Supervisors as Information Producers: Do Stress Tests Reduce Bank Opaqueness?[o]

Giovanni Petrella[*]

Andrea Resti[**]

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Abstract

Supervisory stress tests assess the impact of an adverse macroeconomic scenario on the profitability and capitalisation of a large number of banks. The results of such stress test exercises have recently been disclosed to the public in an attempt to restore confidence and to curb bank opaqueness by helping investors distinguish between sound and fragile institutions. In an unprecedented effort for transparency, the 2011 European Union stress test lead to the release of some 3,400 data points for each of the 90 participating banks. This makes it an ideal setting to investigate a number of hypotheses on the information role of the stress tests.

In this paper we examine the 2011 European stress test exercise to assess whether and how it affected bank stock prices. Our event study analysis shows that the test's results were considered relevant by investors. The market did not simply look at the detailed historical data which was released after the tests, but also attached considerable importance to variables measuring each bank's vulnerability to the simulated downturn scenario. The latter include proxies for liquidity risk and model risk. Information on sovereign debt holdings, while affecting market reaction on a univariate basis, is not statistically significant in a multivariate setting. We also find that the market is not able to anticipate the test results and this is consistent with the idea of greater bank opaqueness prior to the disclosure of the stress test results. Overall, our analysis shows that stress tests produce valuable information for market participants and can play a role in mitigating bank opacity.

Keywords: stress tests, financial crises, bank opaqueness.

JEL Classification: G01; G14; G21.

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[*] Università Cattolica del Sacro Cuore, Milano (giovanni.petrella@unicatt.it).

[**] Bocconi University, Milano (andrea.resti@unibocconi.it).

1 Introduction

Supervisory stress tests assess the impact of an adverse macroeconomic scenario on the profitability and capitalisation of a large number of banks accounting for a significant share of the overall loans and deposits.

Unlike in the internal stress tests used by individual banks for risk management and capital planning purposes required by the so-called "Pillar Two" in the 2004 Basel Accord, supervisory stress tests are run by all involved institutions based on a common scenario[1] and covering an identical forecast window (typically two years). This makes results highly comparable across banks.

Supervisors may keep the outcome of the test confidential, or make it public in an attempt to curb bank opaqueness, help investors distinguish between sound and weak institutions and restore confidence[2].

In order to assess whether stress tests produce valuable information to market participants, this paper investigates the price changes experienced by European banks after the release of the 2011 stress test results.

Our research is motivated by the following.

First, we address the issue of whether stress test results should be disclosed at all. In fact, it has been argued (Das 2011) that publicly-disclosed stress tests are inherently flawed. This follows from the fact that supervisors cannot test adverse scenarios which are extreme enough to provide a truly "stressed" environment (e.g., scenarios involving the default of one or more sovereign entities), as they might scare investors or simply be politically unpalatable; but if downturn scenarios are perceived as too mild by investors, the stress test results may simply be ignored by the market. Furthermore, if macroeconomic conditions in the following months deteriorate more than anticipated by the "stressed" assumptions (possibly leading to the failure of one or more banks which had passed the test), this dents the supervisors' credibility and may lead to greater market uncertainty[3].

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[1] E.g. a 2% decrease in GDP, a 3% surge in the unemployment rate, a 20% drop in stock prices, etc. See §3.1 for further examples.

[2] Especially if weaker banks are forced to recapitalise when the results are announced.

[3] Also, some banks have argued that, if too many details on balance-sheet composition are made public, this could damage business confidentiality and give rise to legal risks. Also, other market participants could gain insights into one bank's risk profile, e.g. by estimating the amount of needed financial hedges and using this information to carry out arbitrage strategies on the CDS market (Bryant 2011).

Following such concerns, some supervisors have decided not to disclose the results[4]. Other supervisors kept making results public, but instead of releasing a simple, "binary" signal ("pass" vs. "fail") considerably increased the depth and width of the data they release to the market. This is the case of the 2011 European stress tests, which enabled investors to "do the modeling themselves", simulating their own downturn scenarios based on an up-to-date, comprehensive, reliable information set.

This leads us to our second motivation: the 2011 European Union stress test (carried out by the European Banking Authority, EBA) involved a relevant role of the supervisor in the information production process. In fact, EBA released up to 3,400 data points for each of the 90 participating banks[5]. This represents an unprecedented database to study stress tests effects and makes possible to investigate the determinants of market reaction by looking at a uniquely rich set of financial indicators. Also, in the EBA stress test the data template used to release results was the same across all banks and was shared with the public ahead of the publication date. Market participants were therefore able to quickly digest the news and adjust market prices.

A third and somewhat minor motivation is the fact that the 2011 EU stress test was openly criticised by some analysts as ineffective, as it failed to reverse the downward trend experienced by bank stock prices in late 2010 and 2011 (Jenkins 2011b). However, in assessing the market reaction to the 2011 stress tests one must take into account that they took place amidst market jitters caused by the Euro sovereign debt crisis. Accordingly, a rigorous econometric analysis is needed, controlling for confounding effects (e.g., bailout plans for Greece) and focusing on the days immediately following the release of stress test results.

Our paper tests several hypotheses. Did the stress tests produce relevant information for market participants ("irrelevance hypothesis")? If the test's results triggered a market reaction, was this reaction caused by the release of more granular historical data ("zoom hypothesis") or by the resiliency indicators generated by the stress test exercise ("stress hypothesis")?

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[4] This is the case of the 2010-11 US Comprehensive Capital Assessment Review ("CCAR"). Unlike in the 2009 US stress tests, in the CCAR there was no disclosure by the Fed of individual stress test results (Dudley 2011).

[5] This compares with 28 data points and 19 banks in the US 2009 stress tests. See §3.1 below for further details.

Our findings lead us to reject the irrelevance hypothesis: the market significantly reacted upon disclosure of the results. This implies that the stress test revealed new information to the stock market. Additionally, the abnormal returns of tested banks are strongly related to some stress test outputs. These include indicators based on detailed historical information, as well as several ratios expressing the banks' vulnerability to the downturn scenario. Our evidence provides support for both the "zoom" and the "stress hypothesis", and shows that stress tests have provided investors with relevant information and are an effective tool to mitigate bank opacity.

Our paper contributes to the existing literature in the following dimensions.

First, it enters the debate on transparency in bank supervision (Jordan 2000a; Dudley 2009; GAO 2010) by empirically showing that more disclosure about banks' assets and losses can help investors gain a better understanding of the risks and value of banks. This in turn reinforces market discipline (Flannery 2001) and facilitates the macro-prudential oversight of financial institutions (Acharya et al. 2009). Our paper also directly contributes to the debate on whether to disclose stress test results. Second, it indirectly contributes to research on bank opaqueness (Morgan 2002a; Mark J. Flannery, Kwan, and Nimalendran 2004a), as the the fact that stress tests results enhance the market's information set and trigger a price adjustment can be seen as a proof that banks are not fully transparent.

The paper unfolds as follows: §2 summarises previous research results on bank opaqueness and stress tests; §3 presents the main features of the 2011 European stress test; §4 states our testable hypotheses; §5 describes our sample, methodology and key variables; §6 shows our main results, while some robustness checks are discussed in §7; §8 concludes.

2 Literature review

Relative to non-financial companies, banks have a higher share of assets which suffer from a strong degree of opaqueness: loans are informationally sensitive and hard to evaluate for outsiders, while liquid assets can easily be sold, and this makes the information in the financial statements rapidly obsolete. As a result, banks may be harder to assess, for outsiders, than firms from other industries.

A proof of bank opacity is the fact that market prices react to supervisory announcements (Jordan 2000b), meaning that investors were not able to anticipate all relevant information.

Also, split ratings tend to occur more often for banks than for non-bank companies (Morgan 2002; Iannotta 2006), suggesting that the latter are harder to assess, due to stronger opaqueness. Regressions of bank stock returns on market indices show higher R-squares (Haggard and Howe 2007); this means that firm-specific information plays a less significant role for bank stock prices because it is harder to extract than for non-banks.

Several supervisory tools are put in place, including deposit insurance and risk-based capital requirements, to prevent lenders and depositors from being scared away by bank opacity. As opacity tends to increase in times of crisis (Flannery, Kwan, and Nimalendran 2010), additional mechanisms are needed to reassure the market during a financial turmoil.

This was possibly the main motivation behind the supervisory stress tests carried out in the US[6] (2009, 2012) and the European Union[7] (2010 and 2011). By disclosing information on each bank's strengths and vulnerabilities, the supervisors aimed at reducing market uncertainty, stabilise stock prices and prevent panic[8]. The idea was that investors, when presented with a rich flow of data (comparable across banks and somewhat "certified" by the supervisors' intervention), would consider banks less opaque, and therefore better differentiate among them when setting individual risk premia.

Table 2 shows the main characteristics of the four exercises[9] and highlights the amount of information disclosed to investors. While the US stress tests and the one carried out in Europe in 2010 only released a few key figures for each bank, the 2011 EU test was significantly more comprehensive, as it provided up to 3,400 data items for each bank; this included a breakdown of sovereign bonds and other credit exposures by country and duration bands [10].

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6 (Federal Reserve 2009a; Federal Reserve 2012). As mentioned in Footnote 4, a stress test exercise was carried out by the FED also in 2011, but results were not publicly disclosed.

7 (Committee of European Banking Supervisors 2010; European Banking Authority 2011a).

