Contagion effects from announcements by regulatory authorities

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Abstract

Concerns have been expressed that public disclosure of outcomes from regulatory inspections of banks could lead to instability of the financial systems due to contagion effects. This paper analyses if the announcement of increases in loan loss reserves by supervisory authorities after a bank inspection lead to contagion in financial markets and whether contagion effects are associated with the choice of audit firms. The study is based on data from Denmark because Denmark has a unique system of open inspection reports. We find clear and strong evidence of negative returns in the announcing banks over the period 2009-2015. We also find a small but reliably negative share price decline among non-announcing peer banks and hence some evidence of contagion. However, the effect is not strong enough to suggest a systemic effect on the entire banking system. Finally, we find no evidence of contagion effects associated with the choice of auditors at the aggregate level, but when we distinguish between different auditor segments we find evidence of auditor contagion concentrated in audits by the same non-Big Four audit firms. This indicates that investors perceive that there are different audit quality segments in the audit market.

1. Introduction.

Does the release of unexpected information by the Financial Supervisory Authorities [FSA] only enhance market discipline or does it lead to contagion effects? The FSA obtain private information about financial institutions through regular reports and on-site inspections. Releasing this information enables market participants to make informed decisions about the bank and such decisions, in turn, discipline the bank's risk taking decisions (Goldstein & Sapra 2014). However, a potentially harmful effect of public disclosure of negative information about a particular bank is that it can also make financial markets unstable through contagion effects. Instability arises if financial institutions are opaque and the FSA release negative (unexpected) information about bank A and markets infer from this that other banks may also be affected. The aim of this paper is to test for contagion effects from the unexpected announcements by the FSA of increases to loan loss reserves based on on-site inspections and to study the role of auditors in propagating the contagion effects.

An analysis of contagion effects is important due to bank regulators' shift in emphasis after the global financial crisis in the first and second decade of the new millennium from a micro-prudential approach to a macro-prudential perspective (Beatty & Liao 2014, p. 346). While the micro-prudential approach is focused on protecting depositors and investors from the costs of distress the macro-prudential perspective is focused on limiting financial system-wide distress. The macro-prudential perspective implies that correlations and common exposures across financial institutions are important. In this context, there has been a debate on the relationship between transparency and stability including how much information bank regulators should disclose about individual banks (Morris & Shin 2002; Morrison & White 2013; Goldstein & Sapra 2014).

Since most developed countries, including the US (Deyoung *et al.* 2001; Bushman 2014), do not release information from on-site inspections and the information they do release are in the form of formalized reports covering all banks, it is difficult to test for possible contagion effects from the release of information from the FSA. However, Denmark operates a unique regulatory environment where the results from on-site bank inspections by the Danish FSA are made publicly available. Specifically, since 2010 it has been mandatory for both inspected Danish banks and the supervisory authorities to publish their findings on their homepage. We exploit this unique setting and focus on the Danish FSA's public disclosure of increases in loan loss reserves - one of the key variables in assessing the performance and risk of banks. Together with Kjeldsen & Raaballe (2015), this study is one of the first studies to analyze information content of on-site inspections by the regulatory authorities, and to our knowledge the first to analyse contagion effects from supervisory authorities' public release of information about insufficient loan loss reserves after an inspection. Based on a comprehensive review of the literature on bank's financial accounting, Beatty and Liao (2014) and Bushman (2014) make a call for empirical research that can reveal insights into when, where and how transparency positively or negatively affects banks and the banking system. Thus this paper fills a much needed gap in the current literature.

Our research questions are: Does the announcement of insufficient loan loss reserves after an on-site inspection by banking supervisory authorities contain new information leading to a negative effect on share prices for the inspected bank? Does this new, if negative, information by the regulatory authorities lead to contagion in financial markets, i.e. does the announcement for Bank A also negatively affect the share price of Bank B,C,..? . Our sample periods includes the recent financial crises. Flannery et al. (2013) show that the opaqueness of banks increases during crises which in turn increases the likelihood of contagion effects from the release of information from Supervisory Authorities during such periods. Finally, considering that insufficient loan loss reserves can be the result of insufficient accounting and management practices leading to potential misrepresentations of financial statements, are contagion effects associated with the choice of audit firms? The assessment of default and recovery rates and expected loan losses is a fundamental issue in a bank and a correction to the loan loss account reflects poorly on the work done by management and the external auditor. If the external auditor is viewed as being too lax by allowing for low probabilities for losses and/or high recovery rates with one bank, then it is probably also the case for the other banks being audited by the same auditing firm (Francis & Michas 2013). An announcement of an increase in e.g. provisions for loan losses will therefore potentially decrease not only the share price of the bank being inspected but also other banks using the same external audit firm or perhaps the same audit firms from a particular (e.g. second tier) quality segment – auditor contagion. We add to the scarce literature on information contagion through financial statement information and the role of auditors in this contagion effect. An analysis of the auditors' role provides interesting insights into questions about brand protection in the audit industry, i.e. whether or not bank investors consider a problematic audit by a specific audit firm to be an isolated event or something which "taints" the audit firm as such. Moreover, the analysis also provides insights into whether investors perceive auditing to be a standardized service or if different segments can be identified. Finally, our analysis provides evidence for the debate regarding the professional qualifications of bank auditors.

We find clear and strong evidence of negative returns in banks announcing increases to the loan loss account over the period 2009-2015, thus announcements of loan losses by the FSA after on-site inspections contains new information for financial markets and financial markets view this as a negative event. We also find a small but reliably negative share price decline among peer banks and hence some evidence of contagion. However, the effect is not strong enough to suggest a systemic effect on the entire banking system even during the recent financial crises.

Finally, we find no evidence of contagion effects associated with the choice of auditors at the aggregate level, but when we distinguish between different auditor segments we find evidence of auditor contagion concentrated in audits by the same non-Big Four audit firms, suggesting that imposing professional requirements for bank auditors or require banks to use a Big-four accounting firm may prevent contagion effects and enhancing financial markets faith in bank's financial accounts.

The rest of the paper is organized as follows. The next section summarizes prior research and develops testable hypotheses about market reactions and contagion effects. Section three briefly characterizes the Danish institutional setting as a foundation for understanding the context of the study. Section four describes our sample selection and research design for the individual hypotheses. Section five presents our empirical results, and the final section six contains the conclusion and limitations.

2. Related research and hypotheses.

Loan loss reserves provide a cushion towards future losses on the loan portfolio. Banks will in general review their loan portfolios on a regular basis. If there is any objective evidence that a financial asset or group of financial assets is impaired for example due to significant financial difficulty (increase in default probability and/or decrease in expected recovery rates) of an obligor or breach of contract, such as default or delinquency in interest or principal payments banks will, in accordance with IAS 39, recognize a loan loss provision in the income statement with a corresponding increase in loan loss reserves in the balance sheet. Additional loan loss provisions decreases the value of the bank and solvency ratios and may, if large enough, close the bank.

Information regarding loan losses are made public in three different ways. Banks publish their own assessment of the loan losses in the financial statements. Banks may also announce changes to the loan loss account outside the regular publication of financial statements if there has been a significant deterioration in the quality of the loan portfolio. Finally, supervisory financial authorities and/or the bank may announce an increase in bank's loan loss reserves after an on-site inspection. In this paper we analyze the announcement by the supervisory authority of an increase in a bank's loan loss reserves after an inspection.

Previous research on market reactions to changes in loan loss reserves has focused on announcement of charges to loan losses outside the financial reports and mostly losses associated with the International debt crisis commencing in 1982 , referred to as the Less Developed Country (LDC) debt crises. The reaction of financial markets to announced increases in loan losses is mixed, Musumeci & Sinkey (1990), Grammatikos & Saunders (1990) and Wahlen (1994) found a positive effect, Liu & Ryan (1995) found a positive effect for banks with sizable frequently negotiated loans. Cornell & Shapiro (1986), Bruner & Simms (1987), Smirlock & Kaufold (1987), Mansur et al. (1990), Lancaster et al. (1993), Liu & Ryan (1995), Docking et al. (1997) found a negative effect from loan loss announcements.

There are several suggestions as to the conflicting results. One explanation is that the annoucements in most of the existing studies are endogenous, that is management, decides when to announce the loan loss provision and by how much (Moyer 1990). Beaver et al. (1989) suggests that only banks with strong earnings who can withstand a "hit to earnings" will announce increases in loan loss reserves. Investors will therefore view an increase in loan loss reserves as a positive signal. Wahlen (1994) shows that an announcement of a loan loss provision contains a discretionary element, interpreted as management's private information, and that this discretionary element increases when cash flow prospects improve. Finally, an announcement of changes to loan loss reserves may be a signal of changes in loan policies and/or other restructurings in the bank making it difficult to interpret the results from the event studies of banks own announcements of increases in loan loss reserves.

Deyong et al. (2001) study whether supervisory authorities' examinations of US banks produce useful information not already reflected in market prices (spread) for subordinated debt. Specifically they construct a proxy for the private information produced during the bank inspections. They find that the examiners' ratings of the safety and soundness of investigated banks ("CAMEL ratings") do not contain private information that is contemporaneously incorporated into subordinated debt prices. However, since the examiners' ratings are confidential, an insignificant market reaction at the time of the inspection does not imply that they contain no value relevant information. It could simply mean that the market has not yet become aware of the information. In additional analyses Deyong et al. (2001) find that the private information predicts future spreads which altogether indicates that the on-site inspections do produce value-relevant information about the future safety and soundness of banks several quarters before this information is impounded in debenture prices. Moreover, they find that the spread primarily reacts to bad news and that it varies with the bank's perceived condition.

This paper differs from the existing US literature in one important way, namely that the announcements are issued by the supervisory authority after an inspection of the bank and therefore both public and exogenous to the banks. This enables us to conduct a much cleaner event study. Kjeldsen and Raaballe (2015) have studied all announcements associated with inspection reports by the Danish regulatory authorities over a smaller time period than ours and they find a negative share price effect from "bad news announcements" which includes announcements about increases in loan loss reserves. We isolate the inspection reports in which the FSA announces that the inspected bank needs to increase its loan loss reserves in order to establish that there are indeed value relevant news in these announcements, i.e. does the regulatory authorities collect and report information about loan loss reserves that is not available to financial markets and how does the financial market react to these announcements. Our first null hypothesis is therefore given by:

H_1: The share price of banks do not react to announcements by the FSA of increases in loan loss reserves.

