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"Liquidity Stress-Testing: An empirical assessment of Greek Banking Sector"

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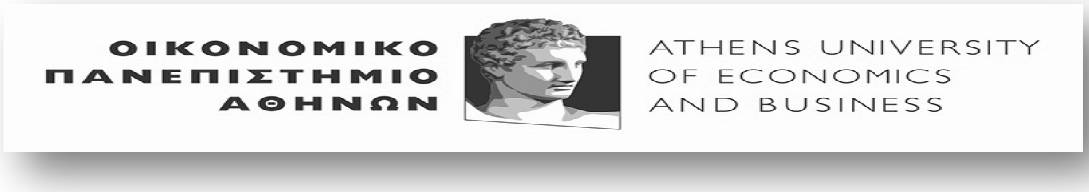

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Abstract

This paper is an attempt to build up a stress test model for banking sector focusing on liquidity risk. The warning indicator utilized to be stressed is the deposits to total assets ratio while variables to capture credit risk and the macroeconomic developments also are included. For this purpose, a novel panel, using the largest Greek banks with annual data covering the period 2000-2012 is estimated under both a static and dynamic approach. Results indicate that under the dynamic approach, both in baseline and stressed scenario, deposits to total assets ratio is a significant factor of liquidity risk and has strong properties for use as a warning indicator for the Greek banking sector. Results also extend to capturing the importance of the credit risk channel as measured by loan loss provisions, which has also a significant impact on banks' liquidity.

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1. Introduction

There is no doubt that the stability of the financial system is a prerequisite for maintaining confidence in an economy and promoting its economic growth. However, a stable financial system, although on a national basis is a necessary condition for a healthy economy, is not a sufficient one since the high degree of globalization especially among the national financial markets has created channels of quick transmission of financial turmoil originated in other parts of the continent.
Therefore, the financial stability must be seen not only as a national issue but also as a global one. It is for these reasons that both national and international authorities have paid much attention to the well-functioning of banks, which are in the heart of a financial system, especially in a multidimensional complex of countries that can be found in the European continent. In recent years, mainly due to the financial crisis in 2007 followed by a sovereign debt crisis for many countries, monetary policy authorities reinforced their efforts, aimed at ensuring financial stability. Financial stability analysis aims at understanding whether the financial system is exposed to shocks and quantifying the possible repercussions of a crisis should a shock occur (Quagliariello, 2009). Most of the financial stability analysis focuses on the stability of the banking sector which acts as the main channel between the financial sector and the real economy.

For this purpose, one of the main tools used for assessing the financial fragility of individual or multiple countries' banking systems, are stress tests methods. Stress tests originated in the early 90's by CreditMetrics and CreditRisk+ (Wilde, 1997) and quickly became popular among researchers due to their usefulness in capturing and measuring some types of risks for banks mainly credit and market risk. These stress tests, by simulating periods of extreme but plausible negative events in the economy, were used to a great extent for calculating the capital requirements of Financial Institutions (FIs) and whether these were according to Basel I and Basel II guidelines. Since then, under the wake of the recent financial turmoil which revealed structural

flaws in the way these initial stress test models had been formulated , stress tests methodologies had further developed and their applications expanded attempting to capture in their analysis both microeconomic and macroeconomic frameworks (e.g. Cihak, 2007). In addition to the aforementioned developments, the debate about the role of regulation/supervision framework weaknesses' might have played in propagating the crisis and the need for its restructuring, as expected has sparked new developments in the area of stress tests research. The most recent attempt to apply stress test, which mainly influenced the choice of my dissertation topic, is the one to be implemented for the largest and systemic 131 banks of the Euro area in late 2014 and is expected to provide regulators with a clear view on how to restore financial stability by revealing the main channels of risks faced by the banks (European Central Bank, press release, 2013).

Another reason for triggering my interest in stress test topic is the event of concurrence both the financial and the debt crisis to their most severe form for economies such as Greece, Spain, Portugal, Italy and Ireland. These economies have many special characteristics that have to be taken into account when developing a stress test. So far, most of stress test studies have assessed the effect of several types of risks for varying time periods, but they have underplayed the impact of liquidity risk. Specifically, International Monetary Fund (IMF) and Bank of International Settlement (BIS) have focused on credit risk as a risk factor affecting the capital adequacy of banks with capitalization acting as the dependent variable. In my study, I intent to develop a stress test model which solely focuses on and analyze the concept of liquidity risk from a different prospective and this is considered the main contribution in my dissertation. Specifically I focus on the deposits to total assets ratio as a plausible liquidity risk warning indicator under a base line and stressed scenarios. To this purpose I form a novel panel consisting of the largest Greek banks taking into account the fact that some of the banks did not operate the whole covering sample period while for others no complete test of data were existent. Therefore an unbalanced panel estimation technique was considered necessary. This is the second

contribution to the existent panel estimation techniques for stress test. Another distinct feature of my model is that stressed scenario is based upon data for year 2012. Finally the estimation method involves both a static and dynamic approach and resumes to a type of Generalized Method of Movements (GMM) instrument variable estimator.

The results suggest that the deposits to assets ratio especially under the dynamic approach have a significant impact on the banks liquidity under the base line and stressed scenarios. Furthermore our model suggest that credit risk channel as represented by loan loss provisions(LLPS) plays a role in the banks liquidity position.

