The effect of the ECB's expanded asset purchasing programme: Did it increase the systemic risk within the eurozone banking sector?

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Abstract

To stimulate the economy and fulfil their mandate of creating price stability the European Central Bank (ECB) implemented the expanded Asset Purchasing Programme (APP) in March 2015. This thesis aims to answer the questions of whether the expanded APP impacted the systemic risk within the banking sector of the eurozone. The results show that since the implementation of the Expanded APP, the long- and short-term systemic risk within the eurozone banking sector has increased. When differentiating between GIIPS and non-GIIPS countries during the APP implementation, results show that the long run systemic risk has decreased where the short-term systemic risk has increased. Since one of the sub programs of the expanded APP concerns the purchase of sovereign debt, the relation between sovereign holdings and systemic risk of a bank is considered. No evidence is found on an existing relationship between the sovereign holdings of a bank and the systemic risk this bank holds.

Keywords: Systemic Risk, Expanded Asset Purchasing Programme, Eurozone banking sector

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1. Introduction

The financial crisis made us painfully aware of the importance of a strong financial system. The fall of Lehman Bank showed that no bank is too big to fail, and that the bankruptcy of a bank can have catastrophic implications for the overall economy. In Europe, several banks had to be bought out by governments and some European governments faced severe financial distress. The financial crisis left scars on the economy in the form of low economic growth and downward-trending inflation. On January 8th 2010, Janet Yellen, at that time Vice Chair of the Federal Reserve Bank, announced that the FED would start with an Asset Purchasing Programme to fulfil their mandate of creating maximum employment and price stability (Federal Reserve Bank, 2010). Approximately five years later, on the January 22nd 2015, the European Central Bank announced their expanded Asset Purchasing Programme. The intentions of the ECB where the same as those of the FED: fulling their mandate of price stability and therefore increasing inflation. The ECB's expanded APP covers four sub-programmes: Assets-Backed Securities Purchase Programme (ABSPP), Corporate Sector Purchasing Programme (CSPP), Public Sector Purchase Programme (PSPP) and the third Covered Bond Purchase Programme (CBPPS3). Together, these programmes intended to provide stimulus to the economy and bringing the key ECB interest rate to its lower boundary (European Central Bank, 2015). The ECB announced that it would make monthly purchases of 60 billion euro, distributed over all four sub-programmes. This unconventional monetary policy caused the interest rate to drop below zero. They also made it more attractive for banks to finance their operation with debt. On the other side, banks were forced to seek other, sometimes more risky investment opportunities to generate profits. The question arises as to whether this low interest rate environment induced by the expanded APP affected the stability of our financial system in a negative way.

One of sceptics of the expanded APP is Jorg Kramer, chief economist at the Commerzbank. In his opinion, there are many risks involved in persistently low interest rate levels. Kramer mentions that due to these persistently low interest rates, households and businesses feel less inclined to reduce their debt levels (Kramer, 2017). Kramer also mentioned that investors turn to equities and real estate, driving prices up and creating bubbles. Even the president of the Dutch Central Bank mentioned in a speech he gave at the yearly dinner of The Society of Business Economists in London that continuing with the expanded APP would impose risks on the financial stability of the eurozone. The expanded APP causes market distortions, which lead to misallocation of assets and impose risk on the stability of the financial system (van Kuppeveld, 2017). These statements are in sharp contrast with the view of the president of the European Central Bank, Mario Draghi. Mario Draghi has mentioned several times that the Eurozone has benefited a great deal from the expanded asset purchasing programme. In a speech he recently gave at the European Banking congress, he mentioned that Europe is in the middle of solid economic expansion and that there is momentum for strong growth in the period ahead. In the same speech,

Draghi mentioned that current monetary policy is helping to reduce leverage within the economy and promotes sustainable economic growth (Draghi, 2017). On June 26 2017, the Financial Times wrote that Eurozone banks have been deemed the safest since the peak of the sovereign debt crisis. They show that the iTraxx Senior European Financials Index declined in the past year, and in July 2017, hit a low of 51 basis points. This implies that markets perceive the European banking sectors to be less risky. Since the premium one has to pay to insure themselves against the default of a bank is at its lowest rate in years (Financial Times, 2017).

Economists have different opinions when it comes to central banks intervening in the economy. Various studies have performed research on the relation between monetary policy and the risk taking of banks. However, most of these studies focus on the risk taking of individual banks and do not consider the impact of monetary policy on the entire financial system. Furthermore, these studies tend to focus on the American banking sector. Thus, this research contributes to the existing literature, since this thesis focuses on the effect of the expanded asset-purchasing programme of the ECB on the systemic risk of the banking sector within the eurozone. Therefore, the following research question is formulated:

Did the Expanded Assets Purchasing Programme of the ECB lead to an increase of the systemic risk within the banking sector in the eurozone?

The outline of this thesis will be as follows; Chapter 2 provides an overview of the existing literature. Chapter 3 provides insight into the data used for this research. In Chapter 4, the hypotheses are presented and the chapter provides a description of the models that are used. Chapter 5 contains an analysis of the results. Finally, Chapter 6 concludes with the answer to the research question and several recommendations for further research.

2. Theoretical Background

2.1. Expanded Asset Purchasing Programme

The asset-purchasing programme of the ECB covers several sub-programmes, each with a specific focus. The main goal of the programme is to provide more liquidity to the economy, stimulate economic activity and increase inflation. The expanded Asset Purchasing Programme consists of four sub-programmes: the third bond-purchasing programme (CBPP3), the asset-backed securities purchasing programme (ABSPP), the public sector purchasing programme (PSPP) and the corporate sector purchasing programme (CSPP).

After the first and second bond-purchasing programmes, the ECB announced on September 4th 2014 a third asset-purchasing programme. CBPP3 focuses on the purchase of euro-denominated covered bonds in both primary and secondary markets (European Central Bank, 2017). The CBPP3 only applies to covered bonds issued by credit instructions established in the euro area.

In order to further incentivize banks to increase their loan supply, the ECB started the Asset Backed Securities Purchasing Programme (ABSPP) on 21 November 2014. By buying asset-backed securities from banks, the ECB provides banks with the funds and liquidity to issue new loans and this mechanism stimulates the real economy (European Central Bank, 2017).

The most commonly known purchasing programme of the ECB is the Public Sector Purchase Programme (PSPP). The ECB started the PSPP on 9 March 2015. The programme covers the purchase of nominal and inflation-linked central government bonds and bonds issued by recognized agencies, regional and local governments, international organisations and multilateral development banks located in the euro area (European Central Bank, 2017).

To further stimulate the pass-through of the purchasing programmes to the real economy, on 8 June 2016, the ECB started the Corporate Sector Purchase Programme (CSPP). The assets covered by the CSPP are euro-denominated investment grade bonds that are issued by a non-credit institution established in the euro area (Lelieveldt and Ruhkamp, 2016).

2.2. Bank risk following from monetary policy

There are several ways monetary policy can impact the economy and the financial sector. Borio and Zhu (2008) describe the existence of the risk taking channel , which implies that monetary policy is transferred to the economy via a change in the risk taking of financial institutions (Borio and Haibin, 2012). One of these risk-taking channels is described as the 'search for yield' (Rajan, 2006), where financial instructions turn to risky assets with higher returns in order to stay profitable in times of low interest rates.

Altunbas et al (2010) focus on the impact of monetary policy on bank risk, using the Expected Default Frequency (EFD) to measure bank risk. They take the interest rate given by the Taylor Rule as a benchmark interest rate. Altunbas et al. (2010) find that in the long run, exceptionally low levels of short-term interest rates contribute to an increase in bank risk taking. In the short term, low interest rates tend to improve the quality of the loan portfolio of a bank, which causes the EDF to decrease. Nonetheless, when the interest drops below the benchmark interest rate, the EDF increases in the long run.

After the financial crisis, one of the most commonly heard explanations for the crisis were the low interest rate levels. Many blamed the persistently low interest rate levels for creating a boom in assets prices, the increase of securitized debt, increased bank risk taking and high amounts of leverage. De Nicol et al (2010) look into this theory and find that it is less straight forward than it appears. They find that the increase in risk taking of banks depends on the level of skin in the game'. This means that well capitalized banks increase their risks, and poorly capitalized banks decrease their risk taking when the policy rate is low. Considering this, the implications of monetary policy depends of the overall health of the banking system (De Nicol, Dell' Ariccia, Leaven and Valencia, 2010).

In 2016, the ECB published an early assessment of the asset-purchasing programme. Among other issues, they considered the risk of the APP. The

ECB divided this risk in three categories: 1) the risk to financial stability, 2) factors that limit the effectiveness of the purchase programme 3) risks of losses on the balance sheet of the ECB (European Central Bank, 2016). With respect to the risk to financial stability, they found that unconventional monetary policy has positive effects on stock markets and the solvency positions of certain classes of financial institutions. However, while some sectors of the financial market are stabilized by unconventional monetary policy, others become more risky. One of the main risks threatening financial stability is long periods of low yields, especially for banks that have to deal with capital shortfall. This also slows down the deleveraging in the financial sector. If banks are unable the raise external capital, low margins will make it more attractive for under-capitalized banks to finance their capital shortfall with debt.