Financial institutions are often characterized as opaque (Flannery *et al.* 2013). The opaqueness arise from two sources; banks use private information collected through credit evaluation etc. to extend loans to customers, releasing the private information would be detrimental to their business model (Diamond 1984). The second source arises from trading activities, in the financial reports the bank can present a very conservative portfolio, but this can be changed the day after the release of the financial statements. Thus to outside investors banks are opaque with respect to risk. Financial statements in the form of quarterly, semi-annual and annual reports and FSA collecting information through on-site visits and the collection of private information from the banks are remedies to enhance the transparency of the banks allowing the FSA and financial market to asses the riskiness of the banks. One of the main questions is if the FSA should release the information they have collected through e.g. on-site inspections beyond what is reported in standard prudential reports.

Goldstein & Sapra (2014) discuss positive and negative effects of public disclosure of supervisory authorities' individual bank stress tests. In addition to promoting bank stability through more informed decision-making, they also argue that public disclosure could potentially enhance the quality of the supervisions because the work of the supervisors and the reactions they take would be subject to greater scrutiny and discussions by outsiders, i.e. it could discipline the supervisors. However, there could also be negative effects associated with public disclosure about a bank's financial condition. Financial settings are typically environments in which market participants care not only about how well capitalized or solvent a bank is (i.e. the bank's fundamental value) but also have strategic concerns where they care about what other market participants believe about the bank's financial condition (Goldstein & Sapra 2014). Morris and Shin (2002) show analytically that in such environments, public disclosures of for example information gathered by regulators lead to underweighting of market participants' own private information and over-reaction to the public information. The additional public information by the regulators crowds out their use of other information sources, and the heightened sensitivities of the market could magnify any noise in the public information for example leading to bank runs that are driven by coordination failures and inefficient investment decisions. Other negative effects of transparency includes for example that it could reduce the incentives of traders in the stock market to produce information and trade on their own collected information, which leads share prices to be less informative (Goldstein & Sapra 2014). If bank supervisors use share prices in their intervention decisions then the whole supervisory process may be harmed.

Bank regulators are particularly sensitive to correlations and negative information transfer from disclosures due to their shift in emphasis from a micro-prudential approach to a macro-prudential perspective where the focus is on limiting financial system-wide distress (Beatty & Liao 2014).

Several channels for contagion exists: systematic effects, information channel and counterparty risk. Whereas these channels all imply negative returns for other banks from an announcement in one bank of increased loan loss reserves, there is also a competitive channel with positive effects to the peer banks.

A loan loss announcement by a bank may reveal systematic or macro economic factors that are relevant to other banks as well. Exposure and losses to e.g. the agricultural sector, is relevant information for all banks with exposure to the agricultural sector and problems in one bank may therefore signal problems for other banks as well. Thus an announcement by one bank may lead to negative stock returns for other banks with agriculture loans reflecting the reduced value of these loans.

Banks have credit exposure to other banks through interbank lending and various derivatives contracts, CDS and SWAP contracts. Financial distress or the closure of a bank therefore causes credit losses in other banks referred to as counterparty contagion.

Also, investors may not be able to distinguish between idiosyncratic and systematic problems in a bank and idiosyncratic problems in one bank may therefore lead to negative stock returns for all banks generating a contagion effect. Idiosyncratic problems e.g. losses from a few large exposures due to bad luck or poor lending policies has, under full information, no impact on other banks.

Most of the existing research analyzing contagion effects have focused on the banks own release of information, e.g. loan losses, or using the closure of banks, including the closure of Lehmann Brothers, as the event ((Aharony & Swary 1983), (Aharony & Swary 1996), (Docking *et al.* 1997; Akhigbe & Madura 2001), (Jorion & Zhang 2007), (Jorion & Zhang 2009), (Egginton *et al.* 2010), (Aragon & Strahan 2012), (Chakrabarty & Zhang 2012), (Fernando *et al.* 2012) and (Helwege & Zhang 2016)). Most of the existing research on contagion is consequently from financial distress settings in which counterparty contagion is an important factor. Our setting is different. We focus on contagion from an exogenous information announcements of loan losses that are based on the supervisory authorities' on-site inspections. In this setting the information effect is probably significantly stronger than the counterparty effect since only the probability of credit loss is affected whereas in the existing studies actual losses are involved.

However, the sign of informational contagion is not necessarily negative, since an idiosyncratic shock to a bank can be a positive event to a competitor. The increase in loan loss reserves reduce the amount of equity capital in the bank and it may force the bank to reduce lending which is an advantage to the competitors, also as a consequence of the announcement funding costs may increase compared with to the competitors, (Egginton *et al.* 2010)).

The contagion (null) hypothesis we are testing is given by:

H2: The share prices of peer banks do not react to an announcements by the FSA of increases in loan loss reserves in inspected banks.

Finally, a demand for additional loan loss reserves by the supervisory authority also raises questions about the quality of the involved banks' financial statements and the work of the involved external auditors. If a bank follows applicable accounting standards, then an inspection by the authorities should not be expected to change the loan loss reserves unless the economic conditions have deteriorated significantly since the last reporting date[1]. The announcement of higher provisions by the authorities is then potentially a signal that the procedures underlying the bank's financial statement information are inadequate. This may induce bank investors to reassess past financial statement information, which likely has an

[1] If deteriorating economic conditions indicate that more loans are impaired and that loan loss reserves consequently should be significantly higher than previously reported we assume that this is price relevant information which the banks should have announced to the capital market.

adverse effect on shareholder wealth at the restating bank (Dechow *et al.* 1996; GAO 2002; Palmrose *et al.* 2004; GAO 2006; Files *et al.* 2009; Myers *et al.* 2013; Files *et al.* 2014) .

However, the questions raised about the quality of the financial statements in the inspected banks may also cause investors to reassess the content and credibility of financial statements issued by peer banks. This again may induce share price declines among peer banks in the industry. Gleason et al. (2008) is a rare study of contagion effects related to the credibility of financial statements and the work of the external auditor. The study is based on a sample of listed firm's restatements from 1997 to 2002. The results show that non-restating peer firms experience a small but reliably negative mean three-day abnormal return of -0.5 percent when an accounting misstatement is first announced by another firm in the industry. Gleason et al. (2008) find the largest decline occurs for the "securities" restatement group which often involves companies in the financial services industry. The findings that accounting restatements lead to share price declines among non-restating firms could potentially be because they provide information about deteriorating economic prospects for the industry. However, additional analyses corroborate that the contagion effects do in fact reflect concerns about the credibility of peer firms' financial statements.

The external, independent audit provides users with an enhanced degree of confidence in the financial statements. If part of a negative information contagion effect can be attributed to the credibility of financial statements then it is possible that the contagion effects are affected by the choice of audit firm. Francis and Michas (2013) find that audit offices with an audit failure – defined as "the presence of one or more clients with overstated earnings that were subsequently corrected" – are more likely to have additional (new) audit failures in the subsequent five years. They also find that other clients that are audited by the office with audit failures have a higher level of abnormal accruals compared to offices with zero audit failures, which is suggestive of lower earnings quality. Taken together this suggests that audit failures in an audit office is not an isolated event, but reflect more systematic audit-quality problems. This contagion effect within the audit firm may result in a contagion effect in the stock market among concurrent clients in audit firms with audit failures which we in this study define as the announcement by the financial supervisory authority of an increase in a bank's loan loss reserves.[2] Results in Gleason et al. (2008) seem to support this. Gleason et al. (2008) find that investors impose an incremental contagion penalty on peer firms with high earnings and high accruals when the peer and restating firms share the same external auditor.

While our study builds on some of the same ideas as in Gleason et al. (2008) there are notable differences. First, Gleason et al. (2008) use restatement data from the GAO database. The GAO database is based on Lexis-Nexis online information service to search for press releases and other media coverage on restatements (GAO 2002). The database includes all restatements irrespective of the entity that prompted the restatement. In other words, the data is not solely based on irregularities discovered by external parties. In fact many

[2] We do not have information about the offices that conducted an audit, and are consequently only able to base our analyses on audit firm names.

restatements are prompted by the companies themselves or the external auditors (GAO 2003). The signals sent to the market about general problems with the credibility of accounting and auditing quality in an industry, and hence the ability to detect contagion effects related to this, are probably stronger if a restatement is prompted by an external party, which is what we use. Second, Gleason et al. (2008) use a general population of firms whereas in this paper we focus on banks where the effect from a contagion effect is likely clearer due to the homogeneous nature of this industry.

The first auditor contagion hypothesis we are testing is given by:

H3a: Peer banks stock returns do not react when the FSA announce increases to loan loss reserves of a bank that uses the same external auditor as the peer banks.

In previous research (for example (DeFond & Zhang 2014), (Lennox & Pittman 2010) , (Francis *et al.* 2009), (Francis *et al.* 1999), (Becker *et al.* 1998), (Francis *et al.* 1999)) the employment of a Big N auditor to conduct the statutory audit is used as a proxy for higher audit quality. The use of a Big N firm makes it more likely that banks have just been exposed to bad luck during the period between the audit (close of the books for the annual report) and the time of the inspection by the supervisory authorities rather than optimistic valuations that were accepted by the external auditors.

This leads to our second auditor contagion hypothesis:

H3b: Peer banks stock returns do not react when the FSA announce increases to loan loss reserves and peer banks use the same non-Big Four audit firm.