8 To quote the Federal Reserve report whereby the 2009 stress test results were released, "the decision to depart from the standard practice of keeping examination information confidential stemmed from the belief that greater clarity […] will make the exercise more effective at reducing uncertainty and restoring confidence in our financial institutions" (Federal Reserve 2009b).

9 Stress testing exercises have also been carried out, with different scope and depth, by most national authorities in the European Union. See (Quagliariello 2009) for a complete picture of macro- and micro-stress testing approaches in many European countries.

10 As most banks did not have an exposure to all countries and duration bands, many data points (about 73% of the total) were filled with zeroes; note however that those were meaningful zeroes, informing that a given bank was not exposed to that specific combination of duration and nationality. Another 5.3% of the

Table 1: Stress Test Exercises in the US and EU

Exercise	Announcement date	Results release date	Banks covered	# of released data items per bank	Minimum capital target(s)	Capital shortfalls found
2009 Supervisory Capital Assessment Program (SCAP) by Federal Reserve, FDIC, OCC, OTS	February 10, 2009	May 7, 2009	19 domestic bank holding companies, covering 2/3 of the assets in the US banking system	17	Common Tier 1 at 4%, Tier 1 at 6%	10 banks, USD 75 bn.
2010 EU Stress Testing Exercise by the Committee of European Banking Supervisors	December 2, 2009	July 23, 2010	91 banks, covering 65% of the assets in the EU banking system and at least 50% for each country	27	Tier 1 at 6%	7 banks (+17 "near fail"), €3.5 bn.
2011 EU Stress Test by the European Banking Authority	January 12, 2011	July 15, 2011	90 banks, covering 65% of the assets in the EU banking system and at least 50% for each country	3,456	Core Tier 1 at 5%	8 banks (+16 "near fail"), €2.5 bn.
2012 Comprehensive Capital Analysis and Review (CCAR) by Federal Reserve	November 22, 2011	March 13, 2012	19 domestic bank holding companies participating in the 2009 SCAP	41	Common Tier 1 at 5%, leverage at 3-4%	4 (shortfall not disclosed)

Stress tests and their market impact have been investigated by some recent papers. (Hirtle, Schuermann, and Stiroh 2009) provide a qualitative assessment of how the 2009 US exercise (the "SCAP") was received by investors: they find that the process was perceived as rigorous and thorough, transparency was appreciated, the aggregate estimated capital shortfall was seen as reasonable and consistent with other analysts' forecasts, the variation across firms was in line with market expectations. In short, the SCAP was appreciated by investors because it did not add any major unforeseen element to the market's information set; the main piece of news was that the supervisors agreed with market perceptions[11].

A quantitative assessment of the SCAP's market impact is provided by (Peristiani, Morgan, and Savino 2010) using standard event study methodology. Several dates are investigated, including the SCAP's initial announcement, the release of some important clarifications regarding its methodology and policy implications (in terms of mandatory capital injections and possible government interventions), and of course the final disclosure of bank-by-bank figures. Results show that the market only reacted to policy-related clarifications and to the publication of stress test results. Investors were able to anticipate what banks would be required to raise extra capital; accordingly, when actual results were

data points included missing values; most of them were, again, "meaningful missings", e.g. to indicate that banks did not expect any state aid in the following months.

[11] However, Hirtle, Schuermann, and Stiroh also note that "whether the reception would have been positive if […] there had been a negative "surprise" about a firm or a group of firms, remains open to debate".

released, the impact on stock prices was not driven by the "gross" capital shortfall for each bank, but rather by its "unanticipated" component (i.e., net of market expectations). Overall, the stress test exercise was informative to investors in the sense that it produced information about the size of the capital gap.

(Blundell-Wignall and Slovik 2010) look at the 2010 EU stress test with a special focus on the treatment of sovereign debt. In the 2010 simulation, government bonds were subject to a haircut only when held in the trading portfolio, while no credit-related losses were imposed on sovereign exposures in the banking book[12]. They show that 83% of the sovereign debt held by EU banks at end 2009 was instead held in the banking book, and conclude that this could explain why the encouraging results of the 2010 stress test failed to reassure the market[13].

(Beltratti 2011) looks at the 2011 EU stress tests and argues that they provided relevant information to the market since their main outcome (i.e., the capital shortfall associated with individual banks) could not be forecast by combining variables that were already known to investors.

(Cardinali and Nordmark 2011) study the stock market reaction to the 2010 and 2011 EU stress tests by looking at cumulative abnormal returns for tested and untested banks. Their main findings are the following. First, the 2010 results were relatively uninformative to investors. Second, the announcement of the methodology to be used in 2011[14] triggered negative CARs for stress-tested banks while non-tested institutions were roughly unaffected. Third, no major difference occurred between PIIGS and non-PIIGS banks[15].

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[12] The trading portfolio, or trading book, consists of financial assets held at fair value and includes the bank's own position in financial instruments for trading purposes (ie., aimed at generating profits in the short run by buying and selling securities) as well as derivatives held to hedge that position. The banking book includes all other exposures (often long term) which are not held in the trading book.

[13] To some extent, their critique also applies to the 2011 exercise, as again no proper haircut was imposed on sovereign bonds outside the trading book; however, the credibility of the results was improved by the fact that losses were imposed also on sovereign exposures held in the banking book, although indirectly (through a floor on the "expected loss rate" applied to exposures towards banks and sovereigns located in different countries, see Appendix 1 for details).

[14] This included the decision to focus on a "core Tier 1" target of 5% which was considerably more conservative than the one used in the past. "Core Tier 1" refers to high-quality capital, such as common equity and government-sponsored hybrid securities, net of a number of deductions to make the final result robust and comparable across different banks and countries.

[15] PIIGS banks are those headquartered in Portugal, Ireland, Italy, Greece and Spain.

The Cardinali and Nordmark study was carried out prior to the release of the 2011 results, hence it only focuses on the market reaction occurring when the stress test was announced and a number of clarifications were issued by EBA. Our paper extends their work by looking at price changes upon the disclosure of the stress test results and by investigating the main financial indicators driving individual bank returns. Furthermore, we evaluate CARs using a test statistic which is robust to event date clustering (see §5.2).

3 The 2011 EU stress test

3.1 Scope and assumptions

The 2011 EU stress test was carried out by EBA on 90 banks accounting for more than 65% of the total assets in the EU banking system[16]. Starting from the actual financial data at end 2010, the simulation covered two years (2011 and 2012) and consisted of two scenarios: baseline and adverse.

Under the baseline scenario a strengthening macroeconomic recovery was assumed, with GDP growth of 1.7% and 2% in the EU. Under the adverse scenario, GDP would instead shrink by 0.4% in 2011 and stay flat in 2012; meanwhile, equity prices would drop by 15%, short-term risk-free rates would increase by 1.40% and long-term ones by 1.25%. Credit spreads for sovereign debts in Europe would also pick-up, with different increases for individual countries. The US dollar would devaluate by 11%.

Based on such assumptions, banks were requested to use their internal models to generate values for balance-sheet items and P&L results. In doing so, however, they had to follow a detailed methodology dictated by EBA. Firm-specific assumptions, as well as results generated by individual banks, were subsequently cross-checked by national supervisors and by EBA, and further calibrated when necessary.

3.2 Key dates

Figure 1 shows the timeline of the 2011 EU stress test. This was first announced by EBA on 13 January 2011 ("first announcement date") with few details concerning the expected duration of the exercise and EBA's commitment to make results public.

[16] A variable number of banks were included for each country, starting from the largest one and stopping when at least 50% of the total assets was covered. National supervisors could add further banks to the sample (e.g., Spain included several other minor banks).

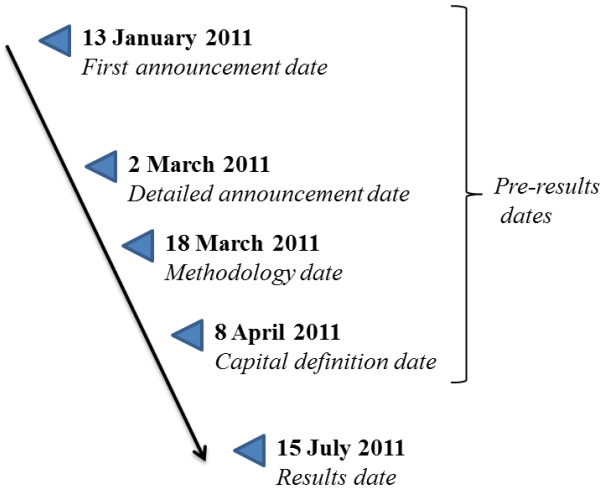

Figure 1: Timeline of the 2011 EU stress test

On 2 March 2011 ("detailed announcement date") EBA outlined the overall logic underlying the simulation exercise and stated that EU national governments might put in place "remedial back stop measures" (i.e., capital increases) to address any weaknesses revealed by the stress test.

The methodology to be used in simulations was disclosed on 18 March 2011 ("methodology date") with a 51-page note[17] describing how the main items in the banks' balance-sheets and P&L accounts had to be generated (including, e.g., haircuts to be applied to sovereign exposures). On that date, EBA also clarified that public support would count as capital as long as it would be fully committed by end April.

On 8 April 2011 ("capital definition date") EBA released the list of banks participating in the stress test exercise, and defined the "core Tier 1 capital" (equity and retained profits) to be used in the test. It also clarified that any form of public support, would be given separate evidence in the stress test results.