The rest of this dissertation is organized as follows: in section 2 a detailed review of relevant literature is provided, section 3 presents the model specification process by stating first its original theoretical foundation and then its final form after econometric and diagnostic tests being carried out. The data description and sources are presented in section 4. Econometric results and their interpretation are analyzed in section 5 and finally section 6 concludes.

2. Literature Review

The literature for stress tests is ever growing and covers more and more financial and economic aspects. Therefore for a comprehensive and complete presentation of the literature relevant to theoretical and empirical studies for stress tests we decided to split it into three parts. The first part covers a survey of stress tests as such, the second refers to stress tests and the risks they explore and the last part discusses tress tests and the country/institutions level of aggregation.

2.1 A Survey on Stress Tests

The financial crisis since 2008 has undoubtedly wakened up the interest of researchers and policy authorities in exploring the causes of such turmoil. At the same time they started developing new and enhancing already existing methods in order to reveal the risks associated with financial instability and foresee the necessary changes for avoiding future financial distress. One of the main tools used for assessing and

forecasting the bankruptcy are stress test methodologies and applications, where either individual banks or the whole financial system are examined for its solvency. These stress test methods, although they share a common target, they diverge in the definitions, methodologies and methods of application. In general terms, stress tests methodologies and applications are not a precise tool but they are an art which requires quantitative techniques, human judgment and a series of discretionary assumptions (Jones et al., 2004). Indeed stress tests comprise one of the main tools for assessing financial fragility, but are not only tools. They are processes which can combine both the microeconomic and macroeconomic perspectives in order to assess the soundness of a financial system (Sundararajan et al., 2002), to measure the risk exposure of a relevant set of institutions and to quantify the sensitivity of an asset portfolio to a range of extreme but plausible adverse events. Since early 90's stress tests methods have been applied with a microeconomic perspective developing credit portfolio models where the two prominent examples are CreditMetrics and CreditRisk+ (Wilde, 1997). Similar exercises were conducted by the rating agencies in order to grade the issuance of corporate bonds. Prior to these, in 1996 the Basel Capital Accord required banks and investment firms to develop stress tests in order to assess the market risk (Basel Committee on Banking Supervision, 2006). Later on, the macroprudential analysis implied by policy authorities, in order to assess the fragility of the whole financial system (IMF 2001), provided the incentive to build up macroeconomic stress tests, in order to identify structural vulnerabilities in the financial system and to assess its resilience to shocks. A well known such analysis framework is the Financial Sector Assessment Program (FSAP) which was introduced in 1999 (Moretti et al., 2008) and is the outcome of a joint effort of IMF and World Bank. A further development of this FSAP model presented a comprehensive macroeconomic stress tests framework, assessing the solvency of both individual banks and whole set of countries (Cihak, 2004). Several attempts in developing of macroeconomic stress tests have been also made by Bank for International Settlements (BIS) which ranges from reevaluating the frameworks where stress tests are used, to studies exploring the process of building appropriate scenarios for the

estimation processes to take place. Furthermore, the Federal Reserve Bank (FED) in US and the Committee of European Banking Supervisors (CEBS) (known today as the European Banking Authority) in Euro area, have conducted a number of macroeconomic stress tests since 2009 providing general guidelines and frameworks for estimating potential threats that financial institutions may come up against (Acharya et al., 2013). Macroeconomic or macroprudential stress tests can be broken down in two main categories of analysis: the sensitivity and the scenario analysis (Quagliariello, 2009). The sensitivity analysis focuses its model estimation only on one risk factor, where on the opposite the scenario analysis incorporates changes in several risk factors simultaneously. A similar distinction has been also been made by Sorge (2004), where the two above approaches are now called the 'piecewise' and 'integrated' one. Applications of scenario and sensitivity analysis have been conducted by FED 2001 and of 2000 applied for central banks of the group of ten, (Fender et al., 2001) and the one conducted by the Committee of the Global Financial System (CGFS) where 293 stress scenarios and 131 sensitivity analysis were applied on 43 large commercial and investment banks, in order to decide which type of risk is viewed as the most important from their perspective (Fender and Gibson, 2001). Nevertheless, a plethora of stress test exercises have been developed, and structured by a scenario analysis approach, even though this method comprises a more complex and costly application but allows more reliable estimates. For that reason as Meleky and Podpiera (2010) mention 'a good co-operation among the macroprudential authorities, the microprudential supervisors and the banking sector, is needed'. Another distinct aspect of the stress test process is that is a step by step approach, where although the distinction between scenario and sensitivity analysis is necessary another distinction is also important in estimating the risk(s) involved and this is the 'top-down' and the 'bottom-up' approaches (Čihák, 2007). In the bottom up approach the impact of a macroeconomic shock is estimated using data on individual portfolios while in the top down approach aggregated data is used. Another way to describe the bottom up and top down approach is that in the former method, policy authorities define the macroeconomic shock or a set of shocks, whereas the in the latter method