3. The Danish institutional setting.

Danish financial institutions, both listed and non-listed banks and savings banks, are supervised by The Danish Financial Supervisory Authority [FSA]. The FSA inspects banks depending on their size and perceived risk. Smaller institutions with an average risk profile is inspected about once every four years, whereas the large institutions are inspected several times every year. Kjeldsen and Raaballe (Kjeldsen & Raaballe 2015) describes the practice in the inspection process in the following way: One or two months prior to the inspection the FSA contacts the bank and request the required material for the inspection. During the inspection this material is analysed by the FSA and management of the bank. A couple of weeks after the inspection the FSA meets with management of the bank and the FSA presents their conclusions. The FSA prepares an extensive report as well as a short resume published on the banks homepage as well as on the FSA's homepage. Prior to 2010 listed banks were required to publish all information relevant for the pricing of the shares. In this paper we assume that increases to loan losses is indeed considered relevant for the pricing of shares and the listed banks therefore publish the information immediately after the receiving the final report from the FSA.

Denmark introduced IFRS in 2005 which changed the rules applicable to loan losses. Before 2005 the amount recognized as loan impairments were based on management's estimates of future losses and they were to some extend used to smooth earnings by building up reserves in financially thriving years to be used in periods with downturns in the economy (e.g. illustrated in Danmarks Nationalbank, 2010, p. 155). The implementation of the international accounting standards in 2005 introduced an "incurred loss model" where loans are impaired and impairment losses consequently recognized if, and only if, there is objective evidence that a "loss event" has occurred after the initial recognition (IAS39.59). The scope for earnings management was severely reduced which lead to a reduction in Loan Loss Reserves[3]. In 2005, 2006 and 2007 the situation was unusual with net negative loan loss provisions (i.e. positive net income) for the whole sector due to the reversal of previous too conservative Loan Loss Reserves[4].

< Insert table 1 here>

Table 1 compares the Danish banking sector to the Euro area, the USA, and the World in the period leading up to the beginning of our sample period. From Table 1, the Danish financial system is characterized by having a much more concentrated banking sector than the US, smaller provisions to non-performing loans, a smaller ratio of defaulting loans to total gross loans, but at the same time similar capital adequacy of deposit takers as the US. The table also shows that the Danish banking sector in many respects is comparable to other countries in the Euro area.

< Insert table 2 here>

In 2010, in the middle of our initial sample period, Denmark had a total of 123 banks and Savings Banks. The supervisory authority divides them into four groups based on size. We exclude 27 very small banks and savings banks with working capital below 250 Mill. DKK (approximately Euro 33 Mill.) and focus on the three largest groups. Table 2 reports descriptive statistics for the remaining 96 financial institutions. Table 2 shows that the largest six banks account for about 85% of the total assets and around 80% of the deposits and issued loans. 12 banks belong to the second largest group with about 7% of the assets and around 9% of the deposits and loans. The 78 smallest banks included in our analysis accounts for roughly the same as the second largest group of banks. A common size balance

[3] Danmarks Nationalbank (2010), Figure 5.2 on page 155: https://www.nationalbanken.dk/da/publikationer/Documents/2010/12/dansk_pengehistorie_6_dk_web.pdf

[4] (Gaston & Song 2014) claims that with respect to the recent financial crisis loan losses were recognized "too little and too late" and the equity reserves were too small causing problems for the banks during and after the crisis. This was also the case for Denmark after the introduction of IFRS in 2005 some banks In Denmark were required to reduce the Loan Loss account.

sheet for the 96 largest Danish banks and savings banks in 2010 (not reported) shows that 46 per cent is invested in loans, and an additional 22 per cent in mortgage backed securities issued by banks and mortgage companies. In Denmark nearly all mortgages are mortgage backed securities issued by banks and mortgage companies, thus the bond holdings on the balance sheet of the banks are primarily mortgage bonds corresponding to mortgage holdings in banks in other countries. A further 13 per cent are claims on other banks and the central bank. On the liability side the banks are financed by 56 per cent deposits, of which 18 per cent are interbank deposits. An additional 15 per cent is financed by issued (mortgage) bonds. Subordinated debt accounts for 3 per cent and equity for 6 per cent on average. Impairment on loans and advances amount to about 3 percent of the total loans. This clearly shows that loan losses is a very important area in the banking sector.

According to § 199 in the Danish Act that regulates the financial services industry (Lov om finansiel virksomhed) Danish banks are required to have at least one state authorized (chartered) auditor. Until 2005 all listed companies were required to have two independent auditors of which at least one should be state authorized (Chartered accountant). This requirement was in force for 75 years, but was abolished with effect for financial statement years beginning on 1 January, 2005.[5] However, some banks continued voluntarily to use two audit firms after the abolishment of the requirement. During the period of analysis, 2009 to 2015, only 5 banks made use of two auditors for one or more of the years in the sample[6][7]. Unfortunately the sample of banks with two auditors is too small to warrant separate analysis[8].

4. Data and research design

We study contagion effects related to the credibility of financial statement information. In order to base the analyses on the same accounting rules and also on accounting regulations that apply to all EU member states, our initial sample period begins in 2005 at the mandatory introduction of IFRS in the EU. For the period 2005 to 2010 we used Infomedia, an on-line database of all Danish newspaper articles, to collect announcement dates for announcement by the FSA of increases in loan loss provisions. We searched for the words "Finanstilsyn" and "hensættelser", the Danish names for the supervisory authority and loss provisions respectively. Requiring both words to be present in the article lead to a total of

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[5] The financial statements of Danish banks are required to follow the calendar year.

[6] Two banks had two auditors in one year, two banks had two auditors for three years and one bank had two auditors for all the years.

[7] Since 2014 all bank auditors have to be certified by the Danish Financial Services Authority. Certification requires among others that the auditor in fixed five year periods is involved in the audit of banks with a minimum number of work hours and that the auditor every year spend a minimum number of hours on courses specifically about the audit of financial institutions.

[8] For general research on the auditors role in the Danish system see e.g. (Thinggaard & Kiertzner 2008; Holm & Thinggaard 2014).

1863 articles. Each article was read for relevance. Prior to 2010 banks were, in theory, required to notify the financial markets if the FSA after an inspection required additional loss provisions. The dates from Infomedia were cross-checked with press releases in the OMX NewsClient containing the official company press releases to the financial markets. The earliest date from either OMX NewsClient or Infomedia was used.

Since 2010 the FSA has been required to publish their findings on their homepage[9]. Again the dates of the publication on the home page were cross checked with OMX NewsClient and the earliest date used.

The basic contagion arises if the regulatory authority issues an announcement of increased loan loss provisions in bank A and this gives rise to decreases in the share prices of banks B,C,…. Thus the contagion effects is measured using the returns of banks B,C,… from an announcement in bank A. Since the regulatory authority also issues announcements for private banks we can include these in our sample, i.e. the announcing bank A does not need to be listed, only banks B,C,…..

< Insert table 3 here>

Table 3 reports the number of FSA required announcements of increases in loan loss reserves for listed and non-listed Danish banks and savings banks from 2005 to 2015. During this period we found a total of 74 announcements for listed banks. 64 out of the 74 were single announcement dates, while on two dates there were two announcements, and two dates had three announcements. Table 3 shows that the first announcements are from 2009. The lack of announcements from 2005 to 2008 can reflect the economic boom period before the financial crisis and/or less scrutiny by the FSA. The first explanation seems very plausible considering that we found 9 announcements with *decreases* in loan loss provisions from 2005 to 2007. These were excluded from the sample. Although our sample period is from 2005 to 2015 the data used for the analysis below is only from 2009 to 2015.

Announcements from non-listed financial institutions are only available from 2010 when the FSA was required to publish inspection reports on their home page. From 2010 to 2015 we found 45 announcements for non-listed banks and savings banks[10]. Non-listed financial institutions are typically smaller than listed and the smaller percentage of announcements for non-listed institutions is probably due to fewer inspections by the FSA.

For hypothesis one we use the announcement for listed banks whereas for hypothesis two and three we use announcement for both listed banks and private (non-listed) institutions.

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[9] https://www.finanstilsynet.dk/da/Tal-og-fakta/Vurderinger-af-finansielle-virksomheder.aspx

[10] Prior to 2010 private institutions were required to publish inspection results in their annual reports.

< Insert table 4 here>

Table 4 reports the number of announcements from individual listed and non-listed institutions. During the period of analysis 2009 to 2015, 6 banks faced a total of four announcements, 5 banks faced three announcements, 11 banks faced two announcement and 13 faced one announcement. Out of the 44 banks listed for the entire period or parts thereof, 9 banks faced no announcements by the FSA. From Table 4, 5 private institutions faced three FSA announcements, 5 institutions faced two announcements and 20 institutions one announcement.

Our first hypothesis about share price effects in the banks for which the FSA announces that loan loss reserves were insufficient is tested using a standard event study methodology, (MacKinlay 1997) (Bartholdy et al. 2007). The event study methodology requires that we calculate the abnormal return ($A_{i,t}$) for each bank i on day t. We use the market model to calculate normal returns. The market model parameters (α_i; β_i) are estimated using the capped benchmark index for Copenhagen Stock Exchange, OMXCBCAP. This index is constructed to be representative for the Exchange across industries as well as capping the weights of large stocks[11]. The index values are retrieved from NASDAQ's homepage[12]. We use an estimation period of 200 trading days and initially an event window of 21 days subsequently reduced to a shorter, more focused window.

Stock prices, market value and trading volume for each bank are retrieved from Datastream.

< Insert table 5 here>

The shares on the Danish Stock Exchange suffer from thin trading. Table 5 provides statistics for the average trading frequency in a window of -5 to +5 days around the announcement date. The table shows that a significant percentage of the shares are not traded on the various dates. The average trade frequencies ranges between 80 per cent and 93 per cent. We note that the highest trade frequencies are observed on the announcement day t_0 and the following date. This indicates that we have retrieved the "correct" dates and it is a first indication that the announcements contain new information to the market. As a counteracting measure to the thin trading issue we utilize trade-to-trade returns, see (Maynes & Rumsey 1993; Bartholdy & Riding 1994) and (Bartholdy *et al.* 2007).

We calculate the trade-to-trade return for each bank "i" at time "t", R_{it}, between observed prices as

$$R_{it} = \frac{P_{it} - P_{it-n}}{P_{it-n}}$$

[11] For details of calculation see (NASDAQ 2014).

