeling of the Ukrainian Banking System During the Crisis

Research Proposal

by

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Glossary

Contagion - the evidence of "excess co-movement" in stock and commodity prices between the financial markets.

Credit risk – the risk that customers fail to comply with their obligations to service debt, or the risk of counterparty default on its obligations.

Foreign exchange risk (FX risk) – the risk of losses due to changes in exchange rates.

Interest rate risk – the risk of declines of earnings due to the movements of interest rates.

Liquidity risk – the risk of inability to cover the maturing liabilities with the available assets; also, the risk of inability to raise funding at a reasonable cost.

Non-performing loan - a loan that is not earning income: full payment of principal and interest is no longer anticipated, principal or interest is 90 days or more delinquent, or the maturity date has passed and payment in full has not been made.

Operational risk – the risk of losses due to malfunctioning of the information systems, reporting systems, and internal risk monitoring rules.

Second round effects (feedback effects) - change in the behavior of the bank portfolio or realignment of the portfolio structure in response to the change in risk factors.

Stress-testing – the procedure of evaluation of a bank's financial position under a severe but plausible scenario with the goal of assisting in decision-making within the bank.

Chapter 1. Introduction

A common feature of past and recent financial crises is the instability in the financial sector, accompanied by downturn in the economic activity. The similar situation has been observed in Ukraine in the course of crisis of 2008 unfolding. First of all, the crisis staggered the stability of the banking system. The situation has been further worsened by significant devaluation of local currency, combined with the big share of loans previously granted in foreign currency[1]. As a result, the decrease of customers' solvency has been observed: during the first quarter of 2009, the quality of banking assets has worsened substantially due to the increase in the share of non-performing loans[2]. Moreover, the volumes of new bank funding attraction and existing loans repayment are negatively influenced by the downsize both in the profits of corporate clients and population. The latter, in turn, result from the crisis consequences in the macroeconomy, such as the decrease in aggregate demand, fall in GDP and real wages, and leaping unemployment.

In the conditions described, maintenance of the banking system stability becomes the key task for the National Bank of Ukraine. The main questions that arise in such context are the following. Firstly, it is needed to determine how sensitive individual banks are to the shocks increase during the crisis. Secondly, it is required to estimate the possibility of whole system failure if certain banks do not survive. Thirdly, the important issue to consider is the amount of the potential costs for the Ukrainian budget, given the bank failures.

Answering these questions requires adequate estimation of the impact of different types of shocks that the banks are exposed to during the crisis. The need for such estimation steams from that the pre-crisis assessments carried out by banks could have understated the size of risks and resulted in insufficient hedging safeguards. Reasons for this problem are twofold. On the one hand, the banks may have had insufficient incentives to form the additional capital hedging from risks with very 'low' probability (as it was thought before the crisis): firstly, holding the excess insuring capital buffers is costly; secondly, the banks could have expected that the National Bank of Ukraine would bail them out and provide additional liquidity in case the need for such intervention arises.

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[1] As of 01.04.2009, 70% of total loans of the banking system in Ukraine have been denominated in foreign currency. Source: Rating agency "Credit Rating", www.credit-rating.ua.

[2] From 01.01.2009 to 01.04.2009, the share of non-performing loans in Ukrainian banks has increased from 3.88% to 6.13%. Source: Rating agency "Credit Rating", www.credit-rating.ua.

On the other hand, the methodology of risk impact assessment could have failed. Stress-testing framework, usually applied in the world banking practice for the purposes of potential shock impact estimation, is uncommon in Ukraine: though the National Bank of Ukraine recommends it for use in the Ukrainian banks, no regulator's recommendations or guidelines concerning the procedure of stress-testing have been provided, so the banks have had to develop the needed methodological and empirical tools themselves. Such treatment from the regulator's side has resulted in that stress-testing was used by only a small number of Ukrainian banks in the pre-crisis period. Even the banks that applied it could have taken the mechanical approach to stress-testing, which resulted in insufficient flexibility of the method and its inability to comprise the rapid changes in market environment as the crisis unfolded.

Moreover, the global crisis that started in 2007 has revealed the weak sides even in the common approach to stress-testing, taken in the banking practice of developed countries. Such weaknesses relate to the following issues:

1) Stress-tests, similarly to other risk-management models, often are based upon historical statistical relationships (for example, correlations between asset prices).Such relationships are assumed to be appropriate for forecasting the development of risk events in future. However, in case the crisis is preceded by a long period of stability, the major shocks to the market that occur in real life will be more severe than the historical-based scenario could have foreseen. Thus, the results of modeling become unreliable.

2) Stress-tests often didn't account for feedback effects arising from the change in behaviour of market participants, and for system-level interactions. Such tendencies can provoke rapid changes in the risk characteristics over time, and initial shocks may increase consequently, as it happened in the recent crisis.

3) Extreme cases usually have low weight in stress-testing models, especially in those based on historical data. Also, the bank risk analytics used to choose mild scenarios, assume insufficient shock size and shorter duration compared to what was observed in real life during the crisis.

4) Stress-testing was often conducted for individual types of risks, or for separate portfolios, which led to improper aggregation of risk exposures (or absence of such aggregation) at the bank level. The correlations between different types of risks have been rarely accounted for, as well. In addition, overall risk exposures may have been underestimated due to omitting certain issues that became crucial during the crisis, such as

the credit quality of portfolios, possible changes in liquidity of financial instruments and duration of potential illiquidity, reputational risk, off-balance sheet exposures (concerning instruments like letters of guarantee, letters of credit and other liabilities related to risk of counterparty default).

Therefore, there arises the need in developing the procedure of stress-testing, which would be able to account for the drawbacks revealed by the recent crisis, and in applying the mentioned procedure to test the stability of Ukrainian banking system. The research interest supporting the latter objective stems from the fact that the majority of previous works describe the application of stress-testing to the banking systems of developed countries, while little attention has been paid to the transition countries. Ukraine, being an example of country in transition, is characterized by certain peculiarities of economy and financial sector such as the significant structural changes in the banking system during the recent decade (growing number of banks, development of the new types of financial instruments, entrance of foreign banks into Ukrainian market), increasing importance of the banking sector and its continuing integration with the economy. All of these factors could contribute to obtaining the research results differing significantly from the findings derived for the developed countries. Apart from that, there is a lack in empirical research on the topic at the banking system level for the countries in transition.