The stress test outcome were released on 15 July 2011[18] ("the results date"). We refer to all other dates as the "pre-results dates"[19].

[17] (European Banking Authority 2011b).

[18] The publication date for the stress test results was announced on 8 July 2011.

[19] On 9 June 2011 a clarification note (European Banking Authority 2011c) was circulated to the banks, aimed at improve consistency across different banks. This addressed several aspects of the stress testing exercise, mainly the treatment of exposures to banks and sovereigns, and implied an upward revision of the haircuts applied to sovereign securities in the trading book (making the test more conservative and

3.3 Disclosed outputs

Individual bank results were disclosed to the public through a MS Excel template including several sections. Disclosed outputs included:

- data on risk-weighted assets and own funds; the latter included a breakdown of items recognised as core Tier 1 by EBA, compulsory deductions, governmental support and other mitigating measures fully committed by 30 April 2011;
- key P&L figures, including net interest income, trading income, impairments, other income/losses and net profit after tax;
- details on provisions, loss rates and coverage ratios for performing and non-performing exposures, with separate evidence on retail, corporate, bank and sovereign portfolios;
- a breakdown of credit exposures by geographic area, counterparty and default status;
- a breakdown of sovereign exposures by geographic area, accounting treatment (e.g. trading book, fair value option, available for sale, etc.), duration band. This included derivative exposures at fair value.

4 Testable hypotheses

We test three major hypotheses concerning the market reaction on the results date and two possible effects occurring on pre-results dates.

As for the results date, the first testable hypothesis is the

- *irrelevance hypothesis*: when the stress test results are released, no price change can be observed over the relevant event window. This signals that the stress testing exercise does not convey new information to the market, possibly because it is technically flawed or lacks credibility (e.g., because political constraints prevent an adequately conservative scenario). This hypothesis is made plausible by the sharp critiques that accompanied the stress tests (Jenkins 2011b; The Economist 2011), the constraints met by EBA in terms of IT and human resources, and the fact that

consistent with the deterioration experienced by PIIGS bonds in the last few weeks), as well as minimum loss rates for sovereign exposures in the banking book. We are not going to investigate this date in detail as the note was not made public.

some national supervisors were sometimes seen as only half-heartedly committed to the data gathering and validation process.

In case the irrelevance hypothesis is rejected, then the market reaction should be consistent with the stress test outcomes and stock returns should be higher for banks which emerge as relatively stronger from the test. If this is the case, however, the market might be using two types of information to identify what banks are stronger. This leads to two additional hypotheses

- *zoom hypothesis*: the market reaction to stress test results is driven by new information concerning historical financial data, that is, by a "zoom" on the banks' current financial statements providing investors with further details hitherto undisclosed (e.g., the breakdown of sovereign exposures to peripheral euro-zone countries). In its most extreme version, this hypothesis implies that investors do not rely on simulated figures (e.g., because the underlying assumptions are too mild) but instead only focus on the detailed historical data released with the stress test results, possibly to define their own downturn scenarios.
- *stress hypothesis*: the market reaction to the stress test results is driven by variables capturing each banks' resilience to the simulated downturn scenario. This means that the simulation run by supervisors is deemed overall sound and credible: it might underestimate the impact of a downturn scenario, but still can spot highlight individual strengths and weaknesses across banks.

The policy implications of the zoom and stress hypotheses are straightforward: if the former prevails and the second is rejected, there is no reason for simulation results to be released to the market. Supervisors should instead carry out stress tests confidentially, without wasting time and efforts in cleaning, releasing, and explaining simulated data. Opacity should be addressed by enhancing the financial data that banks are already mandated to release (e.g., under the so-called Pillar 3 of the Basel Accord). Downturn scenarios and their implications should only be discussed bilaterally between bankers and supervisors.

Regarding pre-results dates, we test for the existence of two further effects:

- *transparency effect*: as soon as a round of stress tests is announced (implying that bank-by-bank results will be disseminated to investors in the future) stock prices of stronger banks rise in anticipation of the benefits associated with lower opaqueness;

- *dilution effect*: when a stress test is announced, investors fear the dilution following from the rights issues that will be imposed upon under-capitalised banks. This leads to a drop in bank stock prices.

If investors can guess how individual banks will emerge from the test (and differentiate pre-results reactions accordingly), then the transparency effect will benefit stronger banks, while the dilution effect will hit weaker ones. If, instead, investors cannot anticipate individual stress test results, then both the transparency and the dilution effects may affect all tested banks, and could in principle offset each other.

5 Sample and methodology

5.1 Sample

We start by taking all 201 banks included in the Thomson Reuters European Banks index (g#LBANKSER), covering more than 75% of the European banking industry by market cap. 51 of these banks participate in the stress test; we add three more listed institutions that took part in the 2011 exercise but are not included in the index[20], and this completes our sample of 54 "tested banks" (out of 90 participating in the stress test, the other 36 being unlisted).

Our control sample ("non tested banks") includes all the institutions (45) that belong to the Thomson Reuters index and are incorporated in countries considered in the stress test, but did not participate in it.

5.2 Methodology

Our test follows standard event study techniques (Campbell, Lo, and MacKinlay 1997). The abnormal return AR_{jt} for bank *i* at time *t* is the difference between the actual stock return R_{jt} and a measure of "normal" return (NR_{jt}) generated by a market model. The latter is a one-factor model based on *country-specific* stock market indices[21]. We do not use a

[20] Allied Irish Banks, Banca Civica and Bankia.

[21] These are the DAX 30 (Germany), Belgium 20 (Belgium), Bulgaria SE SOFIX (Bulgaria), Cyprus General (Cyprus), Prague SE (Czech Republic), OMX Copenhagen (Denmark), IBEX 35 (Spain), OMX Helsinki (Finland), SBF 120 (France), Athex Composite (Greece), Budapest BUX (Hungary), Ireland SE ISEQ (Ireland), FTSE Italia All Share (Italy), Malta SE MSE (Malta), AEX (Netherlands), OSLO SE OBX (Norway), Wiener Borse (Austria), Warsaw General Index 20 (Poland), Portugal PSI 20 (Portugal), Romania BET (Romania), Russian MICEX (Russian Federation), SBI 20 (Slovenia), OMX General (Sweden), Swiss Market (Switzerland), Istanbul SE 100 (Turkey), FTSE All Share (UK).

pan-European index for all banks as sovereign risk represented in 2011 a major driver behind price movements for European stocks. A market model based on a European index would not properly account for country-specific effects, consequently large abnormal returns would probably emerge due to national shocks rather than to firm-specific factors. By using national stock-market indices, instead, one can be confident that residuals will only include idiosyncratic effects.

As a robustness check we also estimate a two-factor model including both national stock market indices (as above) and an industry-specific index (the Morgan Stanley Capital International – MSCI Europe Banks). Such a two-factor model helps control for industry-wide effects and highlight differences across banks; results based on it will be mentioned in the footnotes as appropriate.

Both models are estimated on a 200-day window ranging from t^*-210 to t^*-11, where t^* is the event date to be tested (see §3.2 for details). This estimation window is consistent with previous research[22].

Using cumulative abnormal returns (CARs) we perform both a univariate analysis (on all dates) and multivariate analysis (on the results date).

In our univariate analyses we use a 5-day event window including 2 days before the event and 2 days thereafter (-2,+2). This is general enough to be applied across all announcements without tampering with individual dates, as it incorporates both the risk of a news leak before the announcement and the possibility that investors react slowly as the implications of the news are properly digested.

To assess the statistical significance of the CARs in the univariate analyses we use a modified version of the test statistic recently proposed by (Kolari and Pynnönen 2010). When there is event-date clustering, like in our case, cross-correlation among stocks may lead to over-rejection of the null hypothesis of zero average abnormal returns. To control for this, Kolari and Pynnönen adjust the variance of the mean abnormal return in the event period using the correlation of the residuals in the estimation period:

[22] (Weston, Mitchell, and Mulherin 2004) suggest an estimation window of 200 trading days; (Boehmer, Broussard, and Kallunki 2002) indicate that such estimation window is used by most researchers; (MacKinlay 1997) suggests a 120-day window; (Thompson 1995) supports using 60 observations for monthly data and 250 observations for daily data.

where is the average standardized cumulative abnormal return, is the cross-sectional standard deviation of the standardized cumulative abnormal returns, is the number of stocks and is the average cross-correlation of the estimation period residuals[23].

On the results date we also study the determinants of the CARs with a multivariate Weighted Least Square (WLS) regression model to account for the fact that abnormal returns are estimated values. Each observation is weighted by the inverse of the root mean squared error from the regression used to estimate market model parameters. Observations with smaller variances receive larger weight and therefore have greater influence on the estimates (Greene 1993, 556).

This multivariate analysis uses CARs computed on post-event days only, that is on a (0,+2) window that covers the announcement day and the following two trading days[24]. We do not include any pre-event day because univariate results (see §6.2.1) show no sign of news leaks in the days leading to the announcement; this is confirmed by a thorough inspection of press articles and news releases. We include two post-event days to take into account the amount and complexity of the information that investors had to factor in; this allows enough time for equity analysts to update their models with the new data and to issue new reports[25]. We stop at t^*+2 to eliminate the risk that our results be disturbed by subsequent news[26].

[23] In our tests for differences between subgroups, we estimate the correlation of the residuals separately within the subgroups (i.e., the average correlation within group 1 and within group 2) and between them (i.e., the average correlation between group 1 and group 2).