[12] http://www.nasdaqomxnordic.com.

where n is the age of the price. n=1 implies that the stock price is one day old and n>1 implies that there are days without trades. We assume that the trade-to-trade return is made up of daily unobserved returns, r_{it}, generated by the market model:

$$r_{it} = \alpha_i + \beta_i r_{mt} + e_{it} \,,$$

where r_{mt} is the return on the market index and e_{it} is independent and identically distributed (iid) with standard deviation σ_ε. The observed trade-to-trade return, R_{it}, is given by sum of unobserved returns on the days the stock does not trade. The observed return can therefore be written as:

$$R_{it} = \sum_{s=t-(n-1)}^{t} r_{is} = \sum_{s=t-(n-1)}^{t} \left(a_i + \beta_i r_{ms} + e_i\right) = n_{it}\alpha_i + \beta_i R_{mt} + \sum_{s=t-(n-1)}^{t} e_{is}$$

Where R_{mt} is the trade-to-trade return on the market index calculated over the same days as the return on the stock. Notice that the error term in (*) is a sum of iid variables, thus the standard deviation of the observed error term is:

$$\sqrt{n}_{it}\sigma_i$$

To eliminate the induced heteroscedasticity the following model is estimated:

$$\frac{R_{it}}{\sqrt{n_{it}}} = \sqrt{n_{it}}\,\widehat{\alpha_i} + \widehat{\beta_i}\frac{R_{mt}}{\sqrt{n_{it}}} + e_{it}$$

The abnormal returns are given by:

$$A_{it} = R_{it} - E\left[R_{it}\right] = R_{it} - n_{it}\widehat{\alpha_i} - \widehat{\beta_i} R_{mt}$$

Notice that the abnormal return is a sum of random variables and therefore heteroscedastic, so for the purpose of testing we use the adjusted abnormal returns:

$$A_{it}^{'} = \frac{A_{it}}{\sqrt{n}_{it}} = \frac{R_{it}}{\sqrt{n_{it}}} - \sqrt{n_{it}}\,\widehat{\alpha_i} - \beta_i \frac{R_{mt}}{\sqrt{n_{it}}} = e_{it} \,.$$

Table 5 provides descriptive statistics for the abnormal returns. At the announcement day the average abnormal return is -2.88% and -3.10% on the following day. After these two days the average abnormal return drops significantly. Looking at the standard deviation it appears that they increase significantly at the announcement day until day t+3. The evidence suggest that there is no “leakage” of information, i.e. all the impact from the announcement is found on the announcement day and two to three days after. This is confirmed by looking at Figure 1 which is a graphical representation of the cumulative abnormal returns (CAR’s) in a window from t_{-10} to t_{+10}. Finally, there is strong evidence of skewness and kurtosis thus we need to use non-parametric statistics when testing our first hypothesis. We apply a battery of test statistics based on (Maynes & Rumsey 1993) and (Bartholdy *et al.* 2007). The expressions and details are provided in Appendix 1.

The results in table 5 suggest that the relevant period or event window for our tests of hypothesis one to three is from one day before the announcement day, t-1 to two days after the announcement day t+2. During our tests of hypothesis one, discussed below, we try several different event windows and we settle on an event window of t_0 to t_{+2}, i.e. a three day event window for tests of hypothesis two and three.

In testing our hypotheses 2 and 3 we make use of a modified event study methodology. In the standard event study used for testing hypothesis one we calculate the abnormal return for each stock facing an announcement:

$$AR_{it} = r_{it} - \widehat{\alpha_i} + \widehat{\beta_i} r_{mt}$$

Where alpha and beta are estimated in the estimation period.

Alternatively one can estimate the abnormal return over the estimation period and the event window using the following regression:

$$r_{it} = \alpha_i + \beta_i r_{mt} + \gamma_i DA_{it} + \varepsilon_{it}$$

Where DA_{it} is a dummy variable with the value of 1 if there is an announcement on day "t". Provided that the two models are estimated over the same time interval then ϒ is equal to the abnormal return AR for day t=0. In hypothesis 2 and 3 we analyze the contagion effects for banks with only one auditor for a total of 71 announcements. Thus we need to run an event study for each announcement using all the banks not facing an announcement on the day and testing for contagion is the equivalent to testing if the average abnormal return of the peer banks is zero. If one uses the traditional method then one has to run the above equation approximately 4000 times (for each year: number of banks -1 times number of announcements – numbers provided in Table 3). But more importantly we end up also estimating about 8000 parameters (intercept terms and beta's for each bank for each announcement) and the abnormal returns across banks are correlated invalidating many of the test statistics used for hypothesis 1. Instead for hypothesis 2 we form a portfolio of all banks, but on the day of the announcement and the two following days (i.e. the event window) we drop the banks facing an announcement of loan losses by the FSA:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_j DA_t^j + \varepsilon_{pt}, t = 1/1/2009,..,31/12/2015$$

where r_{pt} is the daily return on a portfolio, p, of all bank stocks listed on day "t" from January 1, 2009 to December 31, 2015, that did not have an announcement on day "t". DA_t is a dummy variable with the value of 1 if the supervisory authority announces that any bank (either listed or private) faces an announcement of an increase in loan loss reserves at time "t". DA^0 is the announcement day and the estimate, $ϒ_0$, is an estimate of the average abnormal return on the announcement day to the peer banks, i.e. an estimate of the contagion effect, corresponding to the abnormal returns in a standard event study. DA^1 and DA^2 represents the two days following the announcement and the sum of the three dummy variables is equivalent to the Cumulative abnormal returns of the contagion effect in a standard event study. Thus a statistically negative coefficient on the dummy variables is indicative of a contagion effect, i.e. the return to banks not facing an announcement react negatively to the announcement of a bank not included in the portfolio. Using the portfolio approach reduces the number of estimated parameters to 5 providing more efficient estimates of our parameter of interests, ϒ's. The downside of this approach is that we assume that the intercept term's and beta's are constant over time.

We generate two portfolios one is equal weighted and one is value weighted. The return on the portfolio is generated by:

$$r_{pt} = \sum_{i=1}^{N_t} \frac{1}{w_{it}} \frac{R_{it}}{age_{it}}$$

We are working with trade-to-trade returns where N_t is the number of banks with trade-to-trade returns on day "t", that is the banks trading on day "t". R is the trade-to-trade return of the bank, age is the number of days between trades and w_{it} is either an equal weight, $1/N_t$, or value weighted by the market capitalization of the bank divided by the total market capitalization of banks trading on day "t". r_{mt} is the return on the stock market index

We also analyse if there is a difference between announcements for listed (L) banks and private (P) loan institutions:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_j DL_t^j + \sum_{j=0}^{2} \lambda_j DP_t^j + \varepsilon_{pt}, t = 1/1/2009,..,31/12/2015$$

Where DL and DP are announcement dummies for listed and private institutions respectively defined the same way as DA above.

Our third hypothesis focus on cases in which restating and peer banks use the same external auditor and cases in which both the restating and the peer banks use the same non-big four audit firm. Table 6 shows a distribution of the audit firms involved in the audit of the restating listed and non-listed banks.

< Insert table 6 here>

From the annual reports we collected information about the auditor(s) for all the listed banks from 2009 to 2015[13]. To analyze contagion effects we drop banks with two auditors. Four listed banks had two auditors for part of the period 2009 to 2015, for a total of 12 audit years. We were not able to ascertain the name of the auditor for an additional 6 audit years. From Table 6 we have a total of 229 audit years where listed banks only have one auditor. The four biggest auditing firms accounts for 84% of all audits. Similar high concentration is found in many other EU countries. A report by Ewers and London Economics from 2006 shows that the total market share of Big Four audit firms for listed companies in terms of

[13] For banks where an annual report is not available we used the minutes from the annual meeting where the auditing firm is elected.

the number of mandates is 70% or higher in a majority of EU member states[14]. We lose three announcements due to the single audit criteria and we therefore have a total 71 announcements/restatements for listed banks and the biggest four auditing firms account for 87% of these. For the private banks we only collect the name of the auditor for the year the banks face an announcement, a total of 47 restatements out of which two of the restatements had two auditors so the final sample is 45 private announcements, where the biggest four auditing firms again account for 87%

The first auditor contagion hypothesis investigates whether a restatement by bank X audited by auditor A has an impact on the return on bank Y also audited by auditor A.

We make use of the same basic methodology as for hypothesis 2. In the first step, for every year, we form an equally weighted portfolio of bank stocks with the same auditor. This generates a total of up to 12 portfolios every year (not all auditors are auditing a listed bank every year) one for each auditing firm auditing listed banks[15].

As before, in order to test for contagion effects, the banks with announcements are dropped from the portfolios during the three days around the announcement.

Next two dummy variables are generated:

SAU – Same auditor: if the announcement for a bank with the same auditor as the auditor portfolio then the value is 1 and 0 otherwise – the dummy variable is lagged one and two periods to capture the event window.

DAU - Different auditor: if the announcement is for a bank with a different auditor than the auditor portfolio then the value is 1 and 0 otherwise – again we also include two lagged dummy variables representing a three day event window.

We have 12 different audit firms involved in the audit of Danish listed banks during the period 2009-2015, thus for every year we form up to 12 portfolios. For each auditing firm, "p", we have the following model:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_p^j SAU_{pt}^j + \sum_{j=0}^{2} \gamma_p^j DAU_{pt}^j + \varepsilon_{pt}$$

for p=1 to 12 and t=1/1/2009 to 31/12/2015.

However, it is not possible to efficiently estimate the model for individual auditing firm/portfolio due to limited number of observations, e.g. the auditing firm Rasmussen and

[14] Study on the Economic Impact of Auditors' Liability Regimes (MARKT/2005/24/F) Final Report To EC-DG Internal Market and Services By London Economics in association with Professor Ralf Ewert, Goethe University, Frankfurt am Main, Germany, September 2006, table 5:

http://ec.europa.eu/internal_market/auditing/docs/liability/auditors-final-report_en.pdf

[15] In Table 7 we have 13 auditing firms bur SPEKT does not audit any listed banks.