2.3. Measures of Systemic Risk

Throughout the years, several measures of systemic risk have been proposed. This section highlights several measures of systemic risk.

One of the most commonly known measures of market risk is Value at Risk (VaR), where the VaR describes the worst loss over a target horizon that will not be exceeded, given a certain confidence level (Jorion, 2007). VaR measures risk at the institutional level and does not provide insight into the contribution of that institution to the overall systemic risk. Adrian et al. (2008) propose the CoVaR as a measure of systemic risk, which is defined as the Value at Risk (VaR) of a financial institution, conditional on other institutions being in distress (Adrian and Brunnermeier, 2008). To measure the contribution of one specific institution to the overall systemic risk, Adrian et al. take the difference between the CoVaR of the institution and the unconditional VaR of the financial system, resulting in the delta CoVaR. The delta CoVaR aims to capture tail dependencies and to include negative spill over dynamics in times of crisis.

Another measure of systemic risk that follows from the VaR is the CAViaR (Conditional Autogresessive Value a Risk) proposed by Engle and Simone (2004). Instead of modelling the entire distribution, they model the quantiles directly (Engle and Simone, 2004). They justify their approach with the empirical observation that the volatility of the stock market returns clusters over time. To correct for this, they use a quantile regression combined with a GARCH model to estimate systemic risk (Engle and Simone, 2004).

A financial institution in distress can oppose large negative spillovers to the real economy. Acharya et al. (2016) describe a systemic risk measure, which takes these spillovers into account in terms of Systemic Expected Shortfall (SES). SES describes the financial institution's contribution to systemic risk as an inclination of a financial institution to be undercapitalised when the system, as a whole, is undercapitalized. Acharya et al. show that the SES was a robust predictor of the 2007-2009 financial crisis. The SES consists of the Marginal Expected Shortfall (MES), the leverage ratio prior to the financial crisis and an error term. The MES shows how the risk taking of a particular part of the bank (a group) contributes to the overall risk taking of a bank. In their paper, Acharya et al. use the equity returns of the 5% worst days in the market

(Acharya, Pedersen, Philippon and Richardson, 2016). A drawback of the SES is that it requires observing a systemic crisis, in order to be able to calculate the SES (Brownlees and Engle, 2016).

Brownlees and Engle (2016) introduce SRISK, defined as the expected capital shortfall of a financial institution, conditional on a continuous market decline (Brownlees and Engle, 2016). SRISK is a function of the size of the firm, its degree of leverage, and its expected equity loss conditional on the market decline, which is called the Long Run Marginal Expected Shortfall (LRMES). The accumulation SRISK of all firms individually is used as a measure of the overall systemic risk within the financial system. This can be interpreted as the amount of capital the government would have to provide to bail out the entire financial system in times of a crisis. For a measure of systemic risk, it is important to have predictive power over an actual systemic crisis. Brownlees and Engle (2016) show that the SRISK peaked after the fall of Leman Brothers in 2008 and showed an increase during the sovereign debt crisis in June 2010 and October 2011.

The majority of the systemic risk measures are based on accounting data. Huang et al. (2009) construct a systemic risk measure based on the insurance premium one has to pay to insure against the default of a bank. This way, you create a market-based and forward-looking measure for systemic risk (Huang, Zhou and Zhu, 2009). Each systemic risk measure has its limitations. For this paper SRISK is chosen as a measure for systemic risk in the long run. Because it combines market data and balance sheet data, and does not require observing an actual crisis. Furthermore, we chose SRISK over the CoVar method proposed by Adrian and Brunnermeier(2008) since the CoVaR measures the systemic risk, conditional on a firm that is in distress and SRISK focuses on a firm's contribution to the total systemic risk conditional on a systemic event. Brownlees and Engle (2016) show that SRISK holds predictive power over the last systemic crisis, and they prove its robustness in several robustness checks.

To consider the impact of the expanded APP of the ECB in the short run, we used the Marginal Expected Shortfall (MES) proposed by Acharya et al. (2016). MES is relatively easy to calculate and holds significant explanatory power about which firm will contribute the most to a potential crisis (Acharya, Pedersen, Philippon and Richardson, 2016).

2.4. SRISK

Brownlees and Engle describe SRISK as the expected capital shortfall of a financial institution, conditional on a prolonged market decline. Where SRISK is a function of the size of the firm, the amount of leverage and the expected equity loss given a long-term market decline, which is called Long Term Marginal Expected Shortfall (LRMES). SRISK can be interpreted as follows: the firm with the highest SRISK will be the largest contributor to the under capitalization of the financial system, when the financial system is in distress. The accumulation of the SRISK of all financial institutions provides a measure of the overall systemic risk of the entire financial system (Brownlees and Engle, 2016).

To measure the distress of a financial firm, Brownlees and Engle (2016) introduce capital shortfall, which is defined as the capital reserves a financial firm needs to hold, subtracted by the equity of the firm:

$$CS_{i,t} = kA_{i,t} - W_{i,t} = k(D_{it} + W_{i,t}) - W_{i,t} \tag{1}$$

where $D_{i,t}$ is the book value of debt of firm i at time t and $W_{i,t}$ is the market value of equity of the firm. $A_{i,t}$ is the value of quasi assets and k represents the capital requirements set by the regulations. Here k is set at 8%, in line with the Basel capital requirements (Settlements, 2011), which apply to the banks in the data set. A negative capital shortfall implies a capital surplus for a bank in times of distress. This means that the bank functions in a proper way and will most likely not face distress in times of economic distress. When a bank has a positive capital shortfall, this implies a loss in times of financial distress and the bank will most likely experience distress. SRISK for bank i on time t represents the capital shortfall of a firm, conditional on a market decline:

$$SRISK_{i,t} = (E_{i,t}(CS_{i;t+h}|R_{m,t;t+h} < C) \tag{2}$$

where $R_{mt+1:t+h}$ represents the market return between periods 1+t and t+h, and C is defined as the threshold of a market decline to be considered a systemic event. Brownlees and Engle assume that in the case of a systemic even debt cannot be renegotiated, since a systemic event will hurt the entire financial system, which makes is difficult to roll over or attract new debt. This assumption leads to the following equation:

$$SRISK = W_{i,t}[k * LVG_{i,t} + (1-k)LRMES_{i,t} - 1] \tag{3}$$

where $LVG_{i,t}$ express the quasi leverage ratio which is calculated as $(D_{i,t} + W_{i,t})/W_{i,t}$ and $LRMES_{i,t}$ denotes the Long Run Marginal Expected Shortfall, the multi period equity return of a bank conditional on a systemic event. The Long Run Marginal Expected Shortfall is calculated using the following formula:

$$LRMES_{i,t} = -E(R_{i,t+1:t+h}|R_{mt+1:t+h} < C) \tag{4}$$

where C is a predetermined threshold that represents a systematic event. Brownlees and Engle (2016) equal C to 10%, and a market drop greater than 10% classifies as a systemic event.

To create a system-wide measure of financial distress across all firms, the following formula is proposed by Brownlees and Engle (2016):

$$SRISK\% = \frac{SRISK_{i,t}}{SRISK_t} \tag{5}$$

where $SRISK_t$ represents the total SRISK of all banks at time t, and $SRISK_{i,t}$ represents the SRISK of the bank i at time t. SRISK % can be interpreted as the systemic risk-share that a specific banks holds to overall systemic risk.

2.5. Marginal Expected Shortfall

Where SRISK has a long-term focus, Marginal Expected Shortfall focuses more on systemic risk in the short term. Archaya et al (2016) define marginal expected shortfall as a measure of how a bank contributes to the overall risk of the financial system. For their model, Archaya et al use the expected shortfall at a 95% level (the worst 5% equity returns on a daily basis). The MES_i represents the MES of bank i, which equals the equity return of bank i, conditional on the market return being smaller than the q% VaR:

$$MES_i = E(R_i | R_m < VaR(R_m, q)) \tag{6}$$

2.6. Sovereign Exposure

One of the sub programmes of the expanded asset-purchasing programme includes the purchase of euro-denominated government bonds. Measuring the changes in government bond holdings during the expanded assets purchasing programme is challenging. Since the holdings of a bank are related to the size of the bank and they are also influenced by the amount of government debt, the ECB is purchasing under the PSPP. In their paper, Crosignani et al. analyse how the design of long-term refinancing operations affects a bank's holdings of securities that are eligible as collateral (Crosignani, Faria-e-Castro and Fonseca, 2018). They use the following variable to measure the holding of government bonds during Long Term Refinancing Operations:

$$Holdings_{i,m,t} = \frac{\frac{Governementbonds_{i,m,t}}{AmountOutstanding_{m,t}}}{\frac{Assets_{i,t}}{TotalAssets_t}} \tag{7}$$

The numerator equals the share of public debt outstanding of maturity m, held by institution i, in month t. This is divided by the size of the bank relative to the size of the entire financial system. This thesis focuses on the difference between countries rather than the difference in maturity. Therefore the maturity component, (m), is substituted by a country component, (c).