the policy authorities imply this kind of shock and analyze its effect on the banking system as a whole. These two approaches are not mutually exclusive, rather they are complementary, even though this matching is not easy, and they act as a useful cross check for each other (Borio et al., 2012). In a survey conducted by IMF in 2013 for a solvency stress test framework applied on the IMF's surveillance of member countries' banking system- S-25 the most systemically important financial systems, they combined the two above mentioned main approaches of bottom up and top down, in order to capture cross validation and the data utilized are on local consolidated basis and the time horizon is for five years in order to take into account Basel III framework. However, this stress test exercise doesn't capture adequately risks in a post crisis period. Moreover, this attempt to build up a solvency stress test, did not take into consideration the integration between solvency and liquidity risk (Jobst et al., 2013).Another aspect, in the implementation process of a stress test, apart from top-down and bottom up choice, is whether the choice of an exogenous shock or a set of shocks is based on historical extreme events – in this case we may draw shocks from the tail of historical distribution (Borio et al,2012) or hypothetical scenarios (Breuer and Krenn, 1999). However, hybrid solutions have been used where both historical and hypothetical extreme but plausible events are combined (Committee on the Global Financial System, CGFS 2005).
Another issue to be decided upon by the stress test applicator is whether the shock or the set of shocks which will stress one or more risk factors are originated from either financial or real economy sector which will in turn affect on banking risks (Quagliariello, 2009). The types of risks, which are usually presented in the banking system, are credit, market, contagion, interest rate, counterparty and liquidity risk. Stress tests methodologies and applications focus on one or more types of risks in order to assess the vulnerabilities caused by exogenous shock either on individual banks or on whole financial systems.

2.2 Stress Tests and Credit Risk

As it has been mentioned above, depending on the stress test analysis –either sensitivity or scenario analysis- the shock or the set of shocks will have an effect on a single risk factor or on a set of risks factors. The most commonly used risk factor is the credit risk. Such an attempt was conducted by IMF (Moretti et al., 2008) in order to assess the financial sector's solvency or capital adequacy according to Basel Accord guidelines. In this paper, stress tests are discussed within the framework of the FSAP model. FSAP stress tests cover more than 120 countries and its aim is to assess the financial stability of a wide- range of financial system using quantitative and qualitative methods based on banks' balance sheet data and early warning systems under macroeconomic scenario analysis. This assessment is applied on bank by bank together with a cross checking of their results through CreditRisk+ and non parametric techniques, emphasizing clearly credit risk than other risks. FSAP also tries to find techniques and methodologies for two main risks namely contagion and liquidity. The latter one is in primary stage and the interpretation of results is based on the number of days a Bank is illiquid or the effect of non- liquidity on capital adequacy ratio (Moretti et al., 2008). Similar to this approach, in 2010 IMF through the "breaking point" methodology, it conducted a stress test process focusing on credit risk and its effect on solvency. This method was applied for underdeveloped financial systems and the analysis is based on 5 banks using ad hoc shocks on scenario analysis methods. The "breaking point method" constitutes a useful tool, even though it is not a stand- alone method, which should be complemented by on site supervision. However it is a useful guide because it gives a sense of the banking system. Therefore it is recommended that in such cases, this kind of methods should be accompanied by similar practices for more types of risks in order to have better monitoring (Ong et al., 2010). In 2011 a stress test exercise, which was also conducted by IMF, was a macro excel based analysis which tried to assess solvency risk through credit risk including Banks which have not adopted Basel II approaches.

In this effort, the lack of data for emerging economies and low income countries combined with the omission of all types of risks that financial institutions confront with, shows that stress tests remain a work in progress because it is necessary to combine more than one risk factor (Schmieder et al., 2011). In addition a survey of pre-crisis credit and portfolio risk models is provided by Foglia (2008). Moreover, in stress test exercises which focus on credit risk it is really important to take into consideration the data used and the method followed depending on the data (Quagliariello, 2009). For example, Pesola (2007) conducted a stress test exercise based on credit risk, using aggregate time series for a panel of ten European countries, but the use of time series could not take into account the credit quality in order to have a more complete assessment for this group of countries. An early study conducted be Pain (2003), based on stress test exercise focused on credit risk of UK banking system, shed light to more prominent econometric approaches such as panel data. Through this study, Pain linked the accounting data to macroeconomic factors using econometric methodology (panel technique). In addition, there are cases where credit risk is assessed through market data with the Merton's model application. A key paper in this area is by Perasan et al. (2006) who built up a stress test exercise for a sample of globally active firms by changing the equity prices into ratings and linking the median sectoral probabilities of default as estimated by Moody's KMV model to macroeconomic variables. However the use of Merton's models has the drawback that it relies on listed companies and households and it does not take into consideration the non-listed ones which comprise an important part of banks' credit portfolios. Nevertheless, stress test exercises that focus on credit risk, it is meant that focus is on forecasting probability of default and assessing defaults on bank balance sheet (Drehman et al., 2006). For this purpose the Loss Given Default is also assumed (Altman et al., 2005). Overall , stress tests exercise that are focused on credit risk, do not have the best and appropriate method because stress tests methodologies and applications depend on data availability and the scope they applied to.

2.3 Stress Tests and other types of Risks

Stress tests are often used by financial institutions as a useful tool for risk management purposes. For this scope there is also a plethora of stress tests applications focused on market risk. Market risk is one of the important types of risk faced by commercial banks. Since 1996 the policy authorities reinforced in order to capture this kind of risk through stress tests exercises in order to assess the capital adequacy of Financial Institutions (Basel Committee on Banking Supervision, 2006). In stress test exercises, market risk is assessed either through historical simulations such as the Long Term Capital Management crisis (CGFS, 2005), or hypothetical stress tests, where only a few risk factors change, such as copulas or factors models (Boss et al., 2006). As it is already mentioned, one of the main issues to be solved before applying a stress test methodology on market risk is the data to be used and the estimation method. In this survey they developed stress test methodologies being applied from large banks and especially those which model market risk, specifically extreme but plausible fluctuations in asset prices. Among the most important results are the ones that reveal (that 2 types of are commonly used, namely the sensitivity and the scenario analysis) that stress tests are seen as complementary tools for risk management and are mainly used for all types of FIs and to a greater extent than Vector Autoregressive models (VAR) for the type of risk mentioned above. More importantly stress tests are considered as the main link between the FI's profile to senior management and subsequently to understand the nature of the firms risk profile (Fender et al., 2001).