Weihe is only present for one year with one announcement. It is therefore not possible to efficiently estimate ϒ's and λ's for individual auditing firm.

To overcome this problem we "stack" the portfolio data on top of each other creating a "pooled" dataset and estimating a common ϒ and δ across all the auditing firms. Each auditing portfolio had initially their own intercept term and beta (constant over time) but the contagion dummies are estimated across all portfolios, i.e. $\gamma's$ and δ's are constant across portfolios. The model was tested for constant intercept term across portfolios (banks specific effects) but we could not reject the hypothesis of constant intercept term across portfolios. Thus we have included a common intercept term for all portfolios but betas across portfolio are allowed to differ thus the (restricted) model estimated is given by:

$$r_{pt} = \alpha + \sum_{p=1}^{12} \beta_p r_{mt} + \sum_{j=0}^{2} \gamma^j SAU_{pt}^j + \sum_{j=0}^{2} \gamma^j DAU_{pt}^j + \varepsilon_{pt}$$

p=1,..12 and T=1/1/2009 to 31/12/2015

The model is estimated using OLS with date and auditing firm clustered residuals[16]. A statistically negative coefficient on the SAU dummy variables is indicative of a negative contagion effect associated with the use of the same audit firm. Hence, a statistically significant coefficient on the SAU dummy variable rejects H3a.

Our second, and final auditor contagion hypothesis investigates whether contagion effects are isolated to cases in which banks facing announcements and their peer banks use a non-Big Four audit firm.

Consequently, we split the auditors into "Big four" and "non-Big four" auditors. Big four auditing firms audit 76% of the accounts for the listed firms and accounts for 87% of the announcements for listed banks in the sample. We break the announcements into the following groups, represented by dummy variables, where x represents the number of days after the event, i.e. the event window. Recall, that for every year we have generated a portfolio of banks with the same auditor:

BigSamex,x=0,1,2: if announcement is for a bank audited by a Bigfour and the audit portfolio is the same Bigfour auditor then the value is 1 zero otherwise.

[16] A traditional approach when many stocks face an event on the same day is to use Seemingly Unrelated regressions. If we had sufficient data then our approach is the equivalent to estimating a system of 12 equations using Seemingly Unrelated Regressions and imposing restrictions on. $\gamma's$ and δ's across equations. In this setup with common explanatory variables OLS and SUR provide the same estimates. However, we do not have the same number of observations for each audit portfolio since some auditors do not audit banks in all of the years. For a SUR estimation we require a "balanced dataset" in our case the same number of observations for each audit portfolio. Since one of our audit firms only audit a listed bank in one year, using SUR we would only be able to estimate the system for that year or drop the auditors not auditing listed banks in every year. This would significantly reduce the number of announcements and the scope of the analysis. Our approach does not suffer from this problem and to account for the dependence we use clustered residuals along time and audit portfolio.

Bigdifx,x=0,1,2: if announcement is for a bank audited by a Bigfour and the audit portfolio has a different bigfour auditor then the value is 1 zero otherwise.

SmallSamex,x=0,1,2: if announcement is for a bank audited by a small auditor and the audit portfolio has the same small auditor then the value is 1 zero otherwise.

Smalldifx,x=0,1,2: if announcement is for a small auditor and the audit portfolio has a different small auditor then the value is 1 zero otherwise.

Bigsmallx,x=0,1,2: : if announcement is for a bank audited by a bigfour and the audit portfolio has a small auditor then the value is 1 zero otherwise.

Smallbigx,x=0,1,2: : if announcement is for a bank audited by a small auditor and the audit portfolio has a bigfour auditor then the value is 1 zero otherwise.

The following model is estimated:

$$
\begin{aligned}
r_{pt} = \alpha + \sum_{p=1}^{12} \beta_p r_{mt} + \gamma_1 Bigsame_t^0 + \gamma_2 Bigsame_t^1 + \gamma_3 Bigsame_t^2 + \gamma_4 Smallsame_t^0 + \gamma_5 Smallsame_t^1 + \gamma_6 Smallsame_t^2 \\
+\gamma_7 Bigdif_t^1 + \gamma_8 Bigdif_t^2 + \gamma_9 Bigdif_t^3 + \gamma_{10} Smalldif_t^1 + \gamma_{11} Smalldif_t^2 + \gamma_{12} Smalldif_t^3 + \\
\gamma_{13} Bigsmall_t^{\prime 0} + \gamma_{14} Bigsmall_t^{\prime 1} + \gamma_{15} Bigsmall_t^{\prime 2} + \gamma_{16} Smallbig_t^0 + \gamma_{17} Smallbig_t^1 + \gamma_{18} Smallbig_t^1 + \varepsilon_{it},\ p = 1,..12
\end{aligned}
$$

A statistically negative coefficient on the Smallsame dummy variables is indicative of a negative contagion effect associated with the use of the same Non-Big four audit firm. Hence, a statistically significant coefficient on the Smallsame dummy variables rejects H3b.

5. Results.

The first hypothesis is given by:

H_1: The share price of banks do not react to announcements by the FSA of increases in loan loss reserves.

Table 7 reports the results of the tests of abnormal returns and table 8 reports the results of the tests of cumulative abnormal returns. The tables show clear and strong evidence of negative returns over the period 2009-2015 regardless of the test statistic used. The results in table 7 and 8 consequently reject H_1.

Most of the impact are centered around announcement day 0 and +1. The average abnormal returns are -2.88 per cent on the announcement day and -3.10 per cent on the following day (CAR: -5.98 per cent). Gleason et al. (2008) report that the mean three-day announcement period abnormal stock return (t_{-1} to t_{+1}) for firms that announce ''securities'' misstatements - which they associate with financial services firms - is -11.7 per cent. Several prior papers have examined the market reactions to restatement announcements from non-financial firms in which errors or irregularities in the financial statements are corrected. Early work shows substantial negative market reactions (Palmrose et al. (2004) find -9%, GAO (2002) find nearly -10%, and Dechow et al. (1996) find -8%), while more recent studies find more modest reactions to restatements (GAO (2006b) find -2%, Files et al. (2014) and Myers et al. (2013) both find -1-2%). In sum: The size of the market reaction in our study seems smaller than the reaction found in Gleason et al. (2008), but remarkably higher than market reactions found in more recent studies.

In order not to overlook any contagion effects we add an additional day and use a three-day event window (t_0 to t_{+2}) in our tests of hypothesis two and three.

Hypothesis 2.

Having established that there are strong negative effects from increases in loan loss reserves, the next issue is if contagion effects can be observed in peer banks.

H2: The share prices of peer banks do not react to an announcements by the FSA of increases in loan loss reserves in inspected banks.

The results are presented in Table 9. The dummy variables measure the abnormal return to the non-restating banks from the announcement of an increase in provisions for loan loss reserves in either a private or listed bank on each of the three event days. For the equal weighted portfolio the announcement dummy on t=+1 is negative and significant which suggests that there are contagion effects. However, for the value weighted portfolio we do not find an effect indicating that the contagion effect is related to the size of the banks. The value of the coefficient DA^1 is -0.0017. This indicates a modest reaction by investors in peer banks to the publication of the inspection reports. In their (general) study of contagion effects associated with accounting restatements, Gleason et al. (2008) similarly find small negative market reactions in non-restating peer firms (mean three day abnormal return of -0.5 per cent) when an accounting misstatement is first announced by another firm in the industry.

Table 10 analyses contagion effects separately for announcements from listed banks and private loan institutions. The results confirm the results from Table 9 namely that there is evidence of contagion but only from listed institutions. It appears that none of the announcements from the private institutions have an impact on the returns of the listed banks. This could for instance be due to investors having a narrow focus on news from the segment that they are able to invest in, i.e. they have a functional fixation on listed banks, or that they perceive that the private bank segment is so different from the listed bank segment for example in terms of the quality of financial reporting that announcements from this segment is considered not to be value relevant. Listed banks are larger than private loan institutions. The results thus seem in accordance with Gleason et al. (2008) who find that contagion stock returns are statistically more negative when a large firm in the industry restates.

Together the small price declines in peer firms suggest that the expressed concerns that the publication of the outcome from regulatory inspections of banks may lead to instability of the financial system are unwarranted.

Hypothesis 3.

H3a: Peer banks stock returns do not react when the FSA announce increases to loan loss reserves of a bank that uses the same external auditor as the peer banks.

The results are presented in Table 11. Here we test if a bank reacts to an announcement in another bank with the same (or a different) auditor without distinguishing between the size or quality segment of the audit firms. Neither the dummy variable for same auditor nor the dummy variable for different auditor are significant. Thus, there is no evidence of informational contagion effects caused by auditors at the aggregate level and H3a is not rejected.

In contrast, Gleason et al. (2008) find that investors impose an incremental contagion penalty on peer firms with high earnings and high accruals when the peer and restating firm share the same external auditor. The different results in our study could be due to the focus on financial institutions and the more recent sample period. The EU for instance issued a new Directive on statutory audits of annual accounts and consolidated accounts in 2006 (Directive 2006/43/EC), a Green paper in 2010 (COM(2010) 561 final), and a new regulation on specific requirements regarding statutory audit of public-interest entities in 2014 (Regulation (EU) No 537/2014) all aimed at improving the effectiveness, independence and consistency of the regulation and oversight of statutory auditors and audit firms. This focus on audit quality could perhaps reassure the investors that audit failures in one bank is an isolated event rather than reflecting more systematic audit quality problems in the particular audit firm. On the other hand, investors may still perceive that there are different segments in the audit market in terms of audit quality. To further explore the effects of auditors we split the auditors into "Big Four" and non-Big Four auditors.

H3b: Peer banks stock returns do not react when the FSA announce increases to loan loss reserves and peer banks use the same non-Big Four audit firm.