Practical implications of the study can be used by the National Bank of Ukraine (NBU) for the purposes of banking supervision and forecasting. In addition, the results from the study can be used for development of policy initiatives by the NBU aimed at supporting the stability of banking system, for instance, enhancing of banks' liquidity buffers. Also, the commercial banks may employ the methodology and research findings in the course of risk management and strategic planning in the crisis conditions, for example, to determine the overall sensitivity of the bank to shocks during the crisis, and to estimate the size of capital needed to insure against the risks.

The theoretical importance of the study lies in that it would allow developing of the adequate model for estimation of the impact of different types of shocks on the Ukrainian banking system. The model designed would incorporate the peculiarities of the Ukrainian banking system as that of the transition country. Moreover, for the first time the overall impact of the shocks on the Ukrainian banking sector will be determined at the system

level, as previously the stress tests have been conducted for the separate Ukrainian banks and separate types of shocks only. Also, this study can contribute to further development of the tools applicable in the crisis conditions and serve as a basis for elaboration of plausible analytical procedures of banking risk analysis, thus assisting in matching of the methodological base currently employed in the Ukrainian banks to the real-life needs and to the practices applied in the developed countries.

The goals of this study are, first, to develop the procedure of stress-testing of the Ukrainian banking system, which would be able to embrace major types of banking risks and to comprise the movements in the financial environment during the crisis, as well as the second-round effects; second, to apply the mentioned procedure in order to estimate the potential impact of the crisis; and third, to work out the practical recommendations for the NBU and the commercial banks, aimed on maintaining the banking system stability in the crisis conditions.

Based on the work goals, the research questions may be defined. First, it is necessary to determine how the different types of shocks influence the stability of the separate Ukrainian banks and that of the whole banking system. Second, it is needed to decide how the separate shocks should be aggregated to get the overall risk measure relevant at the bank level, and how the exposures for banks should be aggregated into system-level measure. Third, the shocks impact on stability of the banking system in the crisis period and the related consequences for the separate banks should be determined. The related task would concern specifying the reasons for the separate banks to withstand the shocks impact or to fail. Finally, it is needed to figure out the potential costs for the state budget which could be required to support the banking system stability in case of bank failures.
The hypotheses related to the questions set are as follows. The stability of the whole system would be found sufficient to withstand the impact of shocks; however, not all the banks would survive the crisis. It is expected that the ownership of the bank, its size, and its importance for the whole system are important for surviving the crisis. Among the shocks explored, the foreign exchange (FX) shock and the credit shock are expected to have the most important impact.

In order to answer the research questions and test the hypotheses, this study would employ the procedure of stress-testing. Such approach allows taking into account the important

linkages between the banking system and the dynamics of key macroeconomic indicators, as well as reflecting adequately the connections between separate banking institutions inside the system. Stress-testing is proposed by Basel Committee of Banking Supervision and used by a number of banks and international financial institutions including World Bank and IMF as a tool for assessment of impact on the bank of significant but possible changes in the business environment. It is also a common method of investigation whether the banking institutions possess the sufficient capital stock to withstand the downturn in financial market and macroeconomy. The procedure of stress-testing will be conducted in the form of scenario analysis, which would allow determining the impact on the overall risks of banking system from the combination of potential shocks: change in the foreign exchange rate, change in interest rate, worsening of credit portfolio quality, change in operational costs, and decrease in market liquidity.

The data to be used include the financial statements and balance sheets of the biggest Ukrainian banks for the period of 2002-2009, obtained from the Association of the Ukrainian Banks. Also, the time series of macroeconomic indicators' dynamics (including inflation, unemployment, FX rates, interest rates, and GDP growth) for the same period can be retrieved from the State Statistics Committee website. Additionally, the interbank lending matrix may be obtained from the NBU.

The following part of this work is organized as follows. Chapter 2 provides the review of the literature related to the research questions and scientific approaches to the topic exploration. Chapter 3 presents the outline of the methodology, argumentation supporting the choice of research approach as well as delimitations of the method and possible ways of overcoming them. Chapter 4 concludes the present work with the time schedule of research.

Chapter 2. Literature Review

The research relevant to the topic, which is investigated in this work, may be subdivided into three groups: literature considering the modeling of individual banking risks, works on the estimation of crisis impact on the separate market agents or groups of agents, and the articles related to the assessment of total risk exposure at the system level.

As for ***the first group*** of studies, its importance lays in that it presents a number of models for estimation of separate risk exposures of banking institutions. Both Ukrainian and Western research literature counts numerous works analyzing the bank exposure to such kinds of risk as credit risk, interest risk, liquidity risk and market risk (Krylova and Nabok, 2008; Finkelshtejn, 2001; Bessis, 2002). The range of methods used, however, is generally limited to gap analysis, duration analysis, scoring models, VaR estimation and Capital-at-risk (CAR) concept (e.g. Chemerys and Uvarov, 2002; Bondarenko, 2007). For example, Chemerys and Uvarov (2002) describe the approach to the interest risk quantification, which is based on the assessing the duration covenants that characterize the sensitivity of financial assets value to the changes in interest rates and allow to perform a rough estimation of the interest rate risks exposures that the financial institution faces. The authors present the detailed description of the economic meaning of duration and the mathematical framework employed for its calculation, focusing on the practical application of the method for the purposes of interest rate risk management in the financial institutions.

Bondarenko (2007) describes the process of developing a scoring model for the estimation of credit risk of a bank. A scoring model is a specific type of mathematical model that involves consideration of individual characteristics of a borrower and determination on this basis of a certain quantitative indicator – a scoring rating – describing the solvency of a borrower, that is, the possibility of successful repayment of a loan, or, contrarily, the probability of default on a loan. This kind of models is applied in estimation of the financial state of a counterparty before the loan is granted, as well as for the purpose of assessment and monitoring of creditworthiness during the life-term of a loan.

The common method used to assess the liquidity risk is gap analysis, the procedure of estimation of the gap between the liquid assets and maturing liabilities of the banking

institutions, by the time baskets defined on the base of remaining term to maturity. If the liabilities exceed the available liquid assets, the bank has to pay attention to the attraction of additional sources of funding. However, as the common assumption of the method is the stability of the funding price, gap analysis doesn't provide the forecast for the liquidity gap dynamics in case the cost of funding increases (Bessis, 2002).