Stress tests exercises are conducted either by policy authorities or as integrated tools for Risk Management purposes and primarily focus on credit and market risks. However, there are more types of risks which financial institutions are faced with and it is important for a complete assessment of an individual bank's insolvency or of a set of countries that stress tests exercises to include in their analysis more types of risks. Such an example is the stress test exercise carried out developed by Cihak

(Cihak, 2007). This exercise is a survey that provides a set of practical applications related to stress tests applied on institution by institution data with an Excel based simulation formula. Its main components of risk are the credit, interest rate, exchange rate, contagion and liquidity risks. Although it provides robust results it remains a simplified approach which cannot capture the dynamics of a system comprised by the financial institutions and the financial markets. However, there are stress tests models continue to focus their analysis solely on specific risks such as liquidity risk. Such a research was presented by Willem (Willem, 2009) where he carries out a liquidity stress test is applied on 82 Dutch Banks. He focuses on market and funding liquidity and he considers first and second round effect including price effects on markets which are conducted by behavioral reactions of heterogeneous banks and idiosyncratic reputation effects, Monte Carlo simulation is used for univariate shocks in order to be combined in multi factor hybrid scenario. The application of this scenario analysis is based on more complex process, where stress weights are used for liquid assets and liabilities and applied on each bank separately, whereas the outcome is the liquidity buffer for one month time horizon. His study's results reveal the significance of the liquidity buffers in limiting idiosyncratic risk. The drawback of the above stress test model is that it does not capture the cost of the buffers themselves and further implementation by the usage of group wide liquidity exposures is suggested. A comprehensive recent survey on liquidity stress tests was conducted by the Basel committee's workgroup. Through this survey, it is concluded that the two measures of liquidity namely Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) being recommended by Basel committee III, are adequate to measure liquidity although they also propose alternative measures for quantifying liquidity in stress test framework, such as deposits, commitments, wholesale funding. Finally they presented cases of liquidity stress testing applied on financial institutions s all over the world and discussed how liquidity risk is combined with other type of risks. Nevertheless, as Borio (Borio et. Al. 2012) argues, liquidity stress tests methodologies and applications still remain in infant stage . In addition to this, is the survey conducted by Drehman and Nikolaou (Drehman and Nikolaou

2009) in order to measure liquidity risk for a one week time horizon using available data to central banks. However the problem that still remains in such exercises is the missing link between shocks and liquidity but also the inability to measure liquidity for longer time horizon. However the above, this study is influential for our research as it combines the liquidity risk measurement and some of the most important components of stress tests methodologies in order to correct some of the above drawbacks. As already mentioned my stress test analysis is concerned with Greek banks and is focused on the measurement of liquidity for Greek Banking system. Previous stress tests exercises on an economy level and for the Greek banking system are reviewed in the following section.

2.4 Stress Tests on Country Level

Stress tests methodologies and applications are used as a useful tool for assessing an individual bank, a set of financial institutions, a country or a set of countries. Policy authorities through stress tests exercises try to measure the solvency and the capital adequacy of individual banks, and for the whole financial systems in order to assess the financial situation of a country or a set of countries and to review their decisions and their governance concerning FI's. Such an example of a country level stress test is the one conducted by IMF, EBA and independent agencies for the Spanish banks (EBA 2011). The stress test outcome was that the gap between the required and the current capital ranged from zero to 57 billion Euros. The first official stress test results come early from both FED and CEBS in 2009 and also repeated by FED and Board of Governors of the Federal Reserve System (FED, 2009-2012), while for CEBS conducted such stress tests (later named as EBA) again in 2010 and 2011 (CEBS/EBA, 2010-2011). A basic problem among others for the above stress tests is the 'correct' measurement of risk on risk weighted assets with fixed weights. Meanwhile researchers from the Bank of Finland has applied a stress test model, Peura and Jokivuolle (2003) calculating the loss-given-default and simulating the capital buffer as required by Basel II and compared to the one actually needed. They