[24] As the stress test results were released after market close, we use the following trading day (18 July) as the event date.

[25] According to I/B/E/S 52 recommendations on the European banks in our sample were issued by equity analysts between Friday July 15 (average release time: 6:43 PM GMT) and Wednesday July 20; two thirds of them concerned stress-tested institutions. While most analyses were published late on July 15, reports continued in the first days of the following week, with 13, 6 and 8 recommendations issued on Monday, Tuesday and Wednesday. This compares with 20 recommendations issued in the same period of 2010 (from Friday 16 to Wednesday 21 July 2010).

[26] On day t^*+3 (July 21) an additional €109bn bail-out plan was agreed by EU Leaders for Greece (Spiegel and Peel 2011), which had a strong positive impact on bank stock prices (Dennis 2011).

5.3 Explanatory variables in the multivariate analysis

To test the stress and zoom hypotheses we regress CARs on the results date on a set of indicators based on the stress test data. As the latter included more than 3,000 items, a selection strategy is needed to focus on the most relevant regressors and avoid the risk of data mining.

Figure 2 outlines our approach. We start with the capital adequacy ratio at end 2012 under the stressed scenario ("stressed CT1 ratio in 2012"). This is based on high quality capital (also known as "Core Tier 1" or CT1) and summarises most factors captured by the stress test exercise (initial capital ratio at end 2010, profitability expectations, credit and market losses, etc.). This ratio was used by EBA as a trigger: a value below 6% was most likely to prompt a request for additional capital. As such, it was most likely to spark market reactions.

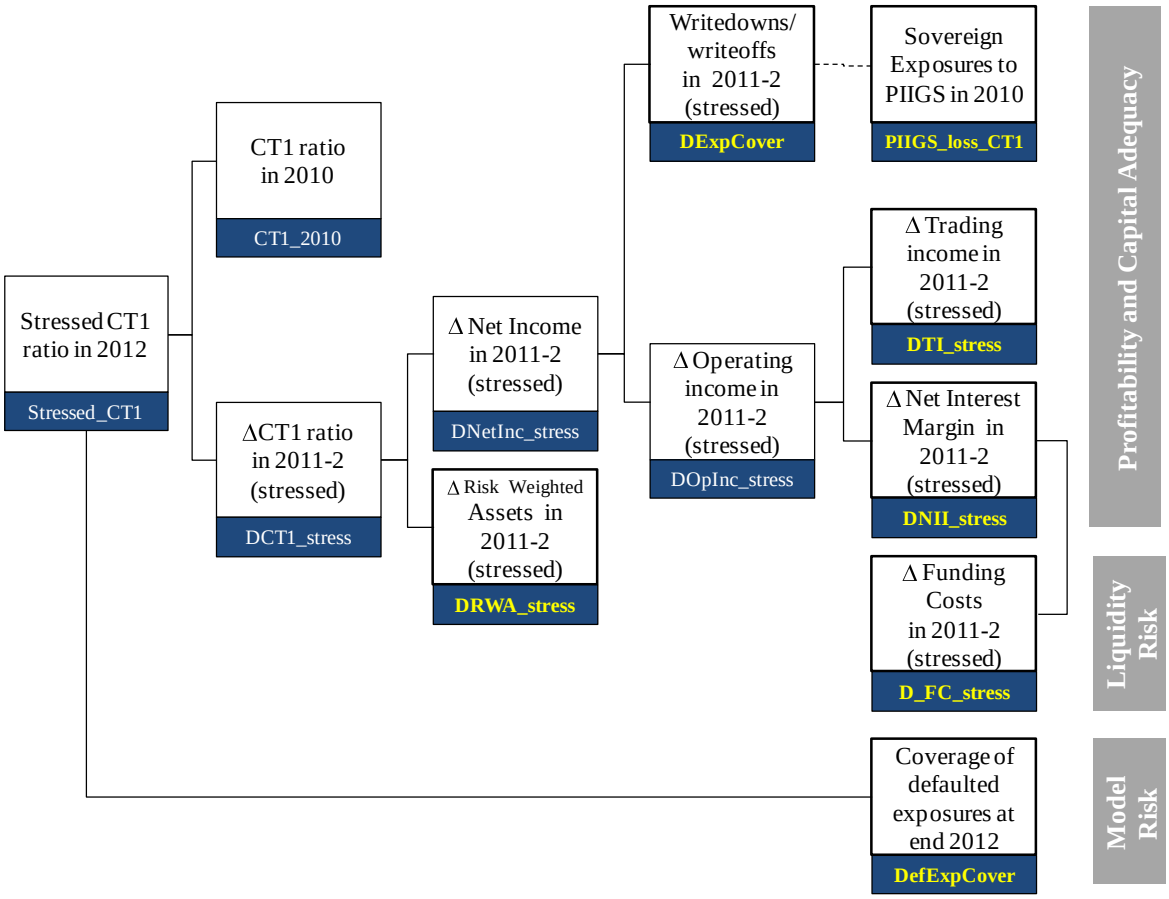

Figure 2: Main variables to be tested

Moving left to right in the figure, we decompose this stressed capital ratio into its two main drivers: the initial capital ratio at end 2010 and the drop in capital adequacy caused by the downturn scenario.

The former indicator ("CT1 ratio in 2010") may have no impact on market prices, as it hardly represents a surprise for investors (information on own funds were already available in the 2010 statements). However, not all items qualifying as supervisory capital under the current rules were deemed acceptable by EBA, as further filters and deductions were imposed in order to ensure conservatism and cross-country consistency. Although the criteria used to define this "Core Tier 1" had been released by EBA a few weeks before the stress test results, their application to individual banks involved some discretionary choices and the final result was, to some extent, uncertain. In this sense, the information on eligible capital might not have been fully anticipated by the market; this is especially true for smaller institutions, as less information on their capital items is usually available and less analyses are provided on them on a continuous basis .

The second indicator (the change in the capital ratio caused by the stress scenario) can in turn be decomposed into two factors: the net profits/losses in stressed 2011 and 2012 (which would affect capital, i.e., the numerator of the ratio) and the change in risk-weighted assets at end 2012 (the denominator). The latter might have played a limited role in the EBA stress test since the simulation methodology required banks to assume that total assets would remain unchanged over the whole forecast window[27]. However, even keeping total assets unchanged, risk-weighted assets could increase due to a shift in the risk-weights (e.g., due to massive downgrades).

As shown in the figure, net profits/losses can be due to operational profits ("Δ Operating Income in 2011-2 (stressed)") and/or to extraordinary credit losses and provisions against credit risk ("Writedowns/writeoffs in 2011-2 (stressed)")[28]. The former are mainly driven by net interest margin and trading income. Under the simulation scheme designed by EBA, interest-based income was strongly affected by the increase in each bank's funding costs.

[27] This was meant to prevent banks from stating that they would achieve capital adequacy through deleveraging (asset cuts) rather than through new capital.

[28] As argued by (Onado 2011), when stress test results were released stock prices may have reacted more to the announcement of a structural drop in the profitability of the traditional banking business (namely, a decrease in net interest margin triggered by higher funding costs) than to the risk of significant one-off losses due to extraordinary events (like sovereign defaults, turmoil in equity and currency markets, etc.).

The idea was that the rise in market rates associated with the stressed scenario would immediately translate into higher wholesale funding costs, while retail deposits would remain partly unaffected. Consequently, institutions relying heavily on interbank facilities would suffer a sharper increase in the average cost of funds. The change in funding costs associated with the stress scenario ("Δ Funding Costs in 2011-2 (stressed)") can therefore be seen as an indirect measure of liquidity risk[29].

Although the EBA and the national supervisors paid considerable attention to the way that individual banks estimated credit losses and write-downs, sovereign risk is an area where the stress test may not have been adequately conservative. As it clearly would have been politically unacceptable, for the European bank supervisor, to assume that one or more EU countries could default, the simulation scheme only required that a set of fixed loss rates be applied to bonds issued by various European countries. This approach was seen as too mild by most analysts and financial columnists[30]. However, as pointed out by EBA itself, the stress test results offered an unprecedented degree of detail on sovereign bonds held by individual banks (including gross and net positions broken down by country and duration bands). Hence, any investor could carry out her own simulations based on more conservative assumptions. To see if this really occurred, we also test a few indicators based on the banks' exposure to PIIGS at end 2010. The main one is a rough estimate of the possible losses on net exposures towards PIIGS countries (which we set equal to 25% of the booked amount), scaled by core Tier 1 capital at end 2010. Using a flat loss rate across all PIIGS countries[31] also ensures that this variable can be used as an indicator of PIIGS debt holdings, since losses and holdings only differ by a constant.

[29] Information on liquidity risk was collected by EBA during the 2011 stress test, but no results were disclosed to the public. Hence "Δ Funding Costs in 2011-2" was one of the few proxies for liquidity risks (possibly the only one) provided to investors. Also, unlike other liquidity indicators (e.g., the ratio of liquid assets to short term claims), which might quickly become obsolete as banks continuously recalibrate their portfolios, this indicator is structural in nature, so it conveys a more stable type of information.

[30] See e.g.(Jenkins 2011a; The Economist 2011). Notably, just a few weeks after the stress tests results were released even the IMF claimed that bank capital in Europe had to be raised significantly above the thresholds used as a safety level in the test (Financial Times 2011).