3. Data

The dataset used for this research consists of data from the following databases: V-Lab, Orbis, DataStream, ECB dataset, European Banking Authority database and the World Bank. The data set includes 62 commercial banks (SIC code 6020) located in the eurozone. It is important to note that the dataset contains only banks that are included in the dataset of the Volatility Institute of the New York University Stern, since they provide the SRISK data. This chapter provides a detailed description of the data and the data sources.

3.1. SRISK Data

The SRISK for the banks within the dataset is obtained via the website of the Volatility Institute of the New York University Stern (V-Lab). The Volatility Institute provides the SRISK, LRMES, Beta, Volatility and the correlation of the largest banks worldwide. This research focuses on banks located in the eurozone. However, since the Volatility Institute does not provide data on all eurozone banks, only banks that are covered in the V-Lab dataset are considered. The Volatility Institute provide data in US dollars. To convert this to euros, the eur/usd exchange rate is obtained from DataStream.

3.2. MES

The MES is calculated using stock data from DataStream. This research focuses on the eurozone market, and therefore, the Euro Stoxx 50 is used as a proxy for the market. The Euro Stoxx 50 is a free-floating index, which consists of the 50 largest companies located in the eurozone (Stoxx, 2018). The MES is calculated using the 5% worst daily overlapping returns of the Euro Stoxx 50 over a rolling window of one year. All stock prices are adjusted for corporate actions using the Adjustment Factor obtained from DataStream. It is important to note that a positive MES implies that the equity returns of this bank where positive during the 5% worst days of the market (and vice versa).

3.3. Sovereign exposure

Data regarding sovereign exposure is obtained from the European Banking Authority database. Since not all of the banks in our data set are covered in the EBA database, the analysis regarding the sovereign exposure covers only 21 banks, where only holdings of sovereign debt of the Eurozone countries are considered. The data, with regard to the monthly purchases under the PSPP, is obtained from the ECB's website.

3.4. Control variables

To make sure that the results are not driven by other factors than the expanded APP, several control variables that may impact the SRISK of a bank are included. The table below lists the control variables and the data sources from which they are obtained.

Table 1: Overview of the Data sources

Control Variables	**Data Source**
Total Assets	Orbis
Tier 1 Capital	Data Stream
Total Debt	Data Stream
Net Income	Data Stream
Non-performing Loans	Data Stream
Inflation	World Bank
GDP Growth	World Bank

The data obtained from DataStream and the World Bank are reported on yearly basis. Since our data set contains quarterly data, linear interpolation is used to transform this to quarterly data.

4. Methodology

4.1. Hypotheses

The main goal of the Expanded Asset Purchasing programme is to stimulate the economy and reach the target inflation level. However, many are concerned that these low interest rate levels increase the riskiness of the financial system. This thesis focuses on the effect of the expanded Assets Purchasing Programme on the systemic risk in the banking system of the eurozone. This leads to the following research question:

Did the Expanded Assets Purchasing Programme of the ECB lead to an increase of the systemic risk within the banking sector in the eurozone?

Highly levered firms tend to take more risk when interest rates are low, since they have less 'skin in the game' according to Nicol et al. (2010). Valencia (2011) developed a dynamic banking model to explore the relationship between the policy rate and bank risk taking. They find that a decrease in the policy rate increases the profitability of a bank in two ways: the low interest rate reduces the funding costs of the bank and increases the surplus a monopolistic bank can charge from its borrowers, and thereby increase the profitability of a bank. In situations where banks have limited liability, a low interest rate environment creates an incentive to increase the loan supply by increasing their leverage. This can lead to excessive risk taking of banks (Valencia, 2011).

In their paper, De Nicol et al. (2010) describe an additional explanation of the increased risk taking of banks as a result of monetary policy. In the long to medium term, banks have to adjust their capital structure, which causes a negative relationship between monetary policy and risk taking (De Nicol et al., 2010). When interest rates are low, banks can increase their profits as previously described. When interest rates rise, the intermediation spreads declines and this will reduce the profits that are needed to restore capital to the optimal level. Banks stay highly levered and bank risk-taking increases. Since banks are expected to be able to adjust their capital structure significantly in the long term and make small adjustment to their capital structure in the short term, it is expected that the systemic risk will increase as a result of the expanded APP. However, this effect will be stronger in the long term than in the short term. This leads to the first and second sub hypotheses:

1. The expanded Asset Purchasing programme of the ECB caused an increase in systemic risk in the long run..

2. The expanded Asset Purchasing programme of the ECB caused an increase in systemic risk in the short term.

The low interest rates induced by the expanded APP make it more attractive for banks to finance their operations with debt. Dell' Aricca et al. (2010) examine the effect of monetary policy on the leverage and risk taking of banks. They find that when banks are able to adjust their capital structure, monetary easing will lead to a higher degree of leverage and higher risk within a bank (Dell'Ariccia, Laeven, and Marquez, 2010). Dell'Ariccia et al. distinguish between the situation where the capital structure of the banks is endogenous and exogenous. When banks are able to adjust their capital structure in response to monetary easing, they have an incentive to increase their leverage since holding capital is costly. However, when banks have limited liability, they tend to take more risk since the costs accompanied with a bankruptcy will be for the depositors and bond holders. Dell' Aricca et al. (2010) find that in the short term, where the capital structure has an exogenous character, a bank is not able to adjust its capital structure, and the degree of leverage tends to decrease with the policy rate. However, when banks can adjust their capital structure in the long run, they tend to increase leverage as the policy rate decreases. The findings of Dell'Aricca et al. (2010) lead to the following sub-hypothesis:

3. The expanded Asset Purchasing Programme has led to an increase of the SRISK leverage component.

The ECB set several requirements which assets need to meet in order to be eligible for the expanded asset purchasing programme. For example, government bonds issued by governments that are under the financial assistance programme are not allowed under the PSPP (European Central Bank, 2015). Countries who were under the financial assistance programme are Greece, Portugal, Spain and Cyprus, and these are three of the five GIIPS countries[1]. During the sovereign debt crisis, the GIIPS countries experienced financial difficulties. In order to compensate lenders for the risks, they were forced to pay high interest rates on their government debt. During and after the sovereign debt crisis, several GIIPS countries went through debt restructuring and political policy adjustments in order to make sure that future debt obligation would be met and to create a safer financial system. Not only governments faced difficulties, but also several GIIPS country banks had to restructure and some had to be bought out by their governments. Currently, the circumstances in most of these GIIPS countries have improved. However, there are still some fundamental financial problems that make investors demand higher interest rates on their loans. The expanded APP caused interest rates to go down in all eurozone countries, and also in GIIPS countries. However, these lower interest rates are mainly caused by the ECB's monetary policy and are not the result of a reduction of risk.

[1] Greece, Italy, Ireland, Portugal and Spain

Therefore, it is expected that GIIPS country banks will be significant contributors to the systemic risk after the implementation of the expanded APP. This led to the fourth sub-hypothesis:

4. GIIPS countries show higher systemic risk during the expanded Asset Purchasing Programme than non-GIIPS countries.

A lesson learned from the sovereign debt crisis is that sovereign debt is not as risk free as is always assumed. The PSPP includes the purchase of nominal and inflation-linked central government bonds and bonds issued by recognized agencies, regional and local governments, international organizations and multilateral development banks located in the eurozone (European Central Bank, 2017). Countries who are receiving financial assistance are excluded from the PSPP. It is interesting to explore if there is a difference in systemic risk between banks with high sovereign holdings and banks with less sovereign holdings. Currently, European government bonds are low yielding assets and from an investment perspective, less attractive for banks. Although government debt is not a risk-free investment, it is still considered as a relatively safe investment. Therefore, it is expected that banks with a higher sovereign holdings bear less systemic risk. This leads to the fifth hypothesis:

5. The sovereign holdings of a bank are negatively related to the systemic risk of the bank during the expanded Asset Purchasing Programme.

4.2. Model description

To find insights to support or reject the hypotheses and to answer the research question, the regressions described in this section are applied. The analysis is based on an Ordinary Least Squares regression with fixed effect within the panels. Keeping the effects within a panel fixed, prevents a situation in which the results are driven by varying factors within a panel rather than varying effects between panels. The regressions do not include time-fixed effects since with variable of interest, the expanded APP Dummy only has a time dimension and a time-fixed effect will absorb the effect the expanded APP had on the systemic risk of eurozone banks. The regressions regarding the GIIPS countries do not include country-fixed effects since the GIIPS countries * expanded the APP interaction dummy, aiming to capture the relation between GIIPS country banks and the systemic risk during the expanded APP. To answer sub-hypotheses one and two, models (9), (10) and (11) are used.

$$\begin{aligned}\frac{SRISK}{TotalAssets} =& \alpha + \delta_1(ExpandedAPPDummy) + \beta_1(Tier1capital/TotalAssets) + \\ & \beta_2(TotalDebt/TotalAssets) + \beta_3(Log(NetIncome)) \\ & + \beta_4(Non-performingloans/TA) + \\ & \beta_5(GDP\%) + \beta_6(Inflation\%) + \epsilon \end{aligned} \tag{8}$$

$$\begin{aligned} SRISK(\%) =& \alpha + \delta_1(ExpandedAPPDummy) + \beta_1(Tier1capital/TotalAssets) + \\ & \beta_2(TotalDebt/TotalAssets) + \beta_3(Log(NetIncome)) \\ & + \beta_4(Non-performingloans/TA) + \\ & \beta_5(GDP\%) + \beta_6(Inflation\%) + \epsilon \end{aligned} \tag{9}$$

$$\begin{aligned} MES\% =& \alpha + \delta_1(ExpandedAPPDummy) + \beta_1(Tier1capital/TotalAssets) + \\ & \beta_2(TotalDebt/TotalAssets) + \beta_3(Log(NetIncome)) \\ & + \beta_4(Non-performingloans/TA) + \\ & \beta_5(GDP\%) + \beta_6(Inflation\%) + \epsilon \end{aligned} \tag{10}$$

To answer the first and the second sub-hypothesis, the effects of the expanded APP on the systemic risk of eurozone banks in the long and short term are considered. The variable of interest here is the δ_1 (Expanded APP Dummy). When considering the long term horizon (SRISK), it is expected to find a positive value of δ_1, since this implies a positive relation between the expanded APP and the long and short term systemic risk of a bank. However, for the short term horizon (MES), a negative value of δ_1 is expected to be found.