use the rating changes for 128 big banks for the G-10 countries covering the period of 1997-2001 and their results suggest that credit losses must be considered when minimum capital requirements are to be projected. A stress test applied for UK banks using a parsimonious VAR technique, Hoggarth et al. (2005) was interesting not only for using macro approach correlating the write –off to loan ratio with key macro variable but also for their results –not proved ex post however - that showed that UK financial system was quite safe to overcome negative shocks similar to the ones that in effect were faced with in the last decade. The stress test on country level continues with the research work taken by Bank of Finland in 2003. They attempt to extend the initial work, (Jokivuolle et al. 2008) on doing stress test on bank's capital requirements under Basel II but now they included macro variables and measured their correlation with corporate credit risk by probabilities to default. Furthermore, in 2010, CEBS (Committee of European Banking Supervisors) provided a wide macro stress test exercise for 91 European banks. This stress test has been conducted on both at system wide and individual institutions' basis using specific data and supervisory information. The stress test was based on a scenario analysis method, focuses on credit, market and sovereign risk in order to assess the capital adequacy of banks and as a result the resilience of the EU banking sector, for a two year time horizon. The stress test takes also into account operational risk by computing the yearly changes in operating profit. Particularly, the key micro parameters used in this simulation are probabilities of default, loss given default and haircut for holdings of government bonds. The purpose of this whole exercise was to measure the tier I capital in EU banking system. The problem was that each country has different governance concerning its financial system and the results do not take into consideration that there are banks which rely on government support. In parallel, in , Melecky and Podpiera(2010), starting from practices applied on central banks in Central and South Eastern Europe, analyzed macro prudential stress tests' weaknesses and strengths, whereas the main contribution through this survey, is the use of judgmental models for the construction of the adverse scenario. Although inconsistent, they allow form cross country examination, when constructing stress scenarios. Credit risk is

associated to NPLS and LLPs. Also for liquidity risk they applied a stress test for this group of countries, except Greece, where these scenarios were based on specific events that could lead to a halt of funding. As liquidity risk indicator the most used ratio is loans to deposits. One of the main advantages of this paper is that they gather together different types of risk exposures and risk factors (for each type of risk mainly credit and liquidity risk under examination). The Bank of Greece has used the deposits and wholesale funding in a static approach for examining liquidity risk as an integrated approach because policy authorities have conducted two main stress tests exercises in order to assess the resilience of Greek financial system. Firstly, in August 2011, the Bank of Greece engaged BlackRock Solutions (BlackRock) to conduct a Diagnostic Assessment of the loan portfolios of a selected group of Greek commercial banks as of 30 June 2011. The Diagnostic Assessment was mandated by the European Commission (EC), European Central Bank (ECB) and the International Monetary Fund (IMF), collectively known as the "Troika," as a condition for the €109 BN assistance package stipulated by the 21 July 2011 Memorandum of Understanding. The banks under examination comprised 7 large and 11 small banks. This macroeconomic scenario analysis with forward-looking macroeconomic assumptions until 2045, focused on loan portfolios of these two groups of Banks, in order to assess the asset quality, data integrity and verification and credit loss projections (CLP). This assessment do not take Bank specific projected operating profit or loss into account nor do they incorporate other factors relevant to Bank capital projections, such as book gains or losses from asset disposals. Likewise, the CLPs do not take into account the Banks' current level of provisions. It is important to note that BlackRock does not express a view on the determination or ability of the Greek State to make payments on guaranteed exposures or to support state owned/affiliated entities. The assumptions made by BlackRock to derive the Credit Loss Projections on state-related loans are purely working assumptions provided by the Central Bank, and do not express an opinion on the ability of the Greek State to meet its obligations, which is outside the scope of the Diagnostic Assessment (BlackRock report, 2011). After two years of debt crisis in Greece which triggered the financial crisis, especially in 2013,

Bank of Greece in co-operation with European authorities and policies and the advisory firm BlackRock, conducted another stress test for Greek Banking system and especially for Alpha, Eurobank, National Bank and Piraeus Bank. This test applied on loan portfolios in order to assess the capital needs of these four systemic banks. The stress test was based on macroeconomic scenario analysis with a time horizon three and a half years. The stress test is divided in two parts where the first one consists on a diagnostic basis on loan portfolios, which was conducted by BlackRock by estimating CLPs for both two scenarios and the second consists on capital needs assessment provided by Bank of Greece and Rothschild, through a bottom up approach. The data of this stress tests are provided by a dynamic balance sheet taking into consideration its composition and size. After stress test exercise, Bank of Greece decided about capital needs and submission for each commercial bank under the baseline scenario. To this end, Bank of Greece, decided that under economic uncertainty, capital needs should be covered by existing capital buffers and mitigating actions (Bank of Greece, 2014). These two stress tests conducted by policy authorities in order to assess the Greek Financial System are limited because they focused on credit risk whereas this financial system depends enough on other types of risk and especially, liquidity risk.

Summarizing the previous review of the stress tests' methodologies and applications, we would argue that when someone wants to examine only the liquidity adequacy of banks he must start from a sensitivity analysis model in order to focus on this specific risk factor. Furthermore the review of studies for the applications of Greek Banking System provide to the researcher guidance for additional research. Therefore my concern with Greek Banking System and stress tests lead me to a formulation of a model which will be able to assess the impact of various bank characteristics on banks liquidity while comparing the Greek Banking System in stressed with non-stressed periods while keeping all other specifications of the model the same. In particular a stressed liquidity risk factor can be considered (such as Deposits to Total Assets ratio) which is likely to have an effect on liquid assets of the whole system taking into

consideration important components of this financial system. This is the purpose and intention of the current study.

3. Model Specification

3.1 Theoretical Approach

Drawing from the Literature review I consider the existence of two (linear) models which have very similar specifications (variables for bank behavior and macroeconomic effects are also considered). The only difference between the 2 models is that the Deposits to Total Assets variable is used separately under two specifications (DEP1 and DEP2) in order to measure/compare its effect both under the baseline and the stressed scenario on the Liquid Assets to Total Assets (LIQAS), the dependent variable.