[31] It may be argued that applying a flat 25% loss rate across all five PIIGS countries (and a 0% loss rate to the remaining ones) may over-simplify the market's view of sovereign credit risk. In §7 we therefore also test an alternative proxy.

The last indicator to be tested is the coverage ratio on defaulted exposures at end 2012. The idea is that, for any amount of defaulted exposures, a bank is safer if a large share of them has already been written-down and/or covered with provisions. A low coverage means a stronger risk of extra losses if recovery rates turn out to be worse than expected; conversely, a coverage ratio close to 100% suggests that very low recoveries have already been factored in and there is limited scope for bad surprises. Hence, all other things being equal, a higher coverage ratio on defaulted exposures makes simulation results more credible. Note that, just like the increase in funding costs can be seen as a proxy for *liquidity risk*, the coverage ratio provides information on *model risk* (i.e., the risk that the internal models used by individual banks prove overly optimistic when simulating stressed results).

Table 2: Main explanatory variables

Variable	*Legend*
Stressed_CT1	Core Tier 1 ratio at end 2012 in the downturn scenario
CT1_2010	Core Tier 1 ratio at end 2010, including mitigating measures up to April 30 2011
DCT1_stress	Decrease in Core Tier 1 moving from 2010 to 2012 (stressed)
DNetInc_stress	Decrease in 2012 net income moving from baseline to stressed, scaled by 2010 total assets
DRWA_stress	Increase in risk-weighted assets moving from 2010 to stressed 2012
DOpInc_stress	Decrease in 2012 operating income moving from baseline to stressed, scaled by 2010 total assets
DNII_stress	Decrease in 2012 net interest margin moving from baseline to stressed, scaled by 2010 total assets
DTI_stress	Decrease in 2012 trading income moving from baseline to stressed, scaled by 2010 total assets
D_FC_stress	Increase in the cost of funding (in basis points) moving from 2010 to stressed 2012
DExpCover	Increase in coverage ratio for credit exposures (due to write-downs and provisions) moving from 2010 to stressed 2012
PIIGS_loss_CT1	Estimated loss on sovereign bonds issued by PIIGS (set to 25% of current value) over Core Tier 1 at end 2010
DefExpCover	Coverage ratio for defaulted exposures in stressed 2012

The black boxes in Figure 2 show the short names of the variables to be tested; the same labels are shown in Table 2, together with full definitions.

6 Findings

6.1 Pre-results dates

We compute cumulative abnormal returns around pre-results dates and compare the reactions of tested and "non tested" banks. Also, we rank tested banks by Stressed_CT1 (i.e., the Core Tier 1 ratio at end 2012 in the downturn scenario) and compute average CARs for the bottom 20% and the top 20%. We then test whether the difference between the two subgroups is statistically different from zero. In this way we check whether the market could anticipate the stress test's outcome (since Stressed_CT1 would only become known on the results date); this would not be the case if banks are opaque.

Table 3 summarises our findings for the pre-results dates. For each announcement we provide CARs over the (-2,+2) window, as well as a breakdown between pre-event and post-event days[32].

The first announcement (with the commitment to publicly disclose the results) has a positive impact on the prices of tested banks[33], but the gap relative to non-tested ones is not statistically significant. Also, the market seems not to be able to anticipate what banks were worse equipped to withstand a stressed scenario, although banks with a high Stressed_CT1 (those for which an increase in transparency would be most beneficial) experience a positive abnormal return in the post-event window.

On the detailed announcement date, EBA made reference to "remedial backstop measures" to be put in place for weaker institutions. This might have increased the perception of a dilution risk, in case new rights issues were pushed through by supervisors at heavily discounted prices. While non-tested banks did not react, tested ones showed an average negative CAR of 2.4%. Again, no special pattern can be observed regarding "bottom" and "top" banks.

When the actual stress test methodology was disclosed, tested banks experienced a negative return again, while no reaction occurred in the control sample. This could be due to the fact that the 2011 methodology was both more conservative and more detailed than

[32] Results based on the two-factor model are qualitatively similar and available upon request from the authors.

[33] Although the list of participating banks was only released at a later stage, these were almost identical to those enrolled in the 2010 exercise, so investors were in a position to make an educated guess.

the one used one year before, so it could lead to a bigger capital shortfall and a stronger dilution[34].

Table 3: Market Reactions around the pre-results dates

		CAR (-2,2)		CAR (-2,-1)		CAR (0,2)	
	# obs	Avg	p-val	Avg	p-val	Avg	p-val
(a) First announcement date (January 13, 2011)							
Full Sample	95	1.8%	0.07	1.1%	0.11	0.7%	0.29
Non Tested Banks	45	0.7%	0.37	0.4%	0.44	0.3%	0.57
Tested Banks	50	2.7%	0.04	1.7%	0.07	1.0%	0.29
Non Tested - Tested		-2.0%	0.15	-1.3%	0.22	-0.6%	0.43
Bottom 20% by Stressed_CT1	9	2.6%	0.26	2.8%	0.14	-0.2%	0.97
Top 20% by Stressed_CT1	9	0.8%	0.47	-0.6%	0.60	1.4%	0.04
Bottom - Top		1.7%	0.37	3.4%	0.02	-1.6%	0.39
(b) Detailed announcement date (March 2, 2011)							
Full Sample	102	-1.4%	0.07	-0.6%	0.23	-0.7%	0.19
Non Tested Banks	51	-0.3%	0.72	0.0%	0.82	-0.3%	0.57
Tested Banks	51	-2.4%	0.02	-1.3%	0.08	-1.2%	0.09
Non Tested - Tested		2.1%	0.01	1.3%	0.02	0.8%	0.12
Bottom 20% by Stressed_CT1	9	-2.1%	0.31	-0.8%	0.24	-1.3%	0.56
Top 20% by Stressed_CT1	10	-2.3%	0.03	-0.9%	0.19	-1.4%	0.20
Bottom - Top		0.2%	0.45	0.1%	0.53	0.1%	0.68
(c) Methodology date (March 18, 2011)							
Full Sample	98	-1.0%	0.20	-0.6%	0.33	-0.4%	0.49
Non Tested Banks	47	-0.2%	0.91	-0.2%	0.83	0.0%	0.97
Tested Banks	51	-1.6%	0.08	-0.9%	0.24	-0.7%	0.25
Non Tested - Tested		1.4%	0.03	0.7%	0.17	0.7%	0.13
Bottom 20% by Stressed_CT1	9	-1.7%	0.19	-1.0%	0.26	-0.7%	0.50
Top 20% by Stressed_CT1	10	0.1%	0.91	-0.1%	0.96	0.2%	0.94
Bottom - Top		-1.8%	0.14	-1.0%	0.30	-0.9%	0.52
(d) Capital definition date (April 8, 2011)							
Full Sample	95	1.1%	0.12	1.1%	0.04	0.0%	0.60
Non Tested Banks	45	0.2%	0.56	0.5%	0.22	-0.3%	0.77
Tested Banks	50	2.0%	0.08	1.7%	0.03	0.3%	0.44
Non Tested - Tested		-1.9%	0.11	-1.2%	0.08	-0.7%	0.33
Bottom 20% by Stressed_CT1	9	-0.6%	0.77	0.7%	0.50	-1.3%	0.61
Top 20% by Stressed_CT1	9	3.8%	0.01	1.8%	0.08	2.0%	0.02
Bottom - Top		-4.4%	0.13	-1.2%	0.77	-3.2%	0.01

This table reports the number of observations and the average cumulative abnormal returns (CARs) estimated over the event windows (-2,2), (-2,1) and (0,2) centered on pre-results dates, with a one-factor model as well as a two-factor model for the full sample, non tested banks, tested banks, bottom 20% banks and top 20% banks based on the Stressed_CT1, as defined in Table 2. This table also reports the p-value of the t test of the null hypothesis that the average standardized CAR (i.e., the CAR divided by the standard deviation of the estimation period adjusted for the length of the event window) is zero and the difference between average standardized CARs of "bottom" and "top" banks is zero.

[34] Furthermore, upon release of the methodological note EBA clarified that only legally binding recapitalisation plans signed before 30 April 2011 would be incorporated in the assessment; this reinforced the trend towards raising capital ahead of the end-April deadline and might have spurred further fears of dilution. During the following weeks many large banks (e.g., Commerzbank and Intesa Sanpaolo) announced capital increases for several tens of billions.

On April 8 the EBA clarified that the definition of capital to be used in the stress test exercise would be more conservative than the one dictated by Basel 2, and would somehow anticipate the additional constraints and limitations brought about by the Basel 3 framework. This had a positive impact on tested banks, especially for the "top" ones, i.e. those which would benefit more from a supervisory "certification" based on strict capital quality standards[35].

Overall, our analysis of pre-results dates provides some support for the dilution effect: the market anticipates that tested banks – more than untested ones – will be under severe scrutiny and might be forced to issue equity with depressive effects on stock prices. We also find that the market is not able to anticipate the stress test results, except on the capital definition date[36]. This evidence is consistent with bank opaqueness prior to the disclosure of the stress test results.

6.2 The results date

6.2.1 Univariate analysis

Table 4 provides detailed univariate tests on the results date. The layout is similar to Table 3, except that banks are not only ranked by Stressed_CT1, but by all the variables in Table 2 since full details for all indicators were known to the market at that time.

Tested banks show a positive reaction over the (-2, +2) window, whereas non-tested banks experience negative abnormal returns (see panel a). The difference between the two groups is statistically significant and this means that the stress test revealed new information to the market on tested banks.