To answer the fourth sub-hypothesis, the same models are used as for the first two sub-hypotheses. For answering the third sub-hypothesis, the $\delta_2 ExpandedAPP Dummy * GIIPSCountry$ is added to the model. This is an interaction dummy between the GIIPS country dummy, which equals one for banks that are located in GIIPS countries, and the expanded APP Dummy, which equals one for the years that the expanded APP is implemented. The interaction dummy variable will have a value of 1 for GIIPS countries during the expanded APP, and zero otherwise. This dummy will also provide insight into the systemic risk of banks in the GIIPS countries during the ECB's expanded APP. Accordingly, the fourth sub-hypothesis is excepted to find a positive value for δ_2.

To gain further insight into which elements of SRISK are contributing to a possible increase, we perform an analysis on the separate components of SRISK. The following models are used to perform this analysis:

$$\begin{aligned} Leverage =& \alpha + \delta_1(ExpandedAPPDummy) \\ & + \delta_2(ExpandedAPPDummy * GIIPSDummy) + \beta_1(Tier1capital) + \\ & \beta_2(NetIncome) + \beta_3(TotalAssets) + \theta(Macroeconomiccontrols) + \epsilon \end{aligned} \tag{11}$$

$$
\begin{aligned}
MarketValueEquity =& \alpha + \delta_1(ExpandedAPPDummy) \\
&+ \delta_2(ExpandedAPPDummy * GIIPSDummy) + \\
&\beta_1(Tier1capital) + \beta_2(TotalDebt) + \beta_3(NetIncome) + \\
&\beta_4(Non - Performingloans) + \\
&\theta(Macroeconomiccontrols) + \epsilon
\end{aligned} \tag{12}
$$

$$
\begin{aligned}
LRMES(\%) =& \alpha + \delta_1(ExpandedAPPDummy) \\
&+ \delta_2(ExpandedAPPDummy * GIIPSDummy) + \beta_1(Tier1Capital) + \\
&\beta_2(TotalDebt) + \beta_3(NetIncome) + \beta_4(Non - Performingloans) \\
&+ \theta(Macroeconomiccontrols) + \epsilon
\end{aligned} \tag{13}
$$

Finally, to find an answer to the fifth and final sub-hypothesis, the following model is used:

$$
\begin{aligned}
\frac{SRISK}{TotalAssets} =& \alpha + \beta_1(SovereignExposure_i + \beta_2(Tier1capital/Totalassets) + \\
&\beta_3(TotalDebt/TotalAssets) + \beta_4(Log(NetIncome)) + \\
&\beta_5(Non - Performingloans/TotalAssets) + \beta_6(Inflation\%) \\
&+ \beta_7(GDP\%) + \epsilon
\end{aligned} \tag{14}
$$

With $Sovereignexposure_j$ being the sovereign holdings of a bank of country j.

5. Results

Table 2 presents the descriptive statistics of all banks in the data set. The average amount of total assets for banks in the data set equals 1496.98 billion euro. The average net income of banks over the analysis period is negative, with the largest negative net income of -24 million euro generated by UniCredit SPA in the first quarter of 2013.[2]. Lastly, the total number of observations per variable is relatively stable.

To be able to interpret the results of the analysis, it is important to check the correlations between the independent variables. Highly correlated independent variables can lead to multicollinearity within the regression, which makes it difficult to interpret the results and to draw conclusions. To check the correlations related to the analysis concerning SRISK, SRISK (%) and MES, a correlation

[2]At that time UniCredit SPA had to reserve large amounts of cash due to bad loans and the had to write down goodwill from acquisitions.

Table 2: Summary Statistics

	SRISK/Total Assets	SRISK(%)	MES (%)	Total Assets	Tier1 capital	Net income	Total Debt	Non-Performing Loans	GDP growth (annual%)	Inflation (annual %)
Average	0.044	0.021	-0.032	1496.980	123.71	-411677.64	576.05	6555759.62	0.23	0.001
Standard Deviation	0.039	0.025	0.028	2989.814	33.98	2649860.294	2058.138	13267656.52	0.064	0.015
Max	0.205	0.318	0.037	22824.79	242.8	9459382.88	9459382.88	84359000	0.333	0.026
Min	-0.27	-0.219	-0.35	1.525	-69	-24632419.49	-15967.21	0	0.163	-0.045
Count	1695	1695	1796	1809	965	1619	1906	1874	1984	1984

This table represents the summary statistics of variables used in the analysis. The SRISK/TA, the SRISK of a bank are correct for the bank's total assets. SRISK(%) is a bank's contribution to the SRISK of the banks in the dataset. The MES(%); equity return of a bank is based on the 95% VaR of the market, using daily overlapping returns on a rolling window of a year. The Tier 1 capital of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro. Total Debt and Net Income of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro. The non-performing loans are what the banks hold on the balance sheet over the period Q1 2009 Q3 2018. Common Equity is the common equity the banks hold on the balance sheet over the period Q1 2009 Q3 2018.

matrix is constructed (Appendix E). Overall, no correlations are found that will cause multicollinearity within the models. This implies that the regression results can be safely interpreted.

Within the dataset regarding the sovereign holdings of eurozone banks, the correlations are significantly high. Due to highly correlated variables, Stata will drop several variables when performing the analysis. These high correlations are caused by the small number of observations and the relatively small amounts of sovereign holdings. Appendices A and B disclose the correlation matrix and the descriptive statistics regarding the sovereign holdings analysis. In order to be able to perform the sovereign holding analysis, separate regression for the sovereign holdings per country are performed. A disadvantage of this methodology is that correlations between the sovereign holdings of banks toward particular countries are not taken into account. Despite the flaws of this methodology, it is the best way to be able to include the sovereign holdings in this analysis. Using this methodology, one will get results that provide a sensible insight in the relation between the systemic risk and the holdings of a bank.

5.1. SRISK

Table 3 includes the results of the analysis of the SRISK, corrected for the total assets of a bank (hereafter SRISK). Overall, strong evidence of a statistically significant influence of the expanded APP on SRISK is found. These results also hold after adding several bank-specific and macro-economic control variables.

When considering model (1), the most basic model, a negative relation between the expanded APP and the SRISK of a bank appears. This effect is significant at a 1% level. However, no conclusions can be drawn from the results of model (1) since there are many other factors that can possibly influence the SRISK of a bank. Therefore, models (2) and (3) correct for several bank specific variables and macro-economic factors. If the macro economic factors are excluded from the analysis, there seems to be no significant effect of the expanded APP on the SRISK of a bank. However, when incorporating macro-economic controls in the analysis, the relation between the expanded APP and SRISK of a bank is significant at a 1% level. For the years during the implementation of the expanded APP the SRISK for eurozone banks, 15 600 euro is higher compared to years prior to the expanded APP. An 15 600 increase in

SRISK during the expanded APP implies that the government needs to provide 15 600 euro more in order to bail out a bank during times of financial distress. Although this effect is statistically significant, it is important to consider the economic significance. A 15 600 increase in SRISK is relatively small, considering the total size of eurozone credit institutions accounts, which are 34 trillion euro (ECB, 2017). Putting this in perspective, for a government to pay 15 600 euro to bail out a bank during times of financial distress is a relatively small price to pay.

Furthermore, the effect of the control variables is in line with the expectations. The total debt of a bank is positively related to SRISK, which is easily explained since, generally speaking, banks with high levels of debt are riskier than banks financed with high levels of equity. Banks that are holding large amounts of equity are more resilient to economic down turn, since they can use their equity buffers to meet their liabilities. Banks that are highly levered need to make payments to their debt holders and when a bank is not liquid enough to meet these payments, there is an increased probability that this bank will face distress. This is also represented in the negative relation between Tier 1 capital and SRISK. Banks with more Tier 1 capital appear to carry less systemic risk. Table 3 describes a negative relation between GDP growth and SRISK. Banks carry less SRISK in times of high GDP (economic) growth, which is intuitive since during times of economic growth, the chances a bank will face distress will be lower. Moreover, banks will also profit from increased economic activity, for example, through an increased credit demand from consumers and companies. Lastly, Table 3 shows a negative relation between SRISK and inflation. Commonly high levels of inflation are associated with low levels of economic growth and economic activity. The probability of a bank facing distress will be high during periods of low economic growth, which is related to higher SRISK.