Another common method for assessment of all types of banking risks, most often applied to market and credit risk estimation, is the calculation of VaR (value-at-risk) and the related measure of CAR (capital adequacy ratio). VaR is a quantitative measure of risk reflecting the size of losses, which at the given confidence level (for example, in 99% of all possible cases) will not be exceeded during the certain period of time. Capital adequacy ratio is the ratio of bank's regulatory capital to the risk-weighted assets. For every VaR estimate related to a certain banking risk exposure, the corresponding additional amount of capital can be determined, which is needed to hedge against this risk (Bessis, 2002). The drawback of these methods is that estimation of VaR requires specifying certain statistical distribution of expected losses, which in practice may be difficult due to absence of the needed data history and unreliability of simulation modeling, as well as due to the fact that distributions best fitting the financial sector data are often very sophisticated, which implies difficulties in further estimation.

The significant drawbacks peculiar for the first group of studies are related to the static nature of the methods and models applied, and the limited applicability of results obtained for strategic management of the banking system. In addition, the application of the mentioned group of methods requires relative stability in the data (absence of strong volatility and sudden severe shocks), which makes them inappropriate for use in the course of risk analysis in crisis conditions.

The second group of studies includes the works concerning the crisis impact on the separate agents and groups of agents in the economy and the banking system. The importance of this branch of literature for present research lies in that it is helpful for developing the scenarios of possible shocks to the banking system, implied by the movements in the macroeconomy. For example, knowing the impact of crisis on the behaviour and financial state of private individuals (or corporates), one can predict the

potential amounts of deposits withdrawal and loans non-repayment in relation to the banking sector.

As a subgroup, this branch of literature includes numerous surveys from US, Western Europe, and Central and Eastern Europe (including Ukraine) concerning the influence of the crisis. For example, Red C (2008) gives an insight on the general impact of crisis on the Irish people. The main findings include the decrease in the disposable income and savings, and the decrease in trust to banks. The quantitative survey conducted by New Bridge (2008) shows that in Ukraine, the majority of people during the crisis would also prefer to keep savings at home instead of banks, and withdraw their deposits. Also, the banks tend to decrease the amounts of lending and set up more severe requirements for borrowers.

The research literature belonging to the second group presents a range of methods used to analyze the impact of crisis on the institutions belonging to different sectors of economy. One of the methods that is most common for Western publications is VaR (Value-at-Risk), employed to estimate the possible fluctuations in macro- and microeconomic indicators and the impact of such fluctuations on the financial state of the institution, that is, maximum possible losses or the probability of default. For example, Pesaran et al (2004) and Alves (2004) use a VAR model to assess the impact of macroeconomic variables on firms' probabilities of default. In Pesaran et al (2004) the VAR includes GDP, consumer prices, the nominal money supply, equity prices, exchange rates, and nominal interest rates for eleven countries for 1979-1999. Alves (2004) constructs a co-integrated VAR, using KMV's corporate expected default frequencies as endogenous variables and macroeconomic factors (the twelve-month change in industrial output, the three-month interest rate, the oil price, and the twelve-month change in a broad stock market index) as exogenous variables. The expected default frequency (EDF) of each EU industrial sector is modelled based on exogenous macroeconomic factors and the EDFs of other industrial sectors to capture the possibility of contagion, or shock transmission between the industries. However, the application of VaR methodology to the analysis of banking institutions is complicated, as it generally doesn't account for the quality of bank's assets, which deteriorates during the crises.

The wide range of methodologies is applied also to model the behaviour of economy as a whole in respect to the banking crises. The Western empirical studies on banking crises

generally use two standard econometric tools. The first is the *signals approach*, which studies and contrasts behaviors of economic indicators for periods before and after a crisis, and identifies the factors that best signal the upcoming crisis based on over- or under-reaching of certain threshold values (Kaminsky and Reinhart, 1999). The paper mentioned analyzes the "twin crises" or the occurrence of both currency and banking crises, in a sample of 20 countries during 1970–95. The authors find that banking crises were frequently related to large exchange rate movements characterizing currency crises. They also show that banking crises were preceded by a decline in output partly reflecting deteriorating terms of trade, rapid financial liberalization characterized by growth of credit and rising cost of credit (interest rates), decline in the growth of exports and appreciating real exchange rates. The second approach estimates the probability of a banking crisis using a *limited dependent variable model* (Demirguc and Detragiache, 2005). The authors study a sample of 31 countries during 1980–1994, and find that low real GDP growth, high real interest rates, high inflation, positive credit growth, and an increase in exposure of banks to the private sector raises the probability of a banking crisis.

Both approaches mentioned consider the significance of individual factors in emergence of banking crises. In contrast, Duttagupta and Cashini (2008) maintain that such crises are most often provoked by a combination of weaknesses rather than a single factor of impact. The authors use a *Binary Classification Tree (BCT) model* to analyze banking crises in 50 emerging market and developing countries during 1990–2005. The BCT identifies key indicators and their threshold values at which vulnerability to banking crisis increases. The three conditions identified as crisis-causing— very high inflation, highly dollarized bank deposits combined with nominal depreciation or low liquidity, and low bank profitability—highlight that foreign currency risk, low level of financial soundness, and macroeconomic instability are the key vulnerabilities that may trigger the banking crises.

The third group of studies describes the approaches to determination of the crisis impact on the banking system as a whole. The significance of such works stems from that they provide tools allowing to grasp the system-wide effects and relationships, which are important to include into analysis in addition to the single-risk or single-bank models.

Numerous literature belonging to this group proposes to use the stress-testing procedure. This approach appeared in the early 1990's; however, the research on the topic has been actively developing since then. The majority of system-level and country-level stress-testing methodologies have been developed in the course of the IMF Financial Sector Assessment Programme (IMF, 2003). Most of these tests have been conducted by the large banks themselves, based on scenarios developed from the Bank of England's Medium Term Macroeconometric Model. Resultantly, a number of papers concerning the development of applied stress-testing scenarios comes from the countries participating in FSAP, such as Czech Republic, UK, Finland, Austria and others.

The most common approach used in IMF country FSAPs are single factor sensitivity tests. These consider the impact of a marked change in one variable, such as the exchange rate or the policy interest rate, on banks' balance sheets. However, these stress tests do not allow for the interaction between macroeconomic variables ('scenarios') such as the impact of changes in the interest rate on real activity and thus on banks' loan portfolio. Scenarios can be developed through a number of methods. One approach is to use a structural macroeconomic model. This was done, for example, in a number of IMF FSAPs on developed countries. Macroeconomic stress tests of the financial system, developed in recent years, assess the vulnerability of the banking system, or more broadly the financial system, to extreme but plausible adverse macroeconomic shocks (Sorge, 2004). Stress tests are important from a central bank's perspective, since they are tractable and provide a useful benchmark to assess the risks to the financial system. An example is the paper by Hoggarth, Sorensen and Zicchino (2005), which uses the macroeconomic approach for stress testing the UK banking system. The distinctive feature of this work is that authors take into account the dynamics between banks' write-offs and key macroeconomic variables, through conditioning the stress test on the historical correlation between the variables and allowing for feedback effects from credit risk to the macroeconomy. The main findings indicate that both UK banks' total and corporate write-offs are significantly related to deviations of actual output level from potential one. The results suggest that "even if the most extreme economic stress conditions witnessed over the nearest future were repeated, the UK banking sector would remain robust" (Hoggarth, Sorensen and Zicchino, 2005). However, the stress tests proposed, like most other methodologies applied in the research on the topic, may not fully capture structural changes in the banking industry.