Table 12 shows some evidence of auditor contagion. Banks audited by the same audit firm react negatively to a Loan Loss Provision announcement by the Supervisory authority but only if the audit firm is a non-Big Four. Thus, while we found no evidence of a general auditor contagion effect in table 11 it appears that there is contagion when the size or quality segment of the involved auditors is considered. The result that auditor contagion is concentrated in audits by the same non-Big Four audit firms indicates that investors perceive that there are different audit quality segments in the audit market. They appear to consider an audit failure – here defined as a correction by the FSA of previously announced and audited loan loss reserves – as an isolated event when the audit was conducted by a Big

Four auditor, whereas they seem to question other work in the industry by the same audit firm, when the audit is conducted by a non-Big Four audit firm. In 2014 as a response to the increased complexity in the audit of banks and in the aftermath of a number of prominent bank failures where the work of the external auditor was questioned, Denmark introduced a new requirement where all bank auditors have to be certified by the FSA. Certification requires among other things that the auditor in fixed five year periods is involved in the audit of banks with a minimum number of work hours obtained in at least three different banks and that the auditor every year spends a minimum number of hours on courses specifically about the audit of financial institutions.[17] This system is expected to reduce the number of auditors that will be able to perform bank audits, and that more work will be conducted by Big Four auditors. In this respect our finding that audit quality failures appear not to have adverse affects on shareholder wealth in other firms as long as high quality Big Four audit firms are involved probably reassures Danish legislators that this decision is right.

7. Conclusion.

This study analyses if the announcement of increases in loan loss reserves by supervisory authorities lead to contagion in financial markets and whether contagion effects are affected by the choice of audit firms. Few studies have analysed contagion effects related to the credibility of financial statements and the work of the external auditor, and previous contagion studies often suffer from endogeneity and/or signaling effects because the studies are based on announcements made by the firms themselves. In this paper we analyze the announcement by an authoritative external source, the Danish Financial Supervisory Authority of an increase in a bank's loan loss reserves following an inspection. First, we establish whether the announcements by the FSA of increases in a bank's loan loss reserves have a positive or negative effect on the share price of the restating bank; i.e., whether the announcements contain value relevant news to the market. We find clear and strong evidence of negative returns over the period 2009-2015.

Next we analyse if such negative events adversely affect shareholder wealth in peer banks. In an equally weighted portfolio we find a small but reliably negative share price decline among non-restating peer banks and hence some evidence of contagion. Concerns have been expressed that the publication of outcomes from regulatory inspections of banks could lead to instability of the financial systems due to such contagion effects. However, the small share price declines in peer firms in our study suggest that such concerns are unwarranted.

Finally, we analyze the role of auditors in contagion effects from restatements of the financial accounts. An analysis of the auditors' role provides interesting insights into questions about brand protection in the audit industry, i.e. whether or not bank investors consider a problematic audit by a specific audit firm to be an isolated event or something which "taints" the audit firm as such. Moreover, the analysis provides insights into the question whether investors perceive auditing to be a standardized service or if different

[17] Statutory order, BEK nr 874 af 01/07/2015.

segments can be identified. First, we test if a bank reacts to an announcement in another bank with the same auditor without distinguishing between the size or quality segment of the audit firms. We find no evidence of contagion effects associated with the use of the same audit firm at the aggregate level. Next we distinguish between different auditor segments and investigate whether there are contagion effects in cases where the restating and peer banks use either the same Big Four or non-Big Four audit firm. Here we find evidence of auditor contagion concentrated in audits by the same non-Big Four audit firms. This indicates that investors perceive that there are different audit quality segments in the audit market.

Together our results suggest that the announcement of inspection reports by the FSA which corrects (increase) previously released information about the size of loan loss reserves are (negative) value relevant news to the stock market, the information adversely affects shareholder wealth in other banks and part of the contagion effect is related to the use of the same audit firm from the non-Big Four segment

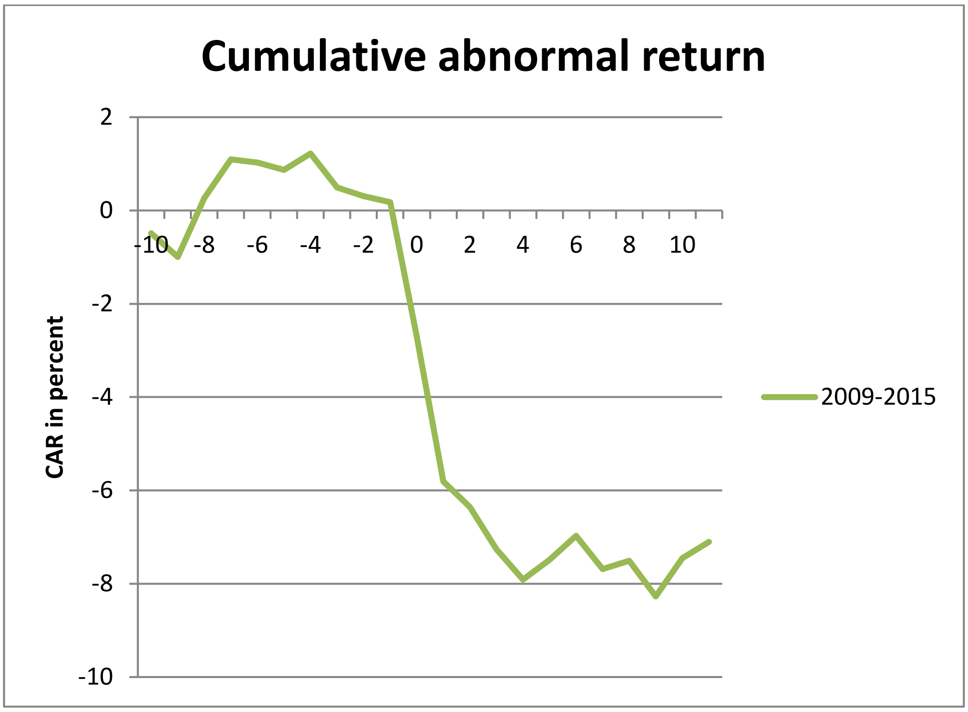
Limitations

While we have collected all available data from Denmark we still have a small sample. This may negatively affect the statistical power of our tests.

Our sample period 2009-2015 covers years both during and after the financial crisis. We cannot rule out that this can have an effect on our results.

In our tests of auditor contagion we should ideally have estimated our regression model for individual audit firms, i.e. have obtained individual indicator variables for “same auditor,” however this was not possible due to the limited number of observations. So we have “preserved” data by stacking data and create a pooled dataset in which we obtain one “same auditor” variable in our opinion suffice for our purpose.

Figure 1.



For calculations of abnormal returns see Table 7.

Table 1. The Danish banking sector compared to the Euro area, USA and the World.

	Denmark	Euro area	USA	World
5 bank asset concentration (%) [1)]	73.19	80.01	27.57	79.12
Bank concentration (%) [2)]	59.58	64.54	19.62	66.00
Bank non-performing loans to gross loans (%) [3)]	1.88	2.88	2.70	3.41
Provisions to non-performing loans (%) [4)]	56.88	58.98	96.27	69.08
Regulatory capital to risk weighted assets (%) [5)]	13.32	12.40	13.52	14.76

Source: Data from World Bank, Financial Structure Dataset.

Concentration measures: average 2000-2010. Other measures: average 2005-2010.

Aggregation method: median

1) Assets of the five largest banks as a share of total commercial banking assets

2) Assets of three largest commercial banks as a share of total commercial banking assets

3) Ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio)

4) Non-performing loans are loans for which contractual payments are delinquent, usually defined as being overdue for more than a certain number of days

5) The capital adequacy of deposit takers. It is a ratio of total regulatory capital to assets held, weighted according to risk of those assets.

Table 2. Size groups share of Total Assets, deposit and loans in 2010.

Finanstilsynet defined the three size groups in the following way: Size group 1 is defined as banks with "working capital (deposit, issued bonds subordinated debt and equity capital) above 50 bill. D.kr., group 2 has working capital between 10 and 50 bill. D.kr. and size group 3 has working capital between 250 mill. D.kr. and 10 bill. D.kr. An additional 27 very small banks with working capital below 250 Mill. D.kr. are not included in the analysis and therefore excluded from the Table.

Table	**Group**			
	1	2	3	Sum
Number of institutions	6	12	78	96
	% of total for the three groups			
% of Total assets of groups 1,2 and 3	85.74	6.73	7.53	100
% of Total lending of groups 1,2 and 3	81.98	8.42	9.59	100
% of Total deposits of groups 1,2 and 3	79.64	9.34	11.02	100

Source: Finanstilsynet: https://www.finanstilsynet.dk/da/Tal-og-Fakta/Statistik/Statistik-om-sektoren/2010/Pengeinstitutter-Statistisk-materiale-2010 - Table1_2PI_xls(3).xls

Table 3. Number of announcements of increases in loan loss reserves.

The number of listed banks is defined as banks with available stock return some time during the year. The number of listed banks differ from year to year due to IPO's and delisting due to acquisitions and defaults. Announcements for private institutions are only available from 2010. The total number of institutions is from FSA's annual reports and is the number of institutions in size groups 1,2 and 3. The number of private institutions is the difference between the total number of institutions and the number of listed banks in our sample.

	Number of announcements from listed banks	Number of listed banks at some point during the year	Number of announcements from private institutions	Number of private institutions	Total number of institutions
2005	0	42	NA		100
2006	0	44	NA		103
2007	0	48	NA		104
2008	0	47	NA		101
2009	5	42	NA	57	99
2010	7	42	0	54	96
2011	13	40	6	51	91
2012	18	37	9	40	77
2013	16	32	12	45	77
2014	7	27	12	40	67
2015	8	27	6	30	57
Total	74		45		

Sources: Infomedia, OMX NewsClient and https://www.finanstilsynet.dk/da/Tilsyn/Tilsynsreaktioner

Table 4. Number of announcements by individual banks during the period 2009 to 2015.

The announcements are by the FSA demanding an increase in loan loss reserves.