Table 3: Results SRISK/TA

	(1) SRISK/TA	(2) SRISK/TA	(3) SRISK/TA
Expanded APP Dummy	-0.00371***	0.000961	0.0156***
	(0.009)	(0.00254)	(0.00369)
Total Debt/TA		0.0111***	0.0103***
		(0.00105)	(0.00102)
Tier1 Capital/TA		-0.290***	-0.288***
		(0.0915)	(0.0897)
LOG(Net Income)		-0.0104***	-0.00624*
		(0.00340)	(0.00350)
Non-Performing loans/TA		-1.487***	-1.502***
		(0.510)	(0.515)
GDP(%)			-0.0928***
			(0.0214)
Inflation (%)			0.376***
			(0.102)
Constant	0.0444***	0.0885***	0.0677***
	(0.000649)	(0.0197)	(0.0204)
Observations	1,695	483	479
Number of Banks	62	44	44
Country Fixed Effects	Yes	Yes	Yes
R-squared	0.004	0.238	0.299

This table includes the results of the fixed effects panel data analysis of the SRISK, corrected for the total assets of 62 commercial banks. With the dependent variables of the Expanded APP dummy, this equals one for the years of implementation of the APP. Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro' s, corrected for the total assets of a bank. Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. Log(Net income) is the log of the Net Income of a bank. Non-performing loans/TA of the banks held on the balance sheet over the period Q1 2009 Q3 2018 are corrected for the total assets of a bank. Inflation(%) is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the GDP growth of the country where the bank is located.Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

5.2. SRISK%

In order to consider SRISK in a system-wide perspective, an analysis using the SRISK share of a bank is performed. The SRISK share of a bank represents a bank's contribution to the SRISK of the entire dataset. The results of the analysis concerning SRISK (%) are presented in Table 4.

The results in Table 4 are similar to the outcomes in Table 3. Table 4 shows strong evidence of an existing relationship between the expanded APP and the SRISK share of eurozone banks. When considering model (1), the most basic model, a significant positive relation between the SRISK share and the expanded APP prevails. After including several control variables, the effect remains statistically significant. The result described by model (3) shows that during the implementation of the expanded APP, the share of SRISK is 0.06%

Table 4: Results SRISK(%)

	(1) SRISK(%)	(2) SRISK(%)	(3) SRISK(%)
Expanded APP Dummy	0.00922***	0.00709***	0.00622**
	(0.00108)	(0.00190)	(0.00288)
Total Debt/TA		0.00871***	0.00879***
		(0.000785)	(0.000798)
Tier1 Capital/TA		-0.244***	-0.257***
		(0.0686)	(0.0701)
LOG(Net Income)		0.000807	0.000305
		(0.00255)	(0.00273)
Non-Performing loans/TA		-0.305	-0.404
		(0.382)	(0.402)
GDP(%)			0.00754
			(0.0167)
Inflation (%)			0.0177
			(0.0798)
Constant	0.0186***	0.00402	0.00726
	(0.000494)	(0.0148)	(0.0159)
Observations	1,695	483	479
Number of Banks	62	44	44
Country Fixed Effects	Yes	Yes	Yes
R-squared	0.043	0.224	0.226

This table includes the results of the fixed effects panel data analysis of the SRISK share of 62 commercial banks. With the dependent variables of the Expanded APP dummy, this equals one for the years of implementation of the APP. The Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro, corrected for the total assets of a bank. The Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. Log(Net income of a bank and non-performing loans/TA are the non-performing loans the banks hold on the balance sheet over the period Q1 2009 Q3 2018, corrected for the total assets of the bank. Inflation(%) is measured by the consumer price index for the country where the bank is located. GDP Growth(%) is the growth of the country where the bank is located.Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

point higher than for the years prior to the expanded APP. This is in line with the findings described in the previous section, as the total SRISK of eurozone banks increases during the implementation of the APP and the SRISK share of a bank also increases. Although this effect is statistically significant, the magnitude of this effect is relatively small and therefore, it is expected that the economic impact will be minor. Similar to the analysis performed on SRISK, a negative relation between Tier 1 capital and SRISK(%) is found and Total Debt and SRISK are positively correlated.

Considering the previously described results, the first sub-hypothesis is accepted:

1. The expanded Asset Purchasing programme of the ECB caused an increase in systemic risk in the long run.

5.3. Marginal Expected Shortfall

To assess the effect of the expanded APP on systemic risk using a short term horizon, the same analysis as for the long term (SRISK) is performed. However, for this analysis the Marginal Expected Shortfall is used to measure systemic risk. Table 5 represents the results of this analysis:

Table 5: Results Marginal Expected Shortfall

	(1) MES	(2) MES	(3) MES
Expanded APP Dummy	-0.00397***	-0.00699***	-0.0167***
	(0.00128)	(0.00139)	(0.00188)
Total Debt/TA		-0.00205***	-0.00159***
		(0.000576)	(0.000525)
Tier1 Capital/TA		0.0875*	0.0823*
		(0.0504)	(0.0461)
LOG(Net Income)		0.0110***	0.00980***
		(0.00187)	(0.00180)
Non-Performing loans/TA		0.388	0.255
		(0.281)	(0.265)
GDP(%)			0.0711***
			(0.0110)
Inflation (%)			-0.109**
			(0.0525)
Constant	-0.0312***	-0.0893***	-0.0844***
	(0.000615)	(0.0109)	(0.0105)
Observations	1,796	486	482
Number of Banks	61	44	44
Country Fixed Effects	Yes	Yes	Yes
R-squared	0.006	0.126	0.240

This table includes the results of the fixed effects panel data analysis of the Marginal Expected Shortfall for 62 commercial banks. With the dependent variables: the Expanded APP dummy, this equals one for the years of implementation of the APP. The Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is tier 1 capital expressed in billions of euro, corrected for the total assets of a bank. Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. The Log(Net Income) is the net income of a bank. Non-performing loans/TA are the loans the banks hold on the balance sheet over the period Q1 2009 Q3 2018, corrected for the total assets of a bank. Inflation(%) is measured by the consumer price index for the country where the bank is located. GDP Growth(%) is the growth of the country where the bank is located. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Considering the base regression (1), a significant negative effect of the expanded APP on the Marginal Expected Shortfall is shown. This also holds after including several control variables, which implicates that the equity returns of a bank conditional on the market return are smaller than the 1 year and 95% VaR are more negative for years of the implementation of the expanded APP. It is important to note that since the start of the expanded APP, equity prices in general have been increasing, and this could possibly influence the results. However, not only the equity prices of individual stocks rose, but also the price

of indices used to proxy the market. This should naturalize the effect of the rising stock prices on the MES. Considering the control variables, Table 5 shows that the total debt of a bank has a significant negative impact on the MES of that bank. When interpreting this result, it is important to keep in mind that a negative (positive) MES is reflected as a shortfall (surplus). A bank with a larger amount of debt will be considered more risky since an increase in the bank's total debt results in a increase in MES (a larger shortfall or decreased surplus). Commonly, banks that are highly levered tend to be more sensitive to economic cycles and also tend to have a higher chance of bankruptcy during an economic down turn. This is also reflected by the negative relation between the MES and total debt, as described in Table 5. The opposite rationale applies to the relation between Tier 1 Capital and MES; a bank with a large amount of Tier 1 capital is considered to be less risky, since these banks have large buffers that can be used in times of economic down turn. The same rationale applies to the positive significance between net income of a bank and the MES.

As for the macro-economic control variables, a significant positive relation between GDP growth and MES shows. The same rationale, as explained in Section 5.1, applies here. The chances that a bank will face distress during times of economic growth will be significantly lower. Historically, times of low economic growth (or economic down turn) are commonly accompanied by high levels inflation. Therefore, the negative significant relation between Inflation and MES can be explained by the same rationale as for GDP growth.

The results discussed above lead to accepting the second sub-hypothesis:

2. The expanded Asset Purchasing programme of the ECB caused an increase in systemic risk in the short term.

5.4. SRISK Breakdown

To gain insight in how the SRISK components influence the increase in SRISK, an additional analysis is performed on the individual SRISK components. The results of this analysis can be found in appendix C.

Model (3) shows a negative significant effect between the APP and the market value of equity. This implies that for the years during the expanded APP, the market capitalization of banks has decreased. This negative relation does not explain the positive relation between the expanded APP and SRISK. Both LRMES and leverage are positively related to the expanded APP dummy. However, this effect is shown to be insignificant. This could imply that although the expanded APP dummy does not have a significant impact on leverage and LMRES individually, taking these two components together does generate a significant impact.

Since no significant effect between leverage and the expanded APP dummy prevails, the third sub-hypothesis is rejected.

3. The expanded Asset Purchasing Programme has led to an increase of the SRISK leverage component.

5.5. GIIPS Countries

The GIIPS countries are known for their large government debt, which makes it interesting to take a closer look at how the systemic risk of banks located in a GIIPS country is influenced by the expanded APP.