A number of related studies have been conducted in Czech National Bank. For example, Cihak (2007) provides an overview of the stress testing of the Czech banking sector conducted by the Czech National Bank. The results of interbank contagion tests (both simple and combined) based on Czech banks' exposures on the interbank market are offered. Also, the paper integrates the stress testing with CNB macroeconomic forecasts, macroeconomic credit-risk model, impact on individual bank portfolios, and interbank contagion. One baseline and three alternative scenarios tested have found the Czech banking sector to be relatively resilient to the shocks.

The studies that describe stress-testing approaches in light of the recent crisis of 2007 are mostly concerned with the development of new scenario types and risk models allowing to capture the interactions between different types of risks, as well as include into analysis the feedback effects and inter-country exposures. For example, the paper by Wong and Hui (2009) proposes the procedure of stress-testing allowing to account for the relationship between market and credit risk, estimated econometrically on the basis of historic data for the system. Based on the designed methodology, the authors conduct a stress-testing of the group of banks in Hong Kong, using the publicly available data for the end of 2007. The findings suggest that the banks tested would be vulnerable to asset price shocks only in case of the long duration of such shocks or the simultaneous influence of interest rates increase due to contractionary monetary policy. Another work by Boss et al (2007) presents the results from stress-testing the exposures of Austrian banking system for two macroeconomic scenarios close to the real-life events of the recent crisis, namely: the shock to the financial markets of CEE countries, to which the Austrian banks have significant credit exposures; and the shock to global economic activity resulting in failures on repayment of the Austrian household loans. Moreover, the authors perform additional sensitivity tests for a credit risk based on potential shock related to foreign currency lending. The results of stress-testing indicate that the Austrian banking system is resilient to the significant shocks 'due to the substantial capital buffers and high level of profitability', as the authors maintain.

This study employs the procedure of stress-testing, as it is the most well-argued and developed approach to the chosen research problem for today. Moreover, it allows taking into account the projected dynamics of key macroeconomic indicators through linking the changes in the banking system to that in the economy as a whole.

Overall, the Western literature related to the topic of this work is rather well-developed, while the number and scientific novice of Ukrainian studies is clearly insufficient.

Consequently, the research conducted would make a valuable contribution into the theoretical and empirical knowledge applied for modeling the banking system of Ukraine, for the following reasons:

- the lack of empirical research at the banking system level in Ukraine;
- the need for developing a stress-testing methodology for general use;
- the necessity of enhancement and further development of the methodological basis of banking risks assessment;
- the importance of shock impact assessment on the banking system of Ukraine as an economy in transition, further strengthened by the development of financial crisis in 2009.

Chapter 3. Methodology

3.1 Concept of Stress-Testing

Stress tests are an analytical technique that can be used to estimate a particular sensitivity of institution to a certain shock. Stress tests were originally developed for use at the portfolio level, to understand the potential risks resulting from extreme movements in market prices. They have now become widely used as a risk management tool by financial institutions. Further, this technique has been employed with the aim of measuring the sensitivity of a group of institutions, such as commercial banks, or even an entire financial system to common shocks.

This work focuses on system-wide, or macrofinancial, stress tests, which measure the impact of shocks on financial system stability. Compared to stress tests for individual financial institutions, the system-wide stress tests have wider coverage, are used for a different purpose, that is, financial sector supervision rather than risk management, focus more on channels of contagion (how a risk to one institution can become a systemic risk), and often have to use more common techniques because of the subsequent complexity of calculations. Also, system-wide stress testing is a much newer concept, and the literature on the topic is thus much shorter than that on stress testing for individual institutions. The system-wide nature of the stress tests, however, does not mean that they should be performed on aggregate data. Applying the tests to the financial system as a whole or to large groups of institutions can conceal substantial exposures at the level of individual institutions, which can lead to failures of these institutions and then contagion to the rest of the system. These exposures can get excluded during the aggregation (Cihak, 2004). So, it is important to perform the stress tests on an bank-by-bank basis while possible, and to analyze not only the aggregate results, but also the dispersion of the results around the aggregate figure. The positive implication from performing the stress tests this way is that they provide to the regulator an additional tool to identify vulnerable banks in the system.

Stress tests can be classified by methodology into three main groups: *sensitivity analysis*, applied to identify how portfolios react to changes in relevant economic variables such as interest rates and exchange rates; *scenario analysis*, which allows to assess the robustness of financial institutions and the financial system to an exceptional but plausible scenario;

and *contagion analysis*, used to model the transmission of shocks from individual banks to the financial system as a whole. (Cihak, 2004a)

The process of stress-testing generally begins with the identification of specific vulnerabilities or areas of concern, followed by the construction of a scenario in the context of a consistent macroeconomic framework. The next step is to map the outputs of the scenario into a form that is usable for an analysis of financial institutions' balance sheets and income statements, then performing the numerical analysis, considering any second round effects, and finally summarizing and interpreting the results. Each stage of the process is important to understanding the sensitivity of a financial system to a particular shock or vulnerability. Those stages are further discussed in detail.

3.2 Steps of Stress-Testing

3.2.1 Identifying the Vulnerabilities

The first stage in the stress-testing process is identification of the main vulnerabilities of the system, which allows isolating possible areas from where the shocks can arise. Such weak areas may be defined through the analysis of macro-level indicators, structural indicators, and micro-level indicators (Jones, Hilbers and Slack, 2004).

Knowledge of the macroeconomic environment (growth rates of consumption, investment, and incomes; unemployment rates; inflation; government deficit; current account deficit; official reserves) can provide the information about overall performance of the financial system and indicate potential sources of shocks. Analysis of such information allows determining what is normal for an economy and comparing it to other countries. Such analysis can also ease the macro simulations described further.

Indicators of the structure of the financial system can help in determination of risks in the financial system. Such indicators include data on ownership and market shares, balance sheet structures, cashflow accounts.