Model 1: Baseline scenario

$$LIQAS_{it} = GDP_i + UNEM_i + ROA_{it} + BS_{it} + CS_{it} + FIN_t + LLPS_{it} + \mathbf{DEP1_{it}}$$

Model 2: Stressed scenario

$$LIQAS_{it} = GDP_i + UNEM_i + ROA_{it} + BS_{it} + CS_{it} + FIN_{it} + LLPS_{it} + \mathbf{DEP2_{it}}$$

Where i stands for the bank and t for the time frequency data. Usually statements of the banks are reported on annual basis which means that studies conducted are better suited investigating the cross section dimension or the panel dimension. The latter approach is preferred as both the static and dynamic relationships between the variables can be explored.

Continuing with the variables included, they are explained as following:

- **$LIQAS_{it}$** is the dependent variable. It acts as a liquidity indicator of the bank representing the ability of each bank to fund their operations and to cover unforeseen funding requirements. Higher values for the banks imply that they are capable of absorbing financial shocks to a greater extent without a negative impact on their business plans.

- **GDP_i** reflects the annual growth rate of the Gross Domestic Product and acts as a control variable of the country's economic performance. Relationship with LIQAS is anticipated as a positive one since a stable and growing

YEAR	BANKS	*LIQVAS*100*	*ROA*	*UNEM*	*DEP1*	*LLPS*
2000	1	7,97619046	0,93	11,3	56,7753102	5,02
2001	1	7,441941235	0,69	10,7	60,3565376	5,64
2002	1	4,655009917	0,59	10,3	60,9790219	5,92
2003	1	3,499743384	0,95	9,7	60,2887905	6,22
2004	1	5,175276771	1,29	10,5	57,237596	5,45
2005	1	4,905098051	1,71	9,9	47,7854424	4,83
2006	1	5,252245299	1,7	8,9	46,4837076	5,22
2007	1	5,860069202	2,66	8,3	51,4497368	6,20
2008	1	5,161561406	1,79	7,7	60,3651031	7,84
2009	1	3,503472401	0,77	9,5	58,8939794	6,20
2010	1	6,117737598	0,23	12,6	55,5931459	4,41
2011	1	3,605661206	-5,77	17,7	49,0507206	2,77
2012	1	2,504806088	-1,56	24,3	48,7475457	2,01
2000	2	6,960145734	1,61	11,3	78,8514631	6,98
2001	2	3,611866554	1,2	10,7	78,1713741	7,31
2002	2	1,975411007	0,9	10,3	67,1284971	6,52
2003	2	4,296932884	2,87	9,7	62,0141726	6,39
2004	2	4,886649874	3,56	10,5	72,0277078	6,86
2005	2	3,954840454	1,71	9,9	43,3905715	4,38
2006	2	4,940431869	1,75	8,9	44,5160089	5,00
2007	2	3,999824312	1,95	8,3	52,927397	6,38
2008	2	4,930875014	1,49	7,7	55,7099801	7,24
2009	2	3,670720076	0,57	9,5	55,8035289	5,87
2010	2	4,159889254	0,19	12,6	51,2603103	4,07
2011	2	4,375732396	-6,68	17,7	43,2233408	2,44
2012	2	3,150411155	-1,71	24,3	46,339268	1,91
2000	3	15,10136217	7,38	11,3	77,2580171	6,84
2001	3	4,714130235	1,08	10,7	85,1172217	7,95
2002	3	1,590152622	0,51	10,3	83,0779898	8,07
2003	3	2,384132486	0,8	9,7	72,5689682	7,48
2004	3	2,124609714	0,9	10,5	77,1761546	7,35
2005	3	4,038069434	1,31	9,9	71,5884164	7,23
2006	3	5,077106305	1,56	8,9	69,6550165	7,83
2007	3	6,781170798	2,36	8,3	67,1025575	8,08
2008	3	4,101735187	1,93	7,7	65,1600702	8,46
2009	3	3,756404624	1,1	9,5	62,8607587	6,62
2010	3	6,261111305	0,59	12,6	56,546243	4,49
2011	3	3,867126094	-10,75	17,7	56,3830009	3,19
2012	3	4,347645034	-1,81	24,3	56,7246649	2,33
2000	4	10,40735282	1,48	11,3	58,140017	5,15
2001	4	8,595050109	0,51	10,7	60,452113	5,65
2002	4	4,025535338	0,49	10,3	51,5645424	5,01
2003	4	5,333808227	0,69	9,7	58,9074866	6,07
2004	4	6,714232398	0,91	10,5	65,3308047	6,22
2005	4	6,240758337	1,7	9,9	55,7514631	5,63
2006	4	5,544153778	2,16	8,9	54,0898966	6,08
2007	4	6,803713843	2,35	8,3	45,799324	5,52
2008	4	6,281956139	1,38	7,7	50,9233879	6,61
2009	4	4,682909219	0,58	9,5	55,6294047	5,86