Figure 1: GIIPS vs Non-GIIPS countries

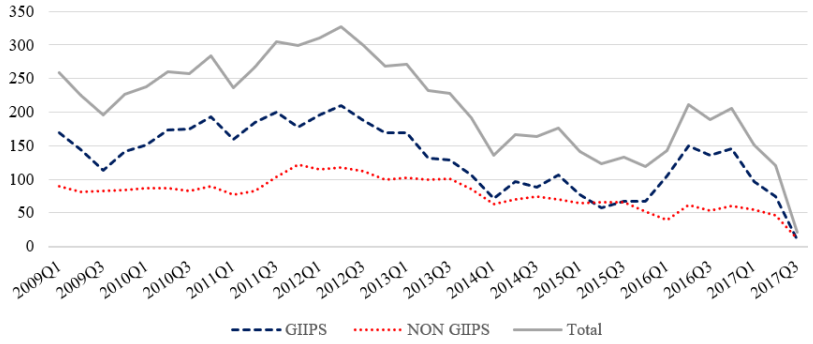

Figure 1 shows the SRISK over Total Assets from the first quarter of 2009 until the second quarter of 2017. The graph shows that GIIPS country banks had systematically higher SRISK than non-GIIPS banks. Pre-expanded APP the SRISK of GIIPS and non-GIIPS country banks were more or less equal. However, from the third quarter of 2015, they started to diverge.

Table 6 includes the results of the statistical analysis performed on GIIPS countries. Considering the results in Table 6, the MES and SRISK (%) are significantly impacted by the Expanded APP * GIIPS Dummy. SRISK (%) is negatively impacted by the GIIPS*Expanded APP interaction dummy. This suggests that GIIPS country banks contributed less to the systems' SRISK during the implementation of the expanded APP. Therefore, one could perceive them as less risky, and this significant effect holds true after including the macro-economic control variables. Since GIIPS country banks are not always perceived as the most stable banks, most of these banks have to compensate their lenders for the risk by paying high levels of interest. The expanded APP caused the interest rates to drop to historically low levels. GIIPS country banks also see the interest they have to pay on their outstanding debt decline, thereby reducing the costs associated with borrowing. Ceterus paribus, these lower interest expenses will make it less likely that a bank cannot fulfil its debt obligations and thereby reduces the default probability of the GIIPS country banks.

As for the MES (%), during the years of the expanded APP implementation, banks located in GIIPS countries had a higher MES compared to non-GIIPS country banks. A possible rationale would be that, in the short term, banks are not able to adjust their capital structure. In order to profit from the low interest rate environment, banks in the GIIPS countries would have to replace their current (high interest rate) debt with new debt at lower interest rates (induced by the expanded APP). Since this process does not take place overnight, the

GIIPS country banks can be considered more risky in the short term and less risky in the longer term. When replacing the expanded APP dummy by the time-fixed effect, similar results are shown. However, the effect of the GIIPS country interaction dummy is no longer significant before controlling macro-economic factors. The result of this analysis are presented in Appendix F.

In conclusion, the expanded APP has a significant negative impact on the systemic risk of GIIPS country banks in the long run. However, in the short term, banks in the GIIPS countries are shown to have a slight increase in their systemic risk. Since banks in the GIIPS countries do not show a consistently higher systemic risk in both the long and short term, the fourth sub hypothesis is rejected.

4. GIIPS countries show higher systemic risk during the expanded Asset Purchasing Programme than non-GIIPS countries.

Table 6: Results GIIPS country analysis

	(1) SRISK/TA	(2) SRISK/TA	(3) SRISK(%)	(4) SRISK(%)	(5) MES(%)	(6) MES(%)
GIIPPSDummy*APPDummy	-0.00532	-0.00683	-0.00612*	-0.00621*	-0.0108***	-0.00971***
	(0.00483)	(0.00468)	(0.00362)	(0.00365)	(0.00261)	(0.00236)
Expanded APP Dummy	0.00390	0.0196***	0.0105***	0.00984***	-0.000986	-0.0110***
	(0.00369)	(0.00459)	(0.00276)	(0.00358)	(0.00200)	(0.00232)
Total Debt/TA	0.0112***	0.0104***	0.00881***	0.00887***	-0.00187***	-0.00145***
	(0.00105)	(0.00102)	(0.000785)	(0.000797)	(0.000568)	(0.000516)
Tier1 Capital/TA	-0.302***	-0.304***	-0.258***	-0.271***	0.0627	0.0605
	(0.0921)	(0.0902)	(0.0690)	(0.0704)	(0.0499)	(0.0456)
LOG(Net Income)	-0.0107***	-0.00660*	0.000463	-2.85e-05	0.0104***	0.00930***
	(0.00341)	(0.00350)	(0.00255)	(0.00273)	(0.00185)	(0.00177)
Non-Performing Loans/TA	-1.529***	-1.569***	-0.354	-0.465	0.305	0.161
	(0.511)	(0.517)	(0.383)	(0.403)	(0.277)	(0.261)
GDP Growth (%)		-0.0948***		0.00574		0.0680***
		(0.0214)		(0.0167)		(0.0108)
Inflation (%)		0.375***		0.0164		-0.110**
		(0.102)		(0.0796)		(0.0516)
Constant	0.0909***	0.0708***	0.00671	0.0100	-0.0846***	-0.0802***
	(0.0198)	(0.0205)	(0.0148)	(0.0160)	(0.0107)	(0.0104)
Observations	483	479	483	479	486	482
Number of BankNumber	44	44	44	44	44	44
R-squared	0.240	0.303	0.229	0.232	0.159	0.268

This table includes the results of the fixed effects panel data analysis of SRISK, SRISK% and MES of 62 commercial banks. The depended variables include: the Expanded APP dummy*GIIPS Country, equals one for GIIPS country banks during the years of implementation of the APP. The Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro, corrected for the total assets of a bank. Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. Log(Net income) is the net Income of a bank. The non-performing loans/TA are the loans the banks hold on the balance sheet over the period Q1 2009 Q3 2018, corrected for the total assets of a bank. Inflation(%) is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the growth of the country where the bank is located. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

5.6. Sovereign exposure

It is interesting to gain more insight in how the sovereign holdings of a bank concerning a country that is eligible for the PSPP influences the systemic risk of this bank. Since these sovereign holdings are highly correlated, it is not possible to include the sovereign holdings towards all countries in one regression. Therefore, separate regressions are performed. The results of these regressions are presented in the table below.

Table 7: Results Sovereign Exposure analysis

	(1) SRISK% Spain	(2) SRISK% Italy	(3) SRISK% Ireland	(4) SRISK% Germany	(5) SRISK% Belgium	(6) SRISK% Austria	(7) SRISK% Portugal	(8) SRISK% Malta	(9) SRISK% Netherlands
Sovereign Holdings	0.00140	0.00209	-5.91e-05	0.00199	0.00272	0.000207	0.000348	0.000740	-0.000574
	(0.00166)	(0.00241)	(0.000170)	(0.00261)	(0.00180)	(0.000274)	(0.000286)	(0.000701)	(0.00289)
Total Debt/TA	-0.168	-0.172	-0.0935	-0.157	-0.210	-0.156	-0.111	-0.0992	0.0161
	(0.229)	(0.228)	(0.237)	(0.232)	(0.207)	(0.232)	(0.171)	(0.177)	(0.373)
Tier1 Capital/TA	-22.18	-22.94	-8.539	-19.95	-37.58	-19.69	-2.505	-3.036	-0.867
	(25.65)	(25.76)	(22.13)	(25.38)	(25.65)	(25.34)	(5.787)	(6.182)	(7.118)
Log(Net Income)	-0.0432	-0.0441	-0.0233	-0.0401	-0.0580	-0.0397	-0.0162	-0.0177	-0.00694
	(0.0525)	(0.0524)	(0.0524)	(0.0529)	(0.0482)	(0.0530)	(0.0338)	(0.0355)	(0.0472)
Non Performing Loans/TA	-7.593	-7.636	-6.211	-7.411	-7.331	-7.386	-9.843	-9.958	-4.513
	(13.31)	(13.23)	(14.46)	(13.55)	(11.88)	(13.58)	(12.44)	(13.14)	(14.84)
GDP	0.0995	0.0993	0.0891	0.0993	0.0429	0.0992	0.0969	0.0767	0.0767
	(0.123)	(0.122)	(0.139)	(0.126)	(0.118)	(0.126)	(0.110)	(0.113)	(0.133)
Constant	0.574	0.588	0.306	0.532	0.778	0.528	0.195	0.230	0.0861
	(0.630)	(0.629)	(0.622)	(0.633)	(0.576)	(0.634)	(0.333)	(0.355)	(0.480)
Observations	20	20	20	20	19	20	21	21	21
R-squared	0.321	0.329	0.192	0.296	0.640	0.293	0.437	0.387	0.171
Number of Banks	11	11	11	11	11	11	12	12	12

This table includes the results of the analysis of the sovereign holdings of seventeen commercial banks. The analysis period is from 2015 until 2017. Yearly data is used for this analysis. Sovereign holdings reflect the sovereign holdings that a bank has on its balance sheet in the specified country. Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro's. Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro's. The Log(Net income) is the net income of a bank. The non-performing loans/TA are the non-performing loans the banks hold on the balance sheet over the period Q1 2009 Q3 2018. Inflation(%) is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the GDP growth of the country where the bank is located. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Considering the results in Table 7, there is no significant relation between the sovereign holdings of a bank and its SRISK (%) during the expanded APP. Nevertheless, this outcome does not come as a surprise since the analysis is performed on a very small number of observations. Due to the high correlations, it was not possible to include all sovereign holdings in the same analysis, which reduced the amount of observation to approximately 20 observations. Therefore, due to the absence of sufficient evidence, the fifth sub hypothesis is rejected.