In addition to using the broad macroeconomic context and structural indicators, a range of financial soundness indicators (FSI) may be used to understand the financial system's

vulnerability to shocks and its capacity to absorb the losses. These indicators are more micro-level because they are typically derived from data on individual institutions or sectors. The health of the financial sector can be analyzed by considering trends in FSIs (capital adequacy, asset quality, profitability, liquidity, and exposure to market risks).

3.2.2 Constructing the Scenarios

The second stage of the process involves examination of the available data and models to determine what can be used to understand the behavior of the system with respect to the main vulnerabilities. Based on this data, a scenario can be constructed in the context of some overall macroeconomic framework or model. Usually, a macroeconometric or simulation model should form the basis of the stress testing scenarios. Using such model provides a forward-looking and consistent framework for analyzing key linkages between the financial system and the real economy. On the basis of analysis performed at the previous stage, it is necessary to determine the macro and financial variables that are the most volatile, deregulated, or likely to have the greatest impact on the financial system. Typically, such variables are sensitive to major shocks and thus can form the basis of a simulation scenario.

In case no macro model is available, it may be necessary to rely on other approaches. The analysis may employ a textbook macro models, appended with the findings from existing empirical research, or models developed for another country having similar conditions (Jones, Hilbers and Slack, 2004).

3.2.3 Balance-Sheet Implementation

The next step of the procedure is to map the outputs of scenarios onto the balance sheets and income statements of financial institutions. There are two main approaches to translating or mapping scenarios into balance sheets: the “bottom-up” approach, where estimates are based on data for individual portfolios, which can then be aggregated, and the “top-down” approach, which uses aggregated or macro-level data to estimate the impact.

The disadvantage of a top-down approach is that applying the tests only to aggregated data could disregard the concentration of exposures at the level of individual institutions and linkages among the institutions (Cihak, 2007). This approach may therefore overlook the risk that failures in a few weak institutions can spread to the rest of the system. The bottom-up approach is able to capture the concentration of risks and contagion, and therefore is considered to produce more precise results, but it requires more data and is more calculationally complex. Having detailed information on exposures of individual banks to individual borrowers should in principle lead to more accurate results than using more aggregated data; however, especially for large and complex financial systems, it may lead to big computational problems. Most macro stress tests therefore try to combine the advantages and minimize the disadvantages of the bottom-up and top-down approaches.

Implementing a stress test also requires to address the question: which institutions should be included in the exercise? The coverage of the stress testing exercise should be broad enough to represent a meaningful critical mass of the financial system, while keeping the number of institutions covered at a feasible level (for example, less than twenty). The total market share of the institutions involved, in terms of assets, deposits, or some other criteria such as importance in the payment system, can be used to determine a cutoff point. In countries with a large number of small institutions, like Ukraine, the usual approach is either aggregating smaller institutions into a single balance sheet or taking a representative sample of institutions, or even ignoring them if they are not systemically important (Jones, Hilbers and Slack, 2004).

Another important question to consider in conducting a stress test is: what are the data constraints? The availability and quality of data impose major constraints on the nature of stress tests that can be performed. As noted in IMF and World Bank (2003), data limitations can come in four forms:

1) Basic data availability, especially in countries where information on balance sheet exposures may not be available;

2) Difficulty isolating specific exposures, especially among financial institutions in case of large complex financial institutions or the ones active in the derivative markets;

3) Lack of risk data, for example, duration or default measures, in countries where risk management systems are less sophisticated;

4) Confidentiality issues, or limitations on what regulator is legally able to share with other parties.

All of the issues outlined are peculiar for Ukraine. To overcome these difficulties, it is possible to work with the larger institutions to get better data or to calibrate some parts of the exercise. To deal with confidentiality issues, it may be possible to conduct the stress testing based on agreed assumptions and methodologies and to share the results in a form that is informative enough of the risk exposures, but would not breach confidentiality laws or protocols.

Another important question to address in performing a system-focused stress test is: how big are the shocks? Stress-testing involves discovering the impact of exceptional but plausible events, so the scenarios considered should be beyond the normal range of experience. Scenarios can be based on historical data, that is, the largest observed changes or extreme values over a specified period, or they can be hypothetical and involve large movements thought to be plausible. Historical scenarios can be more intuitive since they were actually observed, but hypothetical scenarios may be more realistic, especially if the financial structure has changed significantly due to deregulation, liberalization, changes in monetary policy operating procedures, or changes in supervisory policies. Experiences of other countries can also be a useful example (Jones, Hilbers and Slack, 2004).

3.2.4 Considering Second-Round Effects

Most stress testing approaches assume there is no change in the behavior of the portfolio or no realignment of the portfolio structure in response to the change in risk factors. Stress tests are typically applied to a balance sheet at a point in time, and the impact is calculated as if the shock was valued at market prices. This approach is valid if the time horizon is relatively short, or if changes in the underlying portfolio take time to implement. But when the time horizon of a scenario or shock extends beyond a year or more, the assumption of no behavioral response becomes harder to justify. Similarly, for systemically important institutions or for systems as a whole, the assumption of no

feedback effects used in many stress tests may be an oversimplification. The policy environment may change over a longer horizon, as the authorities will react to the shocks.

One approach that is often used to consider second round effects and linkages between institutions is the use of contagion models. These models attempt to estimate the impact of the failure of key institutions on other institutions and on the overall financial system. The practical application of contagion tests is discussed further.

3.2.5 Interpretation of Results and Limitations of the Method

When interpreting stress tests, one needs to consider their limits and the assumptions on which they are built. Typical stress tests view banks as static portfolios rather than actively behaving agents. A thorough examination of vulnerability, however, must take into account the fact that banks adapt dynamically to shocks in the environment. Depending on the kinds of incentives that banks face, these adaptations may overstate or understate the vulnerabilities created by the initial shock. To understand the structure of incentives that banks face in particular circumstances, it is necessary to consider the environment in which banks operate, such as, for instance, the legal, accounting, tax, and regulatory conditions (Cihak, 2004a). Also, while stress test results are useful to evaluate effects of large movements in key variables, they still do not provide a precise measure of the magnitude of losses. As the Committee on the Global Financial System (2000) noted: typically, there are no probabilities attached to the outcomes of stress tests. Another issue against interpreting stress tests simply as predictors of default is related to their mark-to-market nature. While mark-to-market loss estimates provide information about a bank's financial risk exposures, they do not show the ability of a bank to sustain losses. If the underlying model being stressed is incorrectly specified or estimated, then the conclusions drawn from a stress test may be invalid. This potential for "model error" creates the need of comparing stress test results with other measures of risk exposure, such as financial soundness indicators. Stress tests are also unlikely to capture the full range and interaction of risk exposures, such as operational risk and legal risk, and may give only a partial picture of real-life risk exposures. Finally, stress tests typically consider only part of a bank's income generating operations, and thus banks may have significant income flows that are not covered by the stress test scenarios analyzed (Cihak, 2004a).