2010	4	3,891420598	0,09	12,6	51,0861202	4,05
2011	4	3,775518058	-12,42	17,7	44,8477525	2,53
2012	4	4,124999597	-0,81	24,3	53,9581075	2,22
2000	5	10,18562817	1,35	11,3	48,4817769	4,29
2001	5	6,058063	0,77	10,7	40,4779969	3,78
2002	5	3,750982725	0,6	10,3	80,0397474	7,77
2003	5	3,357522054	0,87	9,7	83,0693772	8,56
2004	5	3,016327917	0,42	10,5	85,4306015	8,14
2005	5	3,742630434	-0,4	9,9	77,6622989	7,84
2006	5	3,262771841	0,03	8,9	78,6384755	8,84
2007	5	4,226628459	0,78	8,3	74,7696983	9,01
2008	5	2,684029067	0,45	7,7	65,6040421	8,52
2009	5	2,801095359	0,14	9,5	65,4901874	6,89
2010	5	1,83256804	-0,08	12,6	70,0200143	5,56
2011	5	1,685647728	-5,54	17,7	74,6434634	4,22
2012	5	2,857439564	-4,46	24,3	75,749006	3,12
2000	6			11,3		
2001	6			10,7		
2002	6			10,3		
2003	6			9,7		
2004	6	2,443373625	9,72	10,5	60,2118044	5,73
2005	6	0,830014749	10,57	9,9	21,3027286	2,15
2006	6	2,364840724	3,74	8,9	65,9296498	7,41
2007	6	2,238699963	1,17	8,3	61,4544681	7,40
2008	6	1,802662781	-2,58	7,7	43,6543835	5,67
2009	6	1,805002122	0,59	9,5	50,2219484	5,29
2010	6	1,967954161	-0,25	12,6	45,8709439	3,64
2011	6	1,783597244	-0,87	17,7		
2012	6	1,804624217	-1,05	24,3		
2000	7	1,820518013	3,53	11,3		
2001	7	1,608961529	3,09	10,7		
2002	7	1,443120443	2,89	10,3		
2003	7	1,309560076	2,23	9,7	71,4688905	7,37
2004	7	1,145900578	1,13	10,5	72,3596886	6,89
2005	7	1,659089563	1,09	9,9	78,2496157	7,90
2006	7	1,209814234	1,15	8,9	82,3950996	9,26
2007	7	0,984807766	0,35	8,3	84,6188099	10,20
2008	7	1,216135014	0,03	7,7	75,7451346	9,84
2009	7	0,616289637	0,13	9,5	70,9430853	7,47
2010	7	2,213695423	-0,2	12,6	74,1801976	5,89
2011	7	2,435620716	-0,9	17,7	89,2614132	5,04
2012	7	1,60164504	-1,21	24,3	93,6294815	3,85
2000	8	3,788909637	0,42	11,3	82,6910774	7,32
2001	8	1,521797192	0,06	10,7	73,6948921	6,89
2002	8	1,590962063	0,17	10,3	80,3867911	7,80
2003	8	7,51089364	0,23	9,7	81,017551	8,35
2004	8	9,183081001	0,18	10,5	81,9095278	7,80
2005	8	3,001953112	0,54	9,9	71,0838073	7,18
2006	8	2,956477402	0,52	8,9	77,2326941	8,68
2007	8	3,162601551	0,5	8,3	74,1092288	8,93

2008	8	3,035769777	-1,15	7,7	75,4270116	9,80
2009	8	3,773884369	-2,18	9,5	73,6977427	7,76
2010	8	2,977780987	-2,66	12,6	63,0025202	5,00
2011	8	2,515122771	-2,89	17,7		
2012	8	2,579907312	-2,36	24,3		
2000	9	14,2263065	0,39	11,3	62,4736395	5,53
2001	9	7,617666386	0,43	10,7	60,1666785	5,62
2002	9	2,262233054	0,3	10,3	77,7119109	7,54
2003	9	2,410180848	0,23	9,7	76,8901377	7,93
2004	9	1,929711714	-4,67	10,5	76,9986043	7,33
2005	9	3,106638484	-0,29	9,9	71,5527049	7,23
2006	9	2,601660778	-2,05	8,9	69,7140926	7,83
2007	9	3,002795697	-0,95	8,3	64,3927165	7,76
2008	9	2,114546934	-0,69	7,7	51,5113908	6,69
2009	9	2,227878575	-2,14	9,5	55,5953256	5,85
2010	9	3,843632314	-9	12,6	55,8184779	4,43
2011	9	1,935120867	-21,21	17,7	56,8076424	3,21
2012	9	3,237557634	-3,52	24,3	79,6728673	3,28
2000	10	14,77796844	1,89	11,3	70,2584512	6,22
2001	10	5,260642518	0,85	10,7	74,9233388	7,00
2002	10	3,056985356	0,3	10,3	78,716143	7,64
2003	10	2,560895	0,42	9,7	83,1520178	8,57
2004	10	3,532457892	-0,38	10,5	82,0423282	7,81
2005	10	3,68361281	0,47	9,9	75,4651262	7,62
2006	10	3,521479552	-0,64	8,9	74,1136178	8,33
2007	10	3,424860352	0,61	8,3	67,1628536	8,09
2008	10	3,009070851	-0,78	7,7	61,7170337	8,02
2009	10	3,857171181	-1,5	9,5	55,062517	5,80
2010	10	3,829736524	-2,93	12,6	46,2241709	3,67
2011	10	3,888630049	-2,87	17,7		
2012	10	4,084858565	-2,71	24,3		
2000	11	10,21807126	0,76	11,3	66,6159979	5,90
2001	11	5,799421289	0,47	10,7	73,1576679	6,84
2002	11	4,029004491	0,14	10,3	77,8057362	7,55
2003	11	4,860716589	0,25	9,7	90,3365191	9,31
2004	11	4,599520268	0,36	10,5	93,9069269	8,94
2005	11	3,596085075	0,72	9,9	86,2159308	8,71
2006	11	4,505793722	0,91	8,9	86,0526244	9,67
2007	11	5,037004256	1,07	8,3	86,1459134	10,38
2008	11	4,555439277	0,11	7,7	74,7874105	9,71
2009	11	3,176601896	-1,28	9,5	69,6927323	7,34
2010	11	2,839314406	-1,36	12,6	63,9488149	5,08
2011	11	2,945328688	-1,65	17,7		2,53
2012	11	2,841579129	-1,79	24,3		2,22