5. The sovereign holdings of a bank are negatively related to the systemic risk of the bank during the expanded Asset Purchasing Programme.

5.7. Robustness Check

In order to safeguard the robustness of the previously discussed results, a robustness check is performed. Taking the log of a variable reduces the skewness of this variable, thereby reducing the probability of the results being driven by outliers. Here the variables of interest are SRISK, corrected for the total assets and the share of the SRISK. The data set contains negative values for both the SRISK and the SRISK share, and these observations will be lost when taking the log for this robustness check.

First, we focus on the robustness of the analysis regarding the effect of the expanded APP on SRISK and SRISK (%). The first table in appendix D shows that, in all four models, the effect of the expanded APP on SRISK and SRISK (%) is positive. Nonetheless, this effect is only significant before controlling for GDP growth and inflation. This could suggest that the effect of the expanded APP is, to some extent, driven by these macro-economic factors. However, since the sign of the expanded APP does not change after taking the log of SRISK and SRISK(%), the results of our analysis are considered to be robust.

Considering the robustness of the analysis concerning the GIIPS countries, the results become insignificant after taking the LOG of SRISK/TA and SRISK(%). This implies that one can questions the robustness of these results.

In conclusion, there is no evidence that the results of the analysis performed in the previous sections is driven by outliers and therefore the results are considered robust.

6. Conclusions and recommendations

This thesis aims to find an answer to the question of whether the expanded Asset Purchasing Program increases the systemic risk within the banking sector of the eurozone. To find the answer to this question, an analysis concerning both the short and the long term is performed. In the short term, the expanded APP seem to have a negative effect on the systemic risk of eurozone banks; during the expanded APP the Marginal Expected Shortfall of eurozone banks has increased. When considering the long term, a positive relation between the expanded APP and the systemic risk of a bank is found. During the implementation, the expanded APP banks tend to have higher SRISK. No significant evidence is found on which specific SRISK element is driving this positive relation. For banks located in GIIPS countries, a negative relation between the expanded APP and both SRISK (%) and MES prevails. This suggests that, in that the short term, systemic risk has increased during the expanded APP for GIIPS country banks. However, the long term systemic risk has decreased for these GIIPS country banks. Lastly, an analysis to gain insight into how the sovereign holdings of a bank are related to the long run systemic risk of a bank is performed. No evidence is found on a relation between the sovereign holdings of a specific eurozone country and the long run systemic risk of a bank. Considering the above, the main hypothesis: The Expanded Asset Purchasing Programme leads to an increase in systemic risk for eurozone banks, is accepted.

The results show that policy makers should be aware of the impact that their policy decisions have on the economy. Although expansionary monetary policy can have a stimulating impact on the economy, policy makers should be aware of the negative effects. If central banks do not consider the risk the expanded APP imposes on the stability of the financial system, they might run out of options when a systemic event prevails. Pre-crisis, low levels of interest rates induced by expansionary policy by central banks was one of the factors contributing to the financial crisis. Central banks should be cautious of history repeating itself.

This research uses data obtained from the V-Lab database, and the quality of this research can be improved by running the calculations of SRISK for all eurozone banks using the methodology described by Brownlees and Engle (2016) instead of subtracting the data from the V-Lab database. This provides a broader range of data and reduces the bias in the data set. In order to improve this research and gain further knowledge of the causes of this increase in systemic risk, one could further explore how the sovereign holdings of a bank are related to the systemic risk of this bank. Due to data limitations, this thesis uses only three data points per bank. In order to create more robust results, one should use more observations, over a longer period of time.

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Appendix

A. Correlation Sovereign Holdings

	SRISK/TA	SRISK(%)	MES	Sovereign Holdings IE	Sovereign Holdings ES	Sovereign Holdings IT	Sovereign Holdings DE	Sovereign Holdings BE	Sovereign Holdings AT	Sovereign Holdings PT	Sovereign Holdings MT	Sovereign Holdings NL	Total Debt/TA	Tier1 Capital/TA	Log(net income)	Non Performing Loans/TA	GDP (%)
SRISK/TA	1	0.712	-0.387	-0.435	-0.134	-0.133	-0.094	-0.184	-0.081	0.089	-0.23	-0.193	0.188	0.019	-0.195	0.129	-0.22
SRISK(%)		1	-0.136	-0.301	-0.176	-0.171	-0.164	-0.171	-0.154	0.144	-0.372	-0.15	0.19	0.024	-0.09	0.227	0.088
MES			1	0.181	0.16	0.155	0.163	0.152	0.151	0.076	0.284	0.22	0.07	0.266	-0.233	-0.461	0.168
Sovereign Holdings IE				1	0.913	0.908	0.896	0.974	0.883	-0.112	-0.075	-0.071	0.123	0.1	0.213	0.394	0.037
Sovereign Holdings ES					1	1	0.998	1	0.998	-0.087	-0.063	-0.083	0.184	0.107	0.187	0.354	0.031
Sovereign Holdings IT						1	0.997	1	0.998	-0.085	-0.062	-0.082	0.184	0.105	0.189	0.352	0.039
Sovereign Holdings DE							1	0.999	0.999	-0.086	-0.062	-0.085	0.19	0.11	0.16	0.347	0.018
Sovereign Holdings BE								1	1	-0.084	-0.062	-0.083	0.188	0.106	0.159	0.353	0.032
Sovereign Holdings AT									1	-0.082	-0.061	-0.084	0.191	0.107	0.153	0.344	0.027
Sovereign Holdings PT										1	-0.057	-0.082	-0.054	-0.101	-0.504	-0.077	-0.009
Sovereign Holdings MT											1	0.097	0.115	-0.072	-0.388	-0.193	-0.008
Sovereign Holdings NL												1	-0.129	-0.063	0.198	-0.187	0.175
Total Debt/TA													1	0.391	-0.633	0.359	0.022
Tier1 Capital/TA														1	-0.599	-0.067	-0.018
Log(net income)															1	0.051	0.118
Non Performing Loans/TA																1	0.017

B. Sovereign Holdings Descriptive Statistics

	SRISK/TA	SRISK(%)	MES	Sovereign Holdings IE	Sovereign Holdings ES	Sovereign Holdings IT	Sovereign Holdings DE	Sovereign Holdings BE	Sovereign Holdings AT	Sovereign Holdings PT	Sovereign Holdings MT	Sovereign Holdings NL	Total Debt/TA	Tier1 Capital/TA	Log(net income)	Non Performing Loans/TA	GDP (%)
Average	4.46	0.032	-0.034	161.426	14.445	10.168	7.063	49.723	61.637	43.788	800.418	6.639	0.454	0.025	5.791	0.008	0.091
Standard Deviation	3.552	0.016	0.024	463.254	48.92	34.929	24.347	174.341	218.079	111.156	3976.696	20.024	0.433	0.055	0.536	0.008	0.056
Max	9.2	0.069	0.017	2294.533	304.127	220.347	150.285	1085.645	1373.217	659.172	26245.446	144.953	1.682	0.258	6.522	0.031	0.169
Min	-16.862	0	-0.106	0	0	0	0	0	0	0	0	0	0	0.001	4.379	0	0.051
Count	63	63	64	52	52	52	52	51	52	63	63	63	45	55	26	46	66

C. SRISK Components

	(1) LRMES/TA	(2) Leverage/TA	(3) Market Value of Equity/TA
Expanded APP Dummy	0.00291	0.00893	-0.00477***
	(0.00618)	(0.00565)	(0.000914)
Total Debt/Total Assets	0.0116***		-0.00247***
	(0.00171)		(0.000248)
Tier1 capital/Total Assets	1.217***	0.438***	0.125***
	(0.150)	(0.123)	(0.0217)
Log(Net Income)	-0.00475	-0.00953*	0.00121
	(0.00585)	(0.00535)	(0.000922)
Non Performing Loans/Total Assets	-1.333	-0.369	0.344**
	(0.862)	(0.787)	(0.134)
GDP%	-0.0892**	-0.0573*	0.0134**
	(0.0359)	(0.0331)	(0.00539)
Inflation %	0.326*	0.543***	-0.0730***
	(0.171)	(0.160)	(0.0267)
Constant	0.0429	0.0969***	-7.94e-05
	(0.0342)	(0.0312)	(0.00539)
Observations	479	476	515
Number of BankNumber	44	44	44
R-squared	0.352	0.084	0.243

This table includes the results of the fixed effects panel data analysis of the components used to calculate the SRISK of 62 commercial banks. The dependent variables are: the Expanded APP dummy, this equals one for the years of implementation of the APP. The Tier 1 Capital//TA of the banks over the period Q1 2009 Q3 2017 corrected for the total assets of this bank is expressed in billions of euro. The Total Debt/TA of the banks over the period Q1 2009 Q3 2017, corrected for the total assets of this bank, is expressed in millions of euro. The non-performing loans/TA, the banks hold on the balance sheet over the period Q1 2009 Q3 2018 corrected for the total assets of this bank. GIIPS country * APP Dummy equals one for banks located in GIIPS countries during the implementation of the ECB. Lastly, the macro-economic control variables include inflation(%), GDP Growth(%) and national savings as a percentage of GDP over the analysis period. The probability statistics are given in parentheses. ***, **, and *, indicate significance at 1%, 5%, and 10% levels, respectively.