The analysis and discussion of stress testing results can be facilitated by a clear presentation of the output generated by stress tests, and of the underlying assumptions used to generate the results. The results may be presented by grouping the aggregate impact of the stress tests by type of risk and by scenario. The composition of expected losses, for example, as a proportion of capital or income, can be used to summarize the central results. For bottom-up approaches, descriptive statistics (mean, median, standard deviation, minimum, maximum, and number of institutions in each quantile) and peer group analysis can be used to show how the impact at the aggregate level is distributed across individual institutions (Jones, Hilbers and Slack, 2004).

3.3 Individual Risk Issues

3.3.1 Credit Risk

Measuring credit risk involves estimation of a number of parameters: the probability of default on each instrument; the amount of the losses in the case of default, or loss given default, which may involve estimating the value of collateral; and the probability that other counterparties will default at the same time.

There are two general approaches to system-wide stress tests for credit risk: (i) approaches based on loan performance data, which can be either purely mechanical (assuming certain shocks to performance of loans) or based on a regression analysis between loan performance and macroeconomic variables; (ii) approaches based on data on borrowers (for example, financial leverage, interest coverage). Further, each approach is discussed in detail.

The advantage of approach based on loan performance data is that such data are relatively easily available to supervisors and include information about all sectors, including households, which are usually more difficult to get the data about. The key disadvantage of this approach is that NPLs are lagging indicators of asset quality.

The first subgroup of approaches in this group are those based on asset reclassification. Under this approach, loans and other assets are moved one or more classification categories (classes) down. The effect of the loan reclassification on the capital ratio is

calculated after deducting the additional provisions from both the reported capital and the reported asset amounts. There are various types of asset reclassification. It can be purely mechanical, for example, a certain percent of loans in each category is moved down by a category; or it can be based on experience from past crisis episodes, for instance, the percent of loans reclassified is the same as the percent of loans moving down during the last banking sector crisis. Alternatively, if the detailed information is available, analysis can be based on peer reviews when loans to the same borrower from different banks are reclassified according to the lowest grade assigned by a bank. Another approach is based on supervisory reviews: for example, if recent auditory checks in some banks have found significant differences between the reported and true classification of loans, a stress test could assess what would happen if similar differences were found in other banks.

The second subgroup of approaches in this group are those based on a regression or a VAR model that includes NPLs and macroeconomic factors, such as real interest rates and GDP growth. The regressions can be estimated at sectoral level, if there are data on NPLs by economic sectors, or on the individual bank level to capture the banks' different sensitivities to macroeconomic developments. The latter approach can, though, be too computationally intensive; so it is more common to use regressions for aggregated data.

Approaches based on data on borrowers have the advantage of providing more thorough way of assessment by explicitly modeling linkages between the state of the real sector and the financial sector. Another advantage is that the data on borrowers can help to indicate problems in the loan portfolio earlier than the loan classification data, which is by definition a lagging indicator. A drawback of this approach is that data on borrowers, especially households and SME, are often difficult to obtain and usually available only with long lags.

There is a wide range of possible approaches to modeling credit risk, depending on the availability of data. An approach used in some countries is to estimate a logit model predicting individual bankruptcy probabilities as a function of age, size, industry characteristics, and corporate soundness indicators (leverage, earnings, liquidity, financial strength). The model would include interest and exchange rates on the right hand side, to capture the indirect risk. Individual banks would be included into analysis through their exposures to the various groups of companies. This can then be used to predict banks' potential losses, taking into account collateral as well.

A simpler approach is based on exposure variables. The basic idea of this approach is that if an exposure variable exceeds an estimated threshold, the default rate becomes higher. Similarly to the previous approach, this is mapped into banks' losses, taking into account the value of collateral held by banks. An example of an exposure variable is the net open position in foreign exchange. To measure indirect interest risk, the exposure variable to use would be interest coverage (Cihak, 2004a)..

3.3.2 Foreign Exchange Rate Risk (FX rate risk)

FX rate risk can arise from positions in foreign currency, as well as those in local currency, that are dependent on foreign exchange rates. Foreign exchange rate risk can be direct when banking institutions have positions in foreign currency, or indirect when the foreign exchange positions of the banking institutions' borrowers may affect their creditworthiness.

The *direct FX rate risk* can be assessed through the net open position in foreign exchange. To illustrate this, let F denote the net open position in foreign exchange, C – the capital, ARW – the risk-weighted assets expressed in domestic currency units, and e – the exchange rate in units of foreign currency per unit of domestic currency. A decrease in the exchange rate leads to a proportional decline in the domestic currency value of the foreign exchange exposure, that is $de/e=dF/F$ for $F\neq 0$. Let us assume that this translates directly into a decline in capital: $dC/dF=1$. The impact of the exchange rate shock on the ratio of capital to risk-weighted assets is then expressed as (Cihak, 2004a):

$$\frac{\partial[\frac{C(e)}{A_{RW}(e)}]}{\partial e} \cong \frac{\frac{F}{e}\cdot A_{RW} - C\cdot\frac{\partial A_{RW}}{\partial C}\cdot\frac{F}{e}}{A_{RW}^2} \cong \frac{1}{e}\cdot\frac{F}{C}\cdot\frac{C}{A_{RW}}(1-\frac{\partial A_{RW}}{\partial C}\cdot\frac{C}{A_{RW}}) \qquad (3.3.2.1)$$

where symbol "$\cong$" means that the equation is approximate for changes other than very small. This equation can be rewritten as:

$$\partial[\frac{C(e)}{A_{RW}(e)}] \cong \frac{\partial e}{e}\cdot\frac{F}{C}\cdot\frac{C}{A_{RW}}(1-\frac{\partial A_{RW}}{\partial C}\cdot\frac{C}{A_{RW}}) \qquad (3.3.2.2)$$

The term *dARW /dC,* which reflects the degree of co-movement of capital and risk-weighted assets, may vary from 0 to 1. In the special case of *dARW /dC*=0 when the risk-weighted assets do not change, the change in the capital adequacy ratio equals simply the exchange rate shock times the exposure, measured as a product of *F*/*C*, ratio of net open position in foreign exchange to capital, and *C*/*ARW*, the capital adequacy ratio.