When tested banks are ranked according to the stress test results (see panel b), almost no significant difference can be found between top and bottom ones in the pre-event period[37]. This is again consistent with bank opaqueness prior to the disclosure of the stress test results.

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[35] Even then, however, two out of three pairwise tests are not significant, the only exception being the post event window.

[36] On the capital definition date, however, the market reaction may also have followed from the fact that investors knew about the capital increases that would be carried out by some banks in the following three weeks to meet the April 30 deadline (see Footnote 34).

[37] When one looks at the p-values for the "bottom vs. top" tests, only one out of 12 is below 5% (the Core Tier 1 ratio at end 2010). Even in this case, however, none of the two subgroups (Bottom and Top 20%) shows CARs that are different from zero at 5%. Accordingly, as mentioned in §5.2, our multivariate analysis will focus on the post-event window only.

Table 4: Univariate Analysis of the release date

		CAR (-2,2)		CAR (-2,-1)		CAR (0,2)	
	# obs	Avg	p-val	Avg	p-val	Avg	p-val
(a) Results for full sample, control sample and tested banks							
Full Sample	97	0.2%	0.76	-0.5%	0.42	0.7%	0.28
Non Tested Banks	46	-0.6%	0.28	-0.8%	0.16	0.1%	0.97
Tested Banks	51	0.8%	0.28	-0.3%	0.76	1.1%	0.13
Non Tested - Tested		-1.5%	0.03	-0.5%	0.38	-1.0%	0.06
(b) Results stratified by several financial indicators based on the stress test results							
Bottom 20% by Stressed_CT1	9	-1.1%	0.87	-0.9%	0.93	-0.2%	0.89
Top 20% by Stressed_CT1	10	1.4%	0.34	-1.1%	0.18	2.5%	0.09
Bottom 20% - Top 20%		-2.5%	0.23	0.2%	0.18	-2.7%	0.02
Bottom 20% by CT1_2010	9	1.4%	0.32	0.9%	0.44	0.5%	0.59
Top 20% by CT1_2010	10	0.9%	0.61	-1.2%	0.20	2.1%	0.21
Bottom 20% - Top 20%		0.5%	0.55	2.1%	0.05	-1.6%	0.40
Bottom 20% by DCT1_stress	9	2.3%	0.06	0.1%	0.69	2.2%	0.08
Top 20% by DCT1_stress	10	-0.4%	0.83	-0.5%	0.70	0.2%	1.00
Bottom 20% - Top 20%		2.7%	0.02	0.6%	0.46	2.0%	0.04
Bottom 20% by DNetInc_stress	9	0.1%	0.83	-1.5%	0.19	1.6%	0.32
Top 20% by DNetInc_stress	10	-1.1%	0.99	-1.6%	0.18	0.5%	0.45
Bottom 20% - Top 20%		1.2%	0.83	0.1%	0.61	1.1%	0.61
Bottom 20% by DRWA_stress	9	3.1%	0.05	0.6%	0.89	2.5%	0.02
Top 20% by DRWA_stress	10	-0.1%	1.00	-0.8%	0.41	0.7%	0.59
Bottom 20% - Top 20%		3.3%	0.02	1.4%	0.33	1.8%	0.04
Bottom 20% by DOpInc_stress	9	0.1%	0.81	0.1%	0.76	0.0%	0.89
Top 20% by DOpInc_stress	10	0.1%	0.98	-0.4%	0.64	0.6%	0.74
Bottom 20% - Top 20%		0.0%	0.74	0.6%	0.40	-0.6%	0.86
Bottom 20% by DNII_stress	9	-0.5%	0.99	-0.4%	0.90	-0.1%	0.93
Top 20% by DNII_stress	10	0.5%	0.74	-0.3%	0.81	0.7%	0.57
Bottom 20% - Top 20%		-1.0%	0.77	-0.1%	0.95	-0.9%	0.65
Bottom 20% by DTI_stress	9	-1.1%	0.70	-1.3%	0.52	0.2%	0.99
Top 20% by DTI_stress	10	0.8%	0.60	-0.7%	0.60	1.5%	0.27
Bottom 20% - Top 20%		-1.9%	0.30	-0.6%	0.87	-1.3%	0.19
Bottom 20% by D_FC_stress	9	-0.1%	0.69	-0.9%	0.71	0.8%	0.44
Top 20% by D_FC_stress	10	1.4%	0.32	0.0%	0.98	1.4%	0.20
Bottom 20% - Top 20%		-1.6%	0.64	-1.0%	0.61	-0.6%	0.82
Bottom 20% by DExpCover	8	2.2%	0.12	-1.0%	0.39	3.1%	0.01
Top 20% by DExpCover	8	-1.3%	0.90	-1.3%	0.63	0.0%	0.90
Bottom 20% - Top 20%		3.5%	0.08	0.3%	0.54	3.2%	0.01
Bottom 20% by PIIGS_loss_CT1	9	2.9%	0.03	-0.1%	0.75	3.0%	0.01
Top 20% by PIIGS_loss_CT1	10	-0.7%	0.82	-0.5%	0.77	-0.2%	0.98
Bottom 20% - Top 20%		3.6%	0.04	0.4%	0.57	3.2%	0.00
Bottom 20% by DefExpCover	9	-0.6%	0.82	-1.0%	0.21	0.5%	0.61
Top 20% by DefExpCover	9	1.9%	0.06	-0.5%	0.78	2.4%	0.01
Bottom 20% - Top 20%		-2.5%	0.00	-0.5%	0.05	-2.0%	0.11

This table reports the number of observations and the average cumulative abnormal returns (CARs) estimated over the event windows (-2,2), (-2,1) and (0,2) centered on July 18, 2011, with a one-factor model as well as a two-factor model for the full sample, non tested banks, tested banks, bottom 20% banks and top 20% banks based on the variables defined in Table 2. This table also reports the p-value of the t test of the null hypothesis that the average standardized CAR (i.e., the CAR divided by the standard deviation of the estimation period adjusted for the length of the event window) is zero and the difference between average standardized CARs of bottom and top 20% banks is zero.

In the post-event period, instead, the two subgroups tend to react differently in several cases. Abnormal returns[38] reward institutions which, under the stressed scenario, show a higher amount of Core Tier 1 capital (Stressed_CT1), experience a lower drop in capital adequacy (DCT1_stress) and show a less sharp increase in risk-weighted assets, write-downs and provisions (DRWA_stress, DExpCov). Also, banks with a lower exposure to PIIGS sovereign debt (PIIGS_loss_CT1) experience a better price reaction. Finally, a higher coverage ratio on defaulted exposures (DefExpCover) and a weaker model risk prompt positive abnormal returns. This evidence is consistent with the hypothesis that stress tests help to mitigate bank opaqueness as the announcement of the results revealed additional information about several dimensions of individual banks riskiness.

Other determinants of net income (DOpInc_stress, DTI_stress, DNII_stress) are not significant. The same applies to the amount of eligible capital at end 2010 (CT1_2010) and for our proxy for liquidity risk (D_FC_stress); these indicators, however, prove relevant in the multivariate test discussed in the next Section.

6.2.2 Multivariate analysis

Our dependent variable are the CARs over the (0, 2) window. As for the explanatory variables, we look at Figure 2 and take all variables located at the final "leaves" of the tree starting from the stressed 2012 CT1 ratio. These are: CT1_2010, DRWA_stress, DexpCover, DNII_stress and DTI_stress. By focusing on variables which are not embedded into each other, we ensure that multicollinearity issues are kept under control. This is confirmed by the pairwise correlations in Table 5 and by Variance Inflation Factors (VIFs) analysis[39]. We also consider three other variables which, as discussed in §5.3, are likely to add further insight to the model: PIIGS_loss_CT1 (to account for market concerns that the stress test may not have been conservative enough with sovereign exposures), D_FC_stress (i.e., the impact on funding costs of the stressed scenario, to proxy for liquidity risk) and DefExpCover (i.e., the coverage ratio on defaulted exposures, which provides a measure of model risk).

[38] Results are robust to the market model used to generate abnormal returns (single-factor vs. two-factor model); further robustness checks across models will be produced in the multivariate analysis (§7).

[39] VIFs for the variables in Table 6 range from 1.1 to 2.3.

Table 5: Pairwise correlations among regressors

	CT1 2010	*DRWA stress*	*DExp Cover*	*PIIGS loss CT1*	*DNII stress*	*DTI stress*	*D_FC stress*	*DefExp Cover*
CT1 _2010	1							
DRWA_stress	1%	1						
DExpCover	21%	-28%	1					
PIIGS_loss_CT1	3%	-22%	54%	1				
DNII_stress	19%	-28%	28%	-4%	1			
DTI_stress	-21%	36%	-48%	-21%	-21%	1		
D_FC_stress	8%	10%	-18%	-19%	34%	-16%	1	
DefExpCover	3%	-20%	30%	14%	5%	-21%	0%	1

We start by testing all these potentially-relevant variables, and then move to a more parsimonious model by gradually removing those which are not statistically significant. The first and last step of this procedure are shown in Table 6 (columns I and II).

The main results[40] are the following. The model explains about half of the cross-sectional variance in CARs. All tested variables have the expected sign (see column I) except DNII_stress which, however, is not statistically significant. A positive market reaction is associated with a higher amount of eligible capital at end 2010, a decrease in the risk weights used to compute RWAs, lower credit losses, lower involvement in PIIGS countries, a smaller drop in trading income (and a smaller increase in funding costs) under the stressed scenario, a higher coverage of defaulted exposures.