D. Robustness Check

	(1) Log(SRISK/TA)	(2) Log(SRISK/TA)	(3) Log(SRISK%)	(4) Log(SRISK%)
Expanded APP Dummy	0.0644**	0.0428	0.0646***	0.0364
	(0.0253)	(0.0362)	(0.0247)	(0.0357)
Total Debt/Total Assets	0.00561	0.00726	-0.00809	-0.00415
	(0.0159)	(0.0157)	(0.0156)	(0.0155)
Tier1 capital/Total Assets	0.700	0.123	1.312	1.142
	(1.241)	(1.258)	(1.212)	(1.241)
Log(Net Income)	-0.0837***	-0.0454	0.0109	-0.0178
	(0.0304)	(0.0318)	(0.0297)	(0.0314)
Non Performing Loans/Total Assets	-0.686	-1.020	10.01**	9.372*
	(4.914)	(5.077)	(4.798)	(5.011)
GDP%		-0.608***		0.787***
		(0.206)		(0.203)
Inflation %		3.533***		-0.631
		(0.958)		(0.946)
Constant	-0.939***	-1.133***	-1.859***	-1.724***
	(0.179)	(0.189)	(0.175)	(0.187)
Observations	413	409	413	409
Number of BankNumber	44	44	44	44
R-squared	0.047	0.106	0.035	0.073

This table includes the results of the fixed effects panel data analysis of log(SRISK) and log(SRISK%) of 62 commercial banks. With the dependent variables: Expanded APP dummy, this equals one for the years of implementation of the APP. The Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro, corrected for the total assets of a bank. Total Debt/TA, of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. The Log(Net income), the logarithm of the Net Income of a bank. Non-performing loans/TA, the non-performing loans of a bank over the period Q1 2009 Q3 2018,corrected for the total assets of a bank. Inflation(%) is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the GDP growth of the country where the bank is located. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

	(1) Log(SRISK/TA)	(2) Log(SRISK/TA)	(3) Log(SRISK%)	(4) Log(SRISK%)
GIIPPS Dummy*APP Dummy	-0.0185	-0.0231	-0.0380	-0.0266
	(0.0494)	(0.0484)	(0.0482)	(0.0478)
Expaned APP Dummy	-0.0528	0.0580	0.0886**	-0.0189
	(0.0401)	(0.0482)	(0.0392)	(0.0475)
Total Debt/TA	0.00667	0.00856	-0.00591	-0.00265
	(0.0162)	(0.0159)	(0.0158)	(0.0157)
Tier1TA	0.617	0.0159	1.141	1.018
	(1.262)	(1.279)	(1.232)	(1.262)
LOG(Net Income)	-0.0850***	-0.0471	0.00824	-0.0197
	(0.0306)	(0.0320)	(0.0299)	(0.0316)
Non Performing Loans/TA	-0.736	-1.123	9.903**	9.253*
	(4.922)	(5.087)	(4.802)	(5.020)
GDP Growth		-0.614***		0.780***
		(0.207)		(0.204)
Inflation		3.518***		-0.649
		(0.960)		(0.947)
Constant	-0.931***	-1.122***	-1.842***	-1.711***
	(0.181)	(0.191)	(0.176)	(0.189)
Observations	413	409	413	409
Number of BankNumber	44	44	44	44
R-squared	0.047	0.107	0.036	0.074

is table includes the results of the fixed effects panel data analysis of log(SRISK) and log(SRISK%) of 62 commercial banks. With dependent variables: Expanded APP dummy*GIIPS Country, this equals one for GIIPS country banks during the years of implementation of the APP. The Tier 1 Capital/TA of the banks over the period Q1 2009 Q3 2017 is expressed in billions of euro, corrected for the total assets of a bank. Total Debt/TA of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. Log(Net income), the logarithm of the Net Income of a bank. Non-performing loans/TA, the non-performing of a bank over the period Q1 2009 Q3 2018 is corrected for the total assets of a bank. Inflation(%) is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the GDP growth of the country where the bank is located.

E. Correlation Matrix SRISK, SRISK% and MES

	SRISK/Total Assets	SRISK(%)	MES (%)	Total Assets	Tier1 capital/Total Assets	Net income/Total Assets	Total Debt/Total Assets	LN(Net Income)	GDP growth (annual %)	Inflation (annual %)	Non-Performing Loans/Total Assets	Market Value Equity	Leverage	LRMES
SRISK/Total Assets	1	0.834	-0.27	0.221	-0.243	-0.24	-0.121	0.123	-0.113	0.099	0.08	-0.118	0.37	0.314
SRISK(%)		1	-0.193	0.213	-0.194	-0.159	-0.08	0.087	0.072	0.013	0.11	-0.066	0.247	0.233
MES (%)			1	-0.254	0.26	0.132	0.078	-0.291	-0.069	0.011	-0.18	-0.156	-0.222	-0.559
Total Assets				1	-0.269	0.011	-0.044	0.478	0.009	0.012	-0.099	0.678	0.14	0.346
Tier1 capital/Total Assets					1	0.179	0.384	-0.543	-0.022	0.011	-0.043	-0.242	-0.05	-0.371
Net income/Total Assets						1	0.14	0.188	0.047	-0.067	-0.208	0.059	-0.169	-0.161
Total Debt/Total Assets							1	-0.626	-0.006	-0.091	0.115	-0.044	-0.071	-0.106
LN(Net Income)								1	0.016	-0.103	0.033	0.523	0.156	0.312
GDP growth (annual %)									1	0.093	0.133	0.021	-0.035	0.029
Inflation (annual %)										1	0.085	-0.032	0.144	0.07
Non-Performing Loans/Total Assets											1	0.014	0.034	0.288
Market Value Equity												1	-0.093	0.295
Leverage													1	0.132
LRMES														1

F. GIIPS Country Analysis Time Fixed Effects

	(1) SRISK/TA	(2) SRISK/TA	(3) SRISK(%)	(4) SRISK(%)	(5) MES(%)	(6) MES(%)
GIIPPSDummy*APPDummy	-0.00542	-0.00584	-0.00437	-0.00589*	-0.00887***	-0.00958***
	(0.00405)	(0.00417)	(0.00314)	(0.00323)	(0.00195)	(0.00188)
TotalDebt/TA	0.0104***	0.0105***	0.00964***	0.00971***	-0.000638	-0.000735
	(0.00103)	(0.00103)	(0.000796)	(0.000799)	(0.000503)	(0.000469)
Tier 1 Capital/TA	-0.282***	-0.285***	-0.277***	-0.292***	0.00373	0.0137
	(0.0871)	(0.0888)	(0.0675)	(0.0687)	(0.0426)	(0.0404)
LOG(Net Income)	-0.00498	-0.00574*	0.000437	-0.000268	0.00681***	0.00814***
	(0.00332)	(0.00344)	(0.00257)	(0.00266)	(0.00162)	(0.00156)
Non Performing Loans/TA	-1.466***	-1.536***	-0.961**	-0.969**	-0.722***	-0.573**
	(0.515)	(0.535)	(0.399)	(0.414)	(0.252)	(0.243)
GDP growth		0.0275		0.0374		0.000646
		(0.0302)		(0.0234)		(0.0137)
Inflation		0.468		-0.242		-0.740***
		(0.333)		(0.258)		(0.151)
Constant	0.0733***	0.0747***	0.0231	0.0233	-0.0655***	-0.0739***
	(0.0196)	(0.0206)	(0.0152)	(0.0159)	(0.00960)	(0.00935)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	483	479	483	479	486	482
Number of Banks	44	44	44	44	44	44
R-squared	0.342	0.348	0.285	0.292	0.404	0.445

This table includes the results of the fixed effects panel data analysis of SRISK, SRISK% and MES of 62 commercial banks. With the dependent variables: Expanded APP dummy*GIIPS Country, this equals one for GIIPS country banks during the years of implementation of the APP. The Tier 1 Capital/TA, the Tier 1 capital of the banks over the period Q1 2009 Q3 2017 expressed in billions of euro, corrected for the total assets of a bank. Total Debt/TA, of the banks over the period Q1 2009 Q3 2017 is expressed in millions of euro, corrected for the total assets of the bank. Log(Net income), the logarithm of the Net Income of a bank. Non-performing loans/TA, the non-performing the banks hold on the balance sheet over the period Q1 2009 Q3 2018, corrected for the total assets of a bank. Inflation(%), Inflation is measured by the consumer price index for the country where bank is located. GDP Growth(%) is the GDP growth of the country where the bank is located. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10