The *indirect FX risk* is often more significant than the direct one, because the direct exposure is relatively easy to measure and therefore to regulate. In contrast, it may be more difficult to monitor the foreign exchange vulnerabilities of banks' counterparties, especially in countries with fixed or thoroughly regulated exchange rates. Firms and population in such case can be deceived by the seeming absence of foreign exchange risk and can enter into large open positions in foreign exchange. To get an expression for the indirect risk, let us denote the corporate sector's debt as *Dc*(*e*), equity as *Ec*(*e*), and open foreign exchange position as *Fc*(*e*). Let us assume that, similarly to the case of the bank's net open position, a percentage change in the exchange rate will be mapped into the same percentage change in the domestic currency value of the corporate sector's net open position, which will lead to an equivalent change in the corporate sector's equity: d*Ec*/d*e*=d*Fc*/d*e*=*F*/*e*. The impact of the exchange rate on corporate leverage (*Dc*/*Ec*) is then expressed as (Cihak, 2004a):

$$\frac{\partial[\frac{D_c(e)}{E_c(e)}]}{\partial e} \cong \frac{\frac{\partial D_c}{\partial E_c}\cdot\frac{F_c}{e}\cdot E_c - D_c\cdot\frac{F_c}{e}}{E_c^2} \cong -\frac{1}{e}\cdot\frac{F_c}{E_c}\cdot(\frac{D_c}{E_c}-\frac{\partial D_c}{\partial E_c}) \qquad (3.3.2.3)$$

Thus, if the corporate sector has insufficient amount of foreign exchange, a decline in the exchange rate would lead to an increase in its leverage. Corporate leverage is usually positively correlated with the share of banks' NPLs in total loans (denoted as *NPL*/*TL*):

$$\frac{\partial(\frac{NPL}{TL})}{\partial(\frac{D_c}{E_c})} = a > 0 \qquad (3.3.2.4)$$

The impact of a change in the exchange rate on the *NPL*/*TL* ratio can then be expressed as

$$\partial\left(\frac{NPL}{TL}\right) \cong a \cdot \partial\left(\frac{D_c}{E_c}\right) \cong -\frac{\partial e}{e} \cdot \frac{F_c}{E_c} \cdot a\left(\frac{D_c}{E_c} - \frac{\partial D_c}{\partial E_c}\right) \qquad (3.3.2.5)$$

In the special case when d*Dc*/d*Ec*=0, the change in the *NPL*/*TL* ratio would equal the exchange rate change times the net open position, times the parameter *a*, which can be estimated empirically. To find the impact on capital adequacy, it can be assumed that the credit shock has the form of a transition of performing loans into the nonperforming category. By differentiating *C*/*ARW* with respect to *NPL*/*TL*, and substituting for NPL/TL from the last equation, it follows that (Cihak, 2004a):

$$\partial\left(\frac{C}{A_{RW}}\right) \cong \frac{\partial e}{e} \cdot \frac{TL}{A_{RW}}\left(1 - \frac{\partial A_{RW}}{\partial C} \cdot \frac{C}{A_{RW}}\right) \cdot \pi \cdot \frac{F_c}{E_c} \cdot a\left(\frac{D_c}{E_c} - \frac{\partial D_c}{\partial E_c}\right) \qquad (3.3.2.6)$$

where provisions are assumed to be a fixed percentage (π) of NPLs, and are deducted directly from capital.

3.3.3 Interest Rate Risk

Interest rate risk is the exposure of a bank's financial condition to adverse movements in interest rates. Interest rate changes affect interest income and interest expenses, as well as the balance sheet, through changes in market prices of financial instruments.

The impact of changes in the interest rate on net interest income is typically measured using the "repricing gap" model. The model allocates interest-bearing assets and liabilities into baskets according to the time till repricing, and the gap between assets and liabilities in each basket is used to estimate the net interest income exposure to interest rate changes. The position in interest-bearing financial derivatives can be incorporated into analysis by recalculating the expected future receipts and payments as interest rates change. Two approaches are commonly used to measure the impact of interest rate changes on market prices of financial instruments: the duration model and the gap model. Duration, defined as the weighted average term to maturity of assets or liabilities, is a direct measure of the interest rate elasticity of an asset or liability. The higher is the duration, the more sensitive is the price of an asset or liability to changes in interest rates.

$$\frac{\partial A(r_A)}{A(r_A)} \cong \frac{D_A \partial r_A}{(1+r_A)}\ ,\ \frac{\partial L(r_L)}{L(r_L)} \cong \frac{-D_L \partial r_L}{(1+r_L)} \qquad (3.3.3.1)$$

where $A(r_A)$ and $L(r_L)$ are the market values of assets and liabilities of the banking system; r_A and r_L are annual interest rates on assets and liabilities. From here, the impact of change in interest rate on the banks' capital may be determined. If the capital is defined as $A(r_A) - L(r_L)$ and divided by risk-weighted assets, then, differentiating it with respect to interest rate on assets and substituting from (3.3.3.1), the sensitivity of the ratio (C/A_{RW}) to the changes in interest rate changes will be defined as (Cihak, 2004a):

$$\frac{\partial[\frac{C(r_A, r_L)}{A_{RW}(r_A)}]}{\partial r_A} \cong -\frac{L/A_{RW}}{1+r_A} \cdot (D_A - D_L \cdot \frac{1+r_A}{1+r_L} \cdot \frac{\partial r_L}{\partial r_A}) \cdot \frac{1 - \frac{\partial A_{RW}}{A_{RW}} \cdot \frac{C}{\partial C}}{1 - \frac{\partial A}{A} \cdot \frac{C}{\partial C}} \cong -\frac{(L/A_{RW})}{1+r_A} \cdot GAP_D \qquad (3.3.3.2)$$

with the assumption that the risk-weight assets change proportionately to total assets, that is, $dA_{RW}/A_{RW} = dA/A$. In the expression above, GAP_D is the duration gap, expressed as

$$GAP_D = D_A - D_L \cdot \frac{1+r_A}{1+r_L} \cdot \frac{\partial r_L}{\partial r_A} \qquad (3.3.3.3)$$

An alternative approach to assessing the price revaluation effect of an interest rate shock is gap analysis. Under this approach, expected payments on assets and liabilities are sorted into time baskets according to the time till repricing, for floating-rate instruments, and to the time till maturity, for fixed-rate instruments. The net present value of assets and liabilities can be calculated by discounting the net cashflows in each time basket, while the effect of an interest rate shock may be estimated by rediscounting the net cash flows using the changed interest rates.