Besides net interest income, three other variables are dropped when moving from the complete model to the compact one: DRWA_stress, DTI_stress and PIIGS_loss_CT1.

The lack of significance of DRWA_stress is not surprising, as the change in risk-weighted assets was only driven by changes in risk weights (banks had to keep total assets unchanged throughout the simulation). DTI_stress may lack significance simply because trading income data was affected by the way each bank had allocated securities between the trading and the banking book. PIIGS_loss_CT1 deserves further investigation and will be addressed again in §7, where we control for a number of alternative specifications.

[40] Results based on slightly wider or narrower event windows confirm most of the findings shown in Table 6, although the significance of CT1_ 2010 and D_FC_stress may sometimes decrease. Results based on a two-factor model are qualitatively similar, the only difference being that DRWA_stress has a positive and statistically significant effect on CARs.

Table 6: Cross-Sectional Determinants of the Market Reaction to the Stress Test Results

	(I)	(II)	(III)
Intercept	-0.01	-0.03	-0.01
	0.60	*0.07*	*0.51*
CT1_2010	0.51	0.57	0.42
	0.00	*0.00*	*0.00*
CT1_2010 * SMALL			0.15
			0.04
DRWA_stress	-0.02		
	0.31		
DExpCover	-1.01	-0.89	-1.00
	0.00	*0.00*	*0.00*
PIIGS_loss_CT1	-0.01		
	0.23		
DNII_stress	0.66		
	0.75		
DTI_stress	-7.17		
	0.11		
D_FC_stress [x 10^3]	-0.12	-0.11	-0.11
	0.02	*0.05*	*0.03*
DefExpCover	0.07	0.07	0.07
	0.01	*0.01*	*0.01*
F-test	8.14	13.03	12.41
Prob > F	0.00	0.00	0.00
Adj R^2	0.58	0.58	0.58
# of obs	43	43	43

This table reports the results of weighted least squares (WLS) regressions of cumulative abnormal returns (CARs) over the (0, 2) event window, where 0 is the first trading day following the disclosure of the stress test results (i.e., July 18, 2011). The weight is the inverse of the square root of the market model residual variance. The table shows the value of the coefficient estimates along with the p-value of their t-statistic (in italics). SMALL is a dummy variable set equal to one if total assets fall below the 20th percentile. See Table 2 for the definition of the other explanatory variables.

Variables proxying for liquidity risk and model risk prove significant, suggesting that this type of information was deemed meaningful by investors and that disclosure on those profiles would probably mitigate bank opaqueness.

Our findings lead us to reject the "irrelevance hypothesis" and provide support for the "stress hypothesis". In fact, variables based on simulated data appear to be highly significant in driving the market reaction.

The evidence is mixed as concerns the "zoom hypothesis": on one hand, it is supported by the relevance of CT1_2010; on the other hand, it is weakened by the fact that the most important example of "zoomed" information in the stress test results (i.e., the breakdown

of sovereign exposures towards peripheral euro-zone countries) is not statistically significant in our multivariate analysis.

Regarding CT1_ratio_2010, one could wonder why a variable based on 2010 data had not already been discounted by market prices. Our explanation is that CT1_ratio_2010 may indeed convey new ("zoomed") information as it tells investors about the actual capital items and deductions that EBA and national supervisors deemed appropriate for each bank. This implies that EBA and national supervisors acted as certifiers of the information produced in the stress test. If this were the case, then CT1_ratio_2010 is likely to be especially relevant for smaller banks, as these are the ones for which equity analysts and rating agencies cannot be expected to provide estimates of the eligible capital.

To check this we use a dummy variable named SMALL, set equal to 1 if a bank ranks below the 20th percentile by total assets[41]. We then multiply CT1_ratio_2010 by SMALL, to see if the impact of eligible Core Tier 1 on abnormal returns differs for smaller banks. Results (see column III in Table 6) are consistent with our expectations: the effect of CT1_ratio_2010 is in fact stronger for the smallest banks in our sample.

7 Robustness checks on sovereign risk

Details on sovereign debt holdings across countries and maturity bands were considered highly informative by equity analysts[42], as they allowed to simulate alternative stressed scenarios based on more severe assumptions[43]. This was confirmed by our univariate analysis. The lack of significance for PIIGS_loss_CET1 in Table 6 is therefore surprising, and further tests are needed.

A possible explanation is that data on sovereign debt was in fact relevant, but PIIGS_loss_CT1 does not capture the type of information actually used by investors, either because we are testing the wrong variable (and *a different proxy* would perform better), or because we are looking at data on sovereign debt holdings, but instead we should be

[41] Note that these small banks do not overlap with those failing the stress test, since the latter were mostly unlisted and our sample only includes listed banks.

[42] See, e.g., the reports by Goldman Sachs and Barclays quoted in (Onado 2011).

[43] Indeed, EBA's chairman reportedly invited investors to "do the modelling themselves" based on such raw data (Jenkins 2011a).

focusing on the *unexpected* component of such data (as only new information can trigger price adjustments).

Additionally, data on sovereign debt holdings might partially duplicate information which is common to other independent variables in Table 6, so one should look only at the *original* (orthogonal) information embedded in such variable.

These three explanations are tested below.

Different proxies **-** PIIGS_loss_CT1 might simply be a wrong way of capturing sovereign risk, so other ratios might get better results. To address this concern we experiment with a number of alternative proxies. We first change the numerator: instead of applying a flat 25% loss rate to PIIGS exposures and a 0% loss rate the other ones, we use the country-specific haircuts set by EBA[44]. We then change the denominator and use total assets as a scale variable instead of CT1, as the latter might duplicate information which already enters the model through CT1_2010. Finally, we apply both changes jointly. Regression estimates (available from the authors) were similar to those shown in Table 6; hence our results are robust across alternative proxies for PIIGS-related losses[45].

Unexpected component **-** Only new information reaching the market can cause price adjustments, but sovereign debt holdings are not, *per se*, an unexpected piece of news. Everybody expects Greek banks to hold Athens' Treasury bonds, or French banks to invest on OATs. Accordingly, what triggers market reactions is not the absolute amount of PIIGS debt held by a bank, but rather the difference from its expected value (e.g., the national average). To extract this unexpected component, we regress PIIGS_loss_CT1[46] on a set of country dummies and save the residuals into a new variable called Unexp_PLO (unexpected PIIGS-related losses). This measures the gap between each institution and the country-specific mean. Results are shown in Table 7.

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[44] In the standard simulation exercise the EBA haircuts were only applied to exposures in the trading book. We instead apply them to the banks' overall net exposures to each country (trading and banking book). This produces a more conservative estimate which is not affected by each bank's accounting practices.

[45] Greek debt is found to be significant in (Wolff 2011). We therefore also replaced PIIGS exposures with Greek exposures only but no statistically significant relationship emerged. In fact, Wolf looks at stock returns between July and October 2011, so it cannot be seen as (and is not meant to be) a study on stress test effects, but rather as an analysis of market reactions throughout the sovereign crisis.

[46] As explained in §5.3, although the variable's name refers to losses it also represents holdings of PIIGS debt, since the former are set equal to 25% of the latter.

Table 7: Expected PIIGS Losses by Country

Independent Variables:	AT	BE	CY	DE	DK	ES	FI	FR	GB	GR	HU	IE	IT	MT	NO	PL	PT	SE
Coefficient	0.03	0.29	0.41	0.13	0.01	0.47	0.00	0.13	0.03	0.83	0.00	0.10	0.63	0.02	0.00	0.00	0.47	0.01
p-value	*0.88*	*0.10*	*0.10*	*0.37*	*0.93*	*0.00*	*0.99*	*0.36*	*0.81*	*0.00*	*1.00*	*0.68*	*0.00*	*0.93*	*1.00*	*1.00*	*0.00*	*0.96*
F-test	8.20																	
Prob > F	0.00																	
Adj R^2	0.73																	
# of obs	43																	

This table reports the results of an ordinary least square (OLS) regression of PIIGS_loss_CT1 (estimated loss on sovereign bonds issued by PIIGS over end-2010 Core Tier 1) over individual country dummies. The residuals of this regression are referred to as 'Unexp_PLO' in Table 8.

We then add Unexp_PLO to model (II) in Table 6 and check whether this *unexpected* component affects abnormal returns. Column (I) in Table 8 shows the result: while the coefficient has the expected sign (market prices drop when exposure to PIIGS is higher than expected) it lacks statistical significance[47].

Original information – PIIGS_loss_CT1 is strongly correlated to other regressors in our multivariate model, namely to DExpCover (i.e., new write-downs and provisions on credit exposures). These two variables show a correlation above 50% (see Table 5). This is hardly surprising, as the rise in the expected losses on sovereigns is one of the key factors causing provisions to increase under the stressed scenario (see again Figure 2). Still, not all information in PIIGS_loss_CT1 is duplicated by DExpCover or by the other regressors in Table 6. In fact, if the losses driving DExpCover did not adequately mirror the banks' individual exposures to sovereigns, one would expect the extra (i.e., original) information embedded in PIIGS_loss_CT1 to prove highly relevant for abnormal returns.