Number of announcements	Number of listed banks	Number of private institutions
0	9	NA
1	13	20
2	11	5
3	5	5
4	6	0
Total number of announcements	74	45

Sources: Infomedia, OMX NewsClient and https://www.finanstilsynet.dk/da/Tilsyn/Tilsynsreaktioner

Table 5. Summary statistics for Average abnormal returns and Trading frequencies.

The table reports descriptive statistics of abnormal returns for inspected banks where the FSA on day t_0 announces that the bank needs to increase its loan loss reserves.

Using trade-to-trade returns the following model is estimate over a 200 day estimation period:

$$\frac{R_{it}}{\sqrt{n_{it}}} = \sqrt{n_{it}}\,\widehat{\alpha}_i + \widehat{\beta}_i \frac{R_{mt}}{\sqrt{n_{it}}} + e_{it}$$

The abnormal returns are given by:

$$A_{it} = R_{it} - E\left[R_{it}\right] = R_{it} - n_{it}\widehat{\alpha}_i - \widehat{\beta}_i R_{mt}$$

Descriptive statistics of abnormal returns					
	2009-2015 74 events				
Event day	Trade frequency	Mean	Standard deviation	Coefficient of Skewness	Coefficient of Kurtosis
-5	0.92	-0.16	2.76	0.07	1.72
-4	0.91	0.35	3.76	1.39	5.91
-3	0.88	-0.73	3.41	-0.37	1.23
-2	0.86	-0.19	2.47	-0.02	0.58
-1	0.85	-0.13	4.12	1.29	8.61
0	0.93	-2.88	9.09	-2.26	6.08
1	0.92	-3.10	9.61	-1.17	3.94
2	0.88	-0.55	8.78	2.73	18.77
3	0.91	-0.90	10.21	-5.03	36.47
4	0.85	-0.65	3.53	-1.28	3.64
5	0.80	0.42	4.78	0.00	2.39

Note: In calculating standard deviation, skewness and kurtosis abnormal returns are adjusted by the “age” of the price by dividing the abnormal return by the square root of the age of the stock. For the normal distribution the value of the coefficients of skewness and kurtosis are zero.

Table 6. Distribution of Loan Loss Provision announcements for banks with only one auditor across auditing firms.

	Auditor number	Big four	Listed Banks				Private Banks[1]	
Revisorfirma			Number of audits	Number of restatements[2]	% of listed restatements	% of listed audits being restated	Number of restatements	% of private restatements
BDO ScanRevision A/S	1	0	15	4	5.63	26,67	1	2.22
Beierholm and Mortensen & Beierholm A/S	2	0	7	2	2.82	28,57	4	8.89
Deloitte & Touche Revisionsaktieselskab	3	1	76	20	28.17	26,32	18	40
Ernst & Young, Revisionsfirmaet A/S	4	1	13	1	1.41	7,69	5	11.11
KPMG C. Jespersen	5	1	39	20	28.17	51,28	2	4.44
Leo Hansen, Statsautoristede revisorer	6	0	1	0	0.00	0		
Nielsen og Christensen	7	0	8	2	2.82	25		
Nota	8	0	1	0	0.00	0		
Partner Revision A/S	9	0	3	0	0.00	0		
PricewaterhouseCoopers	10	1	64	21	29.58	32,81	14	31.11
Rasmussen og Weihe	11	0	1	1	1.41	100		
Redmark	12	0	1	0	0.00	0		
SPEKT	13	0	0	0	0.00	0	1	2.22
Total			229	71	100		45	100
BigFour firms			192 (83.84%)	62	87.32%		39	86.67%

[1] We did not collect auditor information for all private banks and savings banks only the ones facing a restatement announcement from the FSA announcements attributed to banks.
[2] The total number of announcements/restatements differs from Table 5. In Table 7 we only look at announcements for banks with one auditor. Three announcement are dropped in Table 7 compared with Table 5 since the banks in question had two auditors.

Table 7. Test statistics for the event study. Tests of abnormal returns.

The table reports the values of non-parametric test statistics of average abnormal returns for inspected banks
where the FSA on day t_0 announces that the bank needs to increase its loan loss reserves.

Test statistics for average abnormal return									
	AR	CAR	T1	T2	T3	T4	T5	T6	T7
	%								
-5	-0.16	-0.16	-0.45	-0.65	-0.28	-0,49	-0.92	-1.76	-1.42
-4	0.35	0.19	0.71	0.44	0.74	0,43	0.13	0.05	0.12
-3	-0.73	-0.54	-1.34	**-2.01**	-1.42	-1,65	-1.42	-1.44	-0.85
-2	-0.19	-0.72	-0.36	-0.81	-0.40	-1,30	-0.48	0.17	0.24
-1	-0.13	-0.85	-0.06	0.18	-0.07	0,15	0.20	0.04	-0.12
0	-2.88	-3.73	**-4.96**	**-7.18**	**-5.57**	**-2,47**	**-2.48**	**-2.11**	-1.53
1	-3.10	-6.83	**-5.99**	**-7.65**	**-6.11**	**-2,58**	**-3.76**	**-2.73**	**-2.37**
2	-0.55	-7.39	-1.13	**-2.08**	-1.12	-1,07	-0.81	-0.70	-0.12
3	-0.90	-8.29	-1.73	**-2.93**	-1.90	-0,90	-0.70	-0.92	-1.08
4	-0.65	-8.94	-1.26	-1.05	-1.32	-1,44	-0.94	-0.21	-0.12
5	0.42	-8.52	0.61	0.86	0.68	0,51	0.58	0.56	0.89

Bold faced is significant at the 5% level.

Description of test statistics provided in the Appendix.

Table 8. Test statistics for the event study. Tests of CAR.

The table reports the values of non-parametric test statistics of cumulative abnormal returns for inspected banks

where the FSA on day t_0 announces that the bank needs to increase its loan loss reserves.

	CAR	T1	T2	T3	T4	T5	T6	T7
(-1,2)	-6.11	**-3.07**	**-8.48**	**-6.43**	**-2.94**	**-3.42**	**-2.75**	**-2.07**
(0,1)	-5.98	**-5.44**	**-10.49**	**-8.26**	**-3.56**	**-4.41**	**-3.43**	**-2.76**
(0,2)	-6.53	**-4.12**	**-9.81**	**-7.39**	**-3.49**	**-4.07**	**-3.20**	**-2.32**
(0,3)	-7.43	**-3.50**	**-9.97**	**-7.35**	**-3.48**	**-3.87**	**-3.23**	**-2.55**
(-5,5)	-8.52	-1.48	**-7.02**	**-5.12**	**-3.09**	**-3.19**	**-2.73**	-1.92

Bold faced is significant at the 5% level.

Table 9.

The following model is estimated:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_j DA_t^j + \varepsilon_{pt}, t = 2009,..,2015$$

Trade—trade-returns are used to calculate the return on the equal and value weighted portfolio of bank returns. During the event window the return on the banks facing an announcement are excluded for the portfolio in the event window (t,t+1,t+2). DA is a dummy variable for announcements for listed banks and private bank or savings bank by the FSA on the date. We have included three dummy representing the event window of t=0, t=+1 and t=+2. T-statistics are in parenthesis.

	Equal weighted portfolio	**Value weighted portfolio**
Intercept	0.0003	-0.0001
	(1.46)	-(0.31)
Market porfolio	0.5274	1.3197
	(24.09)	**(32.99)**
DA^0 - announcements at, t=0	0.0005	-0.0001
	(0.53)	-(0.07)
DA^1 - announcements at, t=1	-0.0017	0.0010
	-(1.99)	(1.06)
DA^2 - announcements at, t=2	0.0004	-0.0002
	(0.46)	-(0.20)

Table 10.
The following model is estimated:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_j DL_t^j + \sum_{j=0}^{2} \lambda_j DP_t^j + \varepsilon_{pt}, t = 2009,..,2015$$

Trade—trade-returns are used to calculate the return on the equal and value weighted portfolio of bank returns. During the event window the return on the banks facing an announcement are excluded for the portfolio in the event window (t,t+1,t+2). DL is a dummy variable for announcements for listed banks and DP is a dummy variable for announcements for private bank or savings bank face by the FSA on the date. We have included three dummy representing the event window of t=0, t=+1 and t=+2. T-statistics are in parenthesis.

	Equal weighted portfolio	**Value weighted portfolio**
Intercept	0.0003	-0.0001
	(1.34)	-(0.24)
Market porfolio	**0.5280**	**1.3190**
	(24.14)	**(32.96)**
DL^0 - listed banks at, t=0	0.0008	0.0007
	(0.68)	(0.52)
DL^1 – listed banks at t=+1	**-0.0034**	0.0002
	-(3.31)	(0.18)
DL^2 - listed banks at t=+2	0.0011	-0.0003
	(0.82)	-(0.30)
DP^0 - private banks at, t=0	0.0006	-0.0013
	(0.37)	-(0.93)
DP^1 – private banks at t=+1	0.0021	0.0020
	(1.64)	(1.50)
DP^2 - private banks at t=+2	-0.0008	-0.0006
	-(0.63)	-(0.50)

Table 11. Tests of the influence of the same auditor.

$$r_{pt} = \alpha + \sum_{p=1}^{12} \beta_p r_{mt} + \sum_{j=0}^{2} \gamma_p^j SAU_{p,t}^j + \sum_{j=0}^{2} \delta_p^j DAU_{p,t}^j + \varepsilon_{pt}$$

Trade-to-trade-returns are used to calculate the return on individual banks. Every year Banks are assigned to one of 12 portfolios based on their auditor. During the event window the return on banks facing an announcement are excluded from the portfolio in the event window (t,t+1,t+2). The 12 portfolios are stacked on top of each other creating a pooled dataset. The following variables are dummy variables representing announcements are included: SAU is equal to one if the announcement bank has the same auditor as the portfolio and zero otherwise. DAU is equal to one if the announcement bank has a different auditor as the portfolio and zero otherwise. The model is estimated using OLS with clustered errors along auditor and time.