3.3.4 Liquidity Risk

Liquidity risk is the risk that assets would not be available to match the maturing liabilities. Stress testing the liquidity of the banking sector involves assessing the impact

on the liquidity gap of a shock like big-scale deposit withdrawals, a large fall in the price of assets, or an exchange rate crisis.

The most challenging step in designing a liquidity stress test is concerned with defining which assets that are normally considered liquid may become illiquid in crisis periods. IMF (2003a) provides the guidelines for defining such groups of liquid assets and liquid liabilities. In addition, off-balance sheet positions, for example, derivatives or commitments by credit lines, can have a significant impact on liquidity and should be also included into the stress tests.

A straightforward approach to stress testing for liquidity risk is to shock the value of liquid resources by a certain percentage or amount. The size of shock could be determined on the basis of past bank failures or on a "rule of thumb", and it should generally be different for different maturities. A "rule of thumb" is that a bank should be able to survive at least five days of a moderate liquidity run without outside support (Cihak, 2004a). The reason for choosing such term is that liquidity should be enough for the bank to survive a 5-day working week until the weekend, when banks are closed. This consideration period would enable the bank and the regulator to assess the situation better and take the precautionary actions.

A version of liquidity risk is the risk of concentration of banks' liabilities. Such risk is typically modelled as if there occurred sudden withdrawals by the banks' largest depositors. Another version of liquidity risk is the event of bank-to-bank contagion of liquidity stress. An example of such contagion could be a run on a bank perceived as "weak," which is triggered by liquidity problems in another bank. Such case is discussed in the following section.

3.3.5 Interbank Contagion Stress Test

Interbank stress testing aims at measuring the risk that the failure of a bank or a group of banks will trigger the failure of other banks within the system.
There may be a number of interbank contagion channels. The most direct one is contagion through uncollateralized interbank lending. Other possible channels include reputational effects, when an observed problem with stability in one bank could complicate for other banks in the system the attraction of funds in international markets, either due to total

impossibility to borrow or because of significant increase in the funding costs. The reputational effect of a failure of a bank can also lead to liquidity runs on other banks that are perceived as weak. Methodologically, modeling reputational effects is similar to modeling contagion through lending exposures. Empirically, however, it is much more difficult to define the "exposures" for reputational risk. For this purpose, other information sources, such as news, may be used.

Further, the focus is put on the risk of contagion through banks' uncollateralized interbank loans. There are two basic types of interbank stress tests: (i) *the pure interbank stress test*, where the shock is the failure of one bank, and the impact on other banks in the system is made through the interbank exposures; (ii) *the integrated interbank stress test*, where the banking system is first subjected to macro shocks or scenarios, and if those trigger a failure of a bank or a group of banks, the interbank stress test is conducted to assess the impact of additional failures through interbank exposures.

The key element of interbank contagion stress testing is a matrix of interbank exposures. The cells of the matrix contain the gross interbank exposures between banks, defined as all uncollateralized lending from one bank to another, including all on- and off-balance sheet exposures. Each row in the matrix corresponds to a bank and the cells in the row give its gross interbank exposure with respect to every other bank in the interbank market.

The pure interbank contagion stress test aims to answer the question of whether the failure of any bank (or group of banks) would lead to failures of other banks in the system. It can also be used to show how much other banks are weakened as a result of one bank's failure, as well as to define which banks are a potential source of systemic risk.

The pure contagion test assumes that there is a failure in a bank (for example, Bank A). The first round of the contagion calculation would than calculate the direct impact of Bank A's failure on each of the other banks, assuming Bank A would not repay its uncollateralized interbank exposures. If some banks fail as a result of Bank A's failure, the second round of the calculation would calculate the impact on each of the remaining banks of these newly failed banks not repaying their uncollateralized interbank exposures. The process can be repeated further if there are new failures after the second run.

Two indicators of systemic risk can be calculated from the pure interbank stress test:

1) a frequency of bank failure indicator, which is the ratio of the cumulative number of failures to the number of banks in the system;

2) statistical measures of the impact on bank system capital (for example, mean, distribution, and quartiles). Specifically, a systemic risk index may be defined as the average reduction in the capital ratios of banks in the system triggered by the failure of the systemically most important banks. Such a measure could be computed for all banks in the system and used to rank them by their systemic importance (Cihak, 2004a).

The macro contagion test differs from the pure contagion test in that it focuses on interbank contagion triggered by a macroeconomic stress. Firstly, it exposes the banking system to a macroeconomic scenario of shocks. Secondly, if the scenario leads to failures of some banks, the pure contagion test is conducted. The main difference is that the contagion takes place in a system that has already been weakened by the macroeconomic scenario or shock, so it is more likely that it will result in further bank failures. If the scenario does not trigger any bank failures, one possible conclusion is that there is no interbank contagion for this particular scenario (however, there might still be liquidity problems, if that banks have imperfect information about their counterparties). Alternatively, it is possible to estimate the largest shock that does not trigger yet a chain reaction in the system. To do this, it is needed to escalate the macroeconomic shocks until the weakest institution (or group of weakest institutions) fails, and calculate the interbank contagion effects as in the pure contagion test.

Similarly to the pure interbank contagion stress test, quantitative measures of systemic risk can be produced, for example, frequency of bank failures. However, the index of systemic risk in such case is different and needs to be decomposed into two components: (i) the average reduction in capital ratios due to the total shock; and (ii) the further reduction in the average of capital ratios implied by the failure of the bank due to the shock, which causes it to default on its loans. This latter index is identical to the one in the pure stress test.

Chapter 4. Project Timeline

April-May 2009 – reviewing the literature, preparing the research proposal including research strategy, task setup, review of literature and general methodology description;

June-August 2009 – detailing the proposal, specifying the approaches to methodology: defining and detailing ways and procedures of estimation, data needed, consequence of steps to perform, number of institutions to include into the analysis, and the criteria for choosing the institutions mentioned;

September-December 2009 – collecting the data for banks (balance sheets, financial statements, possibly interbank lending amounts) and economy (time series of inflation, foreign exchange rates, interest rates, GDP dynamics); developing the model, based on the concepts available from the research literature; transforming the data into the database suitable for research needs;

January-May 2010 – estimating the model, developing the practical and theoretical implications;

May-September 2010 – producing the draft of the thesis;

October-December 2010 – introducing corrections and improvements according to the discussions with fellow students, specialists and advisors; producing second draft of the thesis;

January-May 2011 – preparing the final version of the thesis.

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