To capture such "original information" component we use the residuals of a regression of PIIGS_loss_CT1 on DExpCover (see Table 9, column I) and call them PLO_Orth (PIIGS losses made orthogonal). We then add PLO_Orth to model (II) in Table 6 and check whether PIIGS-related losses are significant. Column (II) in Table 8 shows that this is not the case.

[47] Table 8 reports results for CARs generated through the one-factor model. Results for the two-factor model are qualitative similar and available upon request. An alternative specification was also tested (not reported), where unexpected PIIGS losses/holdings were proxied by PIIGS losses/holdings toward countries other than the one where the bank is legally headquartered; results were qualitatively similar.

Table 8: Robustness checks on sovereign exposures

	(I)	(II)	(III)
Intercept	-0.03	-0.02	-0.03
	0.07	*0.15*	*0.09*
CT1_2010	0.56	0.50	0.55
	0.00	*0.00*	*0.00*
DExpCover	-0.90	-0.91	-0.92
	0.00	*0.00*	*0.00*
Unexp_PLO	0.00		
	0.76		
PLO_Orth		-0.01	
		0.26	
PLO_Orth_All			-0.01
			0.26
D_FC_stress [x 10^3]	-0.10	-0.10	-0.11
	0.06	*0.05*	*0.05*
DefExpCover	0.07	0.07	0.07
	0.01	*0.00*	*0.00*
F-test	10.19	10.77	10.77
Prob > F	0.00	0.00	0.00
Adj R^2	0.52	0.54	0.54
# of obs	43	43	43

This table reports the results of weighted least squares (WLS) regressions of cumulative abnormal returns (CARs) over the (0, 2) event window, where 0 is the first trading day following the disclosure of the stress test results (i.e., July 18, 2011). The weight is the inverse of the square root of the market model residual variance. The table shows the value of the coefficient estimates along with the p-value of their t-statistcs. 'Unexp_PLO' is the residual of the PIIGS_loss_CT1 variable regressed on individual country dummies. 'PLO_Orth' is the residual of the PIIGS_loss_CT1 variable regressed on the DExpCover variable. 'PLO_Orth_All' is the residual of the PIIGS_loss_CT1 variable regressed on all the variables included in model (I) reported on Table 6.

Alternatively, we regress PIIGS_loss_CT1 on *all* the independent variables used in the last column of Table 6 (results are shown in Table 9, column II) and use the residuals ("PLO_Orth_All") to proxy for the unexpected component in PIIGS_loss_CT1. This PLO_Orth_All is then tested in Table 8, column III, but still is not statistically significant.

Overall, the results presented in this Section confirm that sovereign exposures did not add information to market participants beyond that conveyed by other variables based on EBA's "stressed" scenario. This implies that such scenario (and the individual banks' vulnerabilities emerging from it) was considered credible even though it did not incorporate any extreme assumptions. An alternative explanation could be that detailed data on sovereign exposures have been snubbed by investors because their quality and/or

granularity was deemed too poor[48]. However, this would not explain why such data prove significant when considered on a stand-alone basis.

Table 9: Orthogonalisation of Sovereign Exposures (PIIGS_loss_CT1)

	(I)	(II)
Intercept	0.04	0.38
	0.63	0.23
CT1_2010		-5.12
		0.04
DeltaFC_stress [x 10^3]		0.33
		0.75
DefExpCover		0.11
		0.83
ChgExpCover	10.82	12.04
	0.00	0.00
F-test	16.46	5.49
Prob > F	0.00	0.00
Adj R^2	0.27	0.30
# of obs	43	43

Model I is the ordinary least square (OLS) regressions of PIIGS_loss_CT1 (the estimated loss on sovereign bonds issued by PIIGS over 2010 Core Tier 1) on the change in coverage ratio for credit exposures from 2010 to stressed 2012 (in model (I); its residuals are referred to as 'PLO_Orth' in Table 8). Model II is the OLS regression of PIIGS_loss_CT1 on the explanatory variables shown in Table 6, column (II); its residuals are referred to as 'PLO_Orth_All' in Table 8). The table shows the value of the coefficient estimates along with the p-value of the t-statistic (in italics)

8 Final remarks

Stress tests are complex exercises involving scenario design, extensive data gathering, close interaction between banks and supervisors, repeated assessment of the internal models and assumptions, careful calibration and timely disclosure of the results. The debate on their ability to reduce bank opaqueness is often based on anecdotal evidence or event windows biased by unrelated events.

[48] Data quality issues were, in fact, present. (Das 2011) notes, for example, that one British bank only disclosed the European credit exposures in its UK operation, omitting exposures held through other entities below the 5% EBA disclosure threshold. One Italian bank did not separately disclose Eastern Europe exposures, as they were held via their subsidiary in Austria.

In this paper we examine the 2011 European stress test exercise, which provided investors with an unprecedented amount of data, to assess whether and how it affected stock prices. The investigation of the informational role of the stress tests has important policy implications concerning the supervisors' decision to disclose their results.

We find evidence of significant market reactions both on various pre-results dates and upon the release of the test's detailed, bank-by-bank results. This implies that the stress test produced new information that market participants did not have.

Our analysis of pre-results dates provides some support for the dilution effect, since negative CARs are found for tested banks when supervisors made reference to possible "remedial measures" and when a stricter methodology was announced. We also find – consistent with the idea of greater bank opaqueness prior to the disclosure of the stress test results – that the market is not able to anticipate the stress test results, although highly capitalised banks may have benefited from a "certification effect" on the capital definition date.

On the results date, the market reacted significantly to the disclosure of detailed stress test results, leading us to reject the irrelevance hypothesis. The price reaction of tested banks differs from non-tested ones and the former's abnormal returns depend on a number of bank-specific factors. This finding corroborates the informational role of the stress test and support our conclusion that stress tests help mitigate bank opaqueness.

As for the type of information used by the market, a key role is played by ratios measuring the banks' resilience to a downturn scenario. This strongly supports the "stress hypothesis" and indicates that stress tests – although possibly affected by political constraints, model risk and data quality issues – have provided investors with relevant information. Our evidence also shows that the stock price reacted to some new details on current financial data, thus supporting the "zoom hypothesis" too. The fact that we cannot reject the stress hypothesis proves that stress tests convey information to the market that goes beyond the disclosure of more detailed data, and suggests that they should not be hastily removed from the supervisors' toolkit as they can help curb bank opacity.

9 Appendices

Appendix 1 - The main assumptions in the EBA 2011 stress tests

The stress test exercise was based on financial data as of December 31, 2010 and covered a period of two simulated years (2011 and 2012). Two scenarios were tested (baseline and adverse) based on the macroeconomic assumptions reported in the paper.

Banks had to translate these assumptions into their balance sheets based on a "zero growth and constant mix" approach, whereby maturing assets and liabilities were to be replaced by equivalent ones (e.g., the proportion of retail and wholesale liabilities had to be kept constant). The main criteria to be followed by banks to generate simulated results are summarized below.

Defaulted loans had to be estimated by multiplying outstanding balances by expected default rates (accounting for the effects of the adverse scenario where appropriate). The increase in non-performing loans would negatively affect interest receivable.

Migrations of *risk-weighted assets* across different rating/PD buckets had to be simulated by the banks, but were reviewed by EBA and by national supervisors. IRB banks[49] also had to estimate the deterioration in downturn LGDs following from adverse macroeconomic conditions, in order to assess the overall increase in expected losses and regulatory RWAs. RWAs at end 2010 would in any case act as a floor to the banks' projections.

As regards *expected losses* in the adverse scenario, EBA asked banks to apply a 40% LGD and a set of predetermined PDs to exposures towards banks and sovereigns located in different countries (e.g., exposures to Greek counterparts would be subject to a 36% PD). Full provisions against such expected losses had to be charged onto the P&L account.

Securities in the trading book (as well as equity holdings in the "available for sale" portfolio) had to be marked to market based on the parameters underlying the macroeconomic scenario. RWAs on market risk had to be increased to account for the new Basel rules (known as "stressed VaR" and "incremental risk charge"); banks unable to provide internal estimates were asked to apply a 250% scaling factor to 2010 data.

Capital was expected to change due to retained profits, losses and maturing Tier2 issues. Any extraordinary measure (including government support) agreed upon and committed by

[49] In the Basel 2 jargon, IRB banks are those allowed to use internal rating models to compute minimum regulatory capital.

April 30, 2011 could be factored in, but had to be indicated separately. Retained profits were estimated based on the median payout ratio for the last three years.

The shift in market rates had to be translated into the banks' *lending and funding rate* based on a conservative approach. The increase in risk-free rates could be passed on only to variable-rate loans and rolled-over ones; only 50% of the rise in the bank's own credit spread (set equal to the 2-year sovereign spread) could translate into higher lending rates. As regards interest expenses, the banks had to account for an immediate 100% rise of wholesale funding costs, a partial increase in the cost of retail deposits (in line with past records, but also accounting for stronger competition in that market) and a drop in the value of sovereign assets used as collateral in funding transactions.

Commissions, *dividend income* and *administrative costs* had to be kept in line with 2010 levels. Trading income had to be estimated by taking the average amount for the last five years and applying the loss rates implied by the macroeconomic scenario (e.g., a 15% stockmarket drop, losses originating by higher interest rates and credit spreads, etc.).

Impairments on defaulted loans had to be simulated based on the banks' forecasts for loss rates ("LGD"). This included new defaulted exposures, as well as a re-assessment of the loss rates on previously defaulted positions that had not yet been written-off.

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