CS	*DEP2*	*FIN*
5,238608273	56,77531017	0,00
6,255399947	60,35653756	0,00
3,40843022	60,97902191	0,00
6,95076731	60,28879046	0,00
7,176160518	57,23759598	0,00
5,078628061	47,78544236	0,00
5,53227857	46,48370756	0,00
6,182831973	51,44973683	0,00
4,651969375	60,36510308	1,00
6,395341438	58,89397937	1,00
6,43486821	43,3626538	1,00
0,827399685	38,2595621	0,00
-0,57790283	48,74754568	0,00
11,19616758	78,85146309	0,00
10,26505906	78,17137407	0,00
7,512020457	67,1284971	0,00
6,289766677	62,01417262	0,00
5,743073048	72,02770781	0,00
5,685505679	43,39057148	0,00
4,946016381	44,51600894	1,00
6,225202407	52,92739704	1,00
4,376898954	55,70998011	1,00
5,123986648	55,80352885	0,00
4,650170156	39,98304205	0,00
-1,462128476	33,71420582	0,00
-3,431125757	46,33926801	0,00
4,262525183	77,25801714	0,00
4,111639356	85,1172217	0,00
4,420579079	83,07798982	0,00
4,250705607	72,56896823	0,00
4,534694106	77,17615462	1,00
5,188298395	71,5884164	1,00
8,645585202	69,65501648	1,00
7,181595921	67,10255754	0,00
5,522548721	65,16007023	0,00
6,812557308	62,8607587	0,00
7,411936175	44,10606953	0,00
-2,33363313	43,9787407	0,00
-3,738877976	56,72466494	0,00
7,085809109	58,14001696	0,00
3,88417695	60,45211302	0,00
4,133482116	51,56454236	1,00
6,894827649	58,90748661	1,00
5,769228451	65,33080472	1,00
5,888630514	55,75146313	0,00
5,242135966	54,08989658	0,00
6,659070924	45,79932395	0,00
5,264255794	50,92338792	0,00
5,733748227	55,62940474	0,00

4,824736571	39,84717378	0,00
-5,096215585	34,98124694	0,00
-4,121918341	53,95810751	0,00
11,12260768	48,48177694	1,00
6,268039414	40,47799695	1,00
6,993491368	80,03974737	1,00
9,302652716	83,0693772	0,00
7,641762269	85,43060148	0,00
6,14541273	77,66229891	0,00
5,004564046	78,63847549	0,00
8,147931611	74,76969825	0,00
7,210160472	65,60404214	0,00
9,21649807	65,49018739	0,00
8,880841706	54,61561115	0,00
3,805480741	58,22190146	1,00
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		0,00
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24,07233475	60,21180442	0,00
73,47713864	21,30272861	0,00
24,35222512	65,92964983	0,00
15,55742976	61,45446805	0,00
13,6520656	43,6543835	0,00
8,208861406	50,22194841	1,00
4,644132756	35,77933622	1,00
		1,00
		0,00
		0,00
		0,00
		0,00
9,632880487	71,46889053	0,00
9,422892469	72,3596886	0,00
7,502595119	78,24961567	0,00
7,061399877	82,39509963	0,00
5,683593433	84,61880987	1,00
3,596614784	75,74513462	1,00
5,615917407	70,9430853	1,00
4,208774427	57,86055414	0,00
-21,03155911	69,6239023	0,00
-27,73308488	93,62948153	0,00
11,42567184	82,69107737	0,00
5,167258874	73,69489208	0,00
2,995592311	80,38679109	0,00
6,528849878	81,01755097	0,00
6,224480419	81,9095278	0,00
5,148520229	71,08380728	1,00
7,300372049	77,23269413	1,00
6,235474757	74,10922881	1,00

4,659431682	75,42701156
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1,337288647	49,14196577
10,66826312	62,47363947
8,298059441	60,16667848
6,511734496	77,71191086
6,341747597	76,89013769
4,262346062	76,99860433
6,130669713	71,55270486
3,493853279	69,71409256
7,017374009	64,39271646
4,595533509	51,51139078
5,626191438	55,59532562
2,075525986	43,5384128
5,02357812	44,3099611
13,83985113	79,67286731
12,18262504	70,25845119
10,44962712	74,92333881
6,904968758	78,71614299
6,752270833	83,1520178
6,830649877	82,04232821
5,425563217	75,46512619
3,702282847	74,1136178
3,263372379	67,16285361
0,764330041	61,71703372
4,038321414	55,06251696
3,558330947	36,05485329
10,29787582	66,6159979
8,495967494	73,15766792
3,664522246	77,80573623
4,54395307	90,33651909
0,62824583	93,90692687
5,74200126	86,21593081
6,338671785	86,05262439
6,098663985	86,14591345
3,0917278	74,78741054
1,936200184	69,69273234
0,0782001	49,88007564