	Estimate	t-stat
Intercept	0.0006	1.27
Beta for auditor 1 portfolio	0.3385	**44.92**
Beta for auditor 2 portfolio	0.4015	**21.77**
Beta for auditor 3 portfolio	0.5179	**107.21**
Beta for auditor 4 portfolio	0.4385	**45.69**
Beta for auditor 5 portfolio	0.9249	**186.08**
Beta for auditor 6 portfolio	0.2304	**8.79**
Beta for auditor 7 portfolio	0.0717	**12.82**
Beta for auditor 8 portfolio	0.5970	**45.00**
Beta for auditor 9 portfolio	0.6694	**37.01**
Beta for auditor 10 portfolio	0.4251	**135.44**
Beta for auditor 11 portfolio	0.4701	**49.46**
Beta for auditor 12 portfolio	0.4840	**20.02**
SAU: same auditor for t = 0	-0.0018	-1.25
SAU: same auditor for t = +1	0.0008	0.48
SAU: same auditor for t = +2	-0.0002	-0.12
DAU: different auditor for t = 0	0.0005	0.47
DAU: different auditor for t = +1	-0.0037	-0.95
DAU: different auditor for t = +2	0.0035	0.70

Table 12. Analysis of contagion from auditors.

$$r_{pt} = \alpha + \sum_{p=1}^{12} \beta_p r_{mt} + \gamma_1 Bigsame_t^0 + \gamma_2 Bigsame_t^1 + \gamma_3 Bigsame_t^2 + \gamma_4 Smallsame_t^0 + \gamma_5 Smallsame_t^1 + \gamma_6 Smallsame_t^2$$
$$+\gamma_7 Bigdif_t^1 + \gamma_8 Bigdif_t^2 + \gamma_9 Bigdif_t^3 + \gamma_{10} Smalldif_t^1 + \gamma_{11} Smalldif_t^2 + \gamma_{12} Smalldif_t^3 +$$
$$\gamma_{13} Bigsmall_t^{'0} + \gamma_{14} Bigsmall_t^{'1} + \gamma_{15} Bigsmall_t^{'2} + \gamma_{16} Smallbig_t^0 + \gamma_{17} Smallbig_t^1 + \gamma_{18} Smallbig_t^1 + \varepsilon_{pt}$$

Trade-to-trade-returns are used to calculate the return on individual banks. Every year Banks are assigned to one of 12 portfolios based on their auditor. During the event window the return on banks facing an announcement are excluded from the portfolio in the event window (t,t+1,t+2). The 12 portfolios are stacked on top of each other creating a pooled dataset. The following variables are dummy variables representing announcements are included: BigSamex,x=0,1,2: if announcement is made by a bank audited by a Bigfour and the current portfolio has the same Bigfour auditor then the value is 1, zero otherwise. Equivalent for small auditors SmallSamexx. Bigdifx,x=0,1,2: if announcement is made by a bank audited by a Bigfour and the current banks has a different bigfour auditor then the value is 1 zero otherwise. Again the same definitions for a small auditor SmallDifx. Bigsmallx,x=0,1,2: : if announcement is made by a bigfour and the current banks has a small auditor then the value is 1 zero otherwise. Smallbigx,x=0,1,2: : if announcement is made by a small auditor and the current banks has a bigfour auditor then the value is 1 zero otherwise. To save place we do not report the beta values since they are close to the ones reported in Table 13. The model is estimated using OLS with clustered errors along auditor and time.

	Estimate	t-stat
Intercept	0.0006	1.26
Bigsame for t =0	-0.0003	-0.45
Bigsame for t =1	-0.0003	-0.30
Bigsame for t = 2	0.0009	1.34
Smallsame for t =0	-0.0160	**-3.01**
Smallsame for t = 1	0.0144	1.35
Smallsame for t = 2	-0.0045	**-2.07**
Bigdif for t = 0	-0.0011	-1.50
Bigdif for t = 1	-0.0015	-1.28
Bigdif for t = 2	-0.0009	-0.87
Smalldif for t = 0	-0.0034	-0.32
Smalldif for t = 1	-0.0156	-1.13
Smalldif for t = 2	0.0142	0.67
Bigsmall for t = 0	0.0018	0.58
Bigsmall for t = 1	-0.0058	-0.77
Bigsmall for t = 2	0.0076	0.75
Smallbig for t = 0	0.0023	0.92
Smallbig for t = 1	0.0005	0.26
Smallbig for t = 2	-0.0002	-0.08

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Appendix 1. Test statistics.

Stock prices are retrieved from Datastream and have several problems: If there is no trade then the price from "t-1" is entered for time "t", thus we cannot distinguish between a day with no trades (Datastream enters the price for t-1) and a situation with trades but the price at time "t" is the same as at time "t-1". Furthermore, volume data is either entered as missing, zero or positive, thus volume data on its own cannot be used to identify days with trades. To identify if a given price on Datastream is a traded price or an "old price" we use the following procedure: A missing trade is identified if volume is either missing or zero and return on the stock is zero. Conversely, we assign a trade to the price if volume is zero and return is not zero or volume is positive

From the text we have the following expressions for abnormal returns:

$$A_{it} = R_{it} - E\left[R_{it}\right] = R_{it} - \widehat{n_{it}\alpha_i} - \widehat{\beta}_i R_{mt}$$

Where A is the abnormal trade-to-trade return , R and R_m are the trade-to-trade returns on the stock and the market recpectively and alpha and beta are the estimated coefficients from the market model. . The heteroschedastic adjusted abnormal returns is given by:

$$A_{it}^{'} = \frac{A_{it}}{\sqrt{n_{it}}} = \frac{R_{it}}{\sqrt{n_{it}}} - \sqrt{n_{it}}\,\widehat{\alpha}_i - \beta_i \frac{R_{mt}}{\sqrt{n_{it}}} = e_{it}$$

Where n is the age of the price.

T1 (Brown & Warner 1980) and (Brown & Warner 1985).

For each day in the event window(0,1,2)

$$T_t^1 = \frac{\sum_i^{N_t} A_{it}^{'}}{\sqrt{\sum_i^{N_t} n_{it} s_i^2}} \sim N(0,1)$$

$$\text{where } s^2 = \frac{1}{T_i - 1}\sum_{t=1}^{T_i}\left[A_{it}^{'}\right]^2$$

Where N_t is the number of trade-to-trade returns on day "t", i.e. the number of stocks that traded on day "t" in the event window. T_i is the number of trade-to-trade returns in the estimation period for stock "I".

The test for CAR is given by:

$$CarT^1_{0to+2} = \frac{\sum_i^{N_0} A^0_{it} + \sum_i^{N_{+1}} A^1_{it} + \sum_i^{N_{+2}} A^{+2}_{it}}{\sqrt{\sum_i^{N_{01}} n_i s_i^2 + \sum_i^{N_{+1}} n_{i+1} s_i^2 + \sum_i^{N_{+2}} n_{i+2} s_i^2}} \sim N(0,1)$$

T2 (Brown & Warner 1985).

Here we use standardized abnormal returns:

Where

$$A^s_{it} = \frac{A'_{it}}{\sqrt{n_{it}}\, S(A'_i)}$$

$$S\left(A'_i\right) = \sqrt{\frac{1}{T_i - 1} \sum_{t=1}^{T_i} \left(A'_{it}\right)^2}$$

$$T2 = \frac{1}{\sqrt{N_t}} \left(\sum_{i=1}^{N_t} \left(A^s_{it}\right) \right)$$

T3 (Brown & Warner 1980, 1985)?

$$T3 = \frac{\frac{1}{N_i} \sum_{i=1}^{N_i} A'_{it}}{S\left(\overline{A'}\right)}$$

where

$$S\left(\overline{A'}\right) = \sqrt{\frac{1}{T - 1} \sum_{t=1}^{T} \left(\overline{A'_t}\right)^2}$$

$$\overline{A'} = \frac{1}{N_i} \sum_{i=1}^{N_i} A'_{it}$$

T4 (Boehmer *et al.* 1991)

This test takes into consideration increases in variance in the event window.

$$T4 = \frac{\frac{1}{N_i}\sum_{i=1}^{N_i} A_{it}^s}{\sqrt{\frac{1}{N_i(N_i-1)}\sum_{i=1}^{N_i}\left(A_{it}^s - \frac{1}{N_i}\sum_{i=1}^{N_i} A_{it}^s\right)^2}}$$

T5 Rank test (Maynes & Rumsey 1993)

This is a non-parametric test based on ranks of standardized abnormal returns in both the estimation and event window.

$$T5_t = \frac{1}{\sqrt{N_t}}\sum_{i=1}^{N_t} K_{it}^{'}\,, \quad K' = \frac{K_{it} - \frac{1}{2}(T_i+1)}{\sqrt{(T_i^2-1)/12}}\,, \quad K_{it} = Rank\left(A_{it}^s\right),$$

Where K is the rank of the standardized returns over the estimation and event window. Here T is the number of observations over the estimation and event period.

T6. (Cowan 1992; Cowan & Sergeant 1996).

This is a non parametric test based on the signs of the signs the abnormal returns.

$\hat{p} = \frac{1}{N}\sum_{j=1}^{N}\frac{1}{T_j}\sum_{t=1}^{T_j}\varphi_{jt}$ where $\varphi_{it} = 1,\ if\ A_{it} > 0,\ and\ \varphi_{it} = 0\ otherwise.$ Estimated over the estimation period. For each day in the event window we calculate the following statistics:

$$T6_t = \frac{\sum_{i=1}^{N_t}\varphi_{it} - N_t \times \hat{p}}{\sqrt{N \times \hat{p}(1-\hat{p})}}$$

T7 Sign test ((Corrado & Zivney 1992))

$$T_7 = \frac{\frac{1}{\sqrt{N_0}}\sum_{j=1}^{N_0} G_{j0}}{S(G)}$$

Where $G_{it} = sign\left(A_{it} - median\left(A_i\right)\right), t = -248, .., +1$

$$s\left(G\right) = \sqrt{\frac{1}{T}\sum_{t}^{T}\left(\frac{1}{\sqrt{N_t}}\sum_{i=1}^{N_t} G_{it}\right)^2}$$