LOW INTEREST RATES AND BANK RISK-TAKING: HAS THE CRISIS CHANGED ANYTHING? EVIDENCE FROM THE EUROZONE

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Abstract. This paper examines the impact of monetary policy on bank risk-taking and the influence of the recent financial crisis on this relation. We use a dataset of 571 commercial banks from Eurozone and analyze the relation on the period from 1999 to 2011, with emphasize on the period 2008 to 2011. We use non-performing loans, loan loss provisions and Z-score as measures for bank risk-taking, while for monetary policy the proxies are short-term interest rates (computed using a Taylor rule) and long-term interest rates. We determine the relation between the two by taking into account some specific control variables and analyze it using an entity fixed-effects model and Generalized Method of Moments, alternatively. Empirical results point to a negative relation between interest rates and bank risk-taking. In addition to this, results show that the crisis has led to an additional negative impact on the relation between interest rates and bank risk-taking for the turmoil period 2008-2011.

Keywords: monetary policy, bank risk-taking, financial crisis, monetary transmission mechanism

JEL classification: G01, G21, G28.

1 INTRODUCTION

The effects of monetary policy on the banking system have been widely studied during the past years. The recent financial crisis has brought into discussion...
the importance of the relationship between monetary policy decisions (measured through the official interest rates) and the risk-taking behavior of banks.

Various empirical studies (Delis and Kouretas, 2011; Altunbas et al., 2010; Maddaloni and Peydro, 2011) demonstrated that banks are willing to take on more risk when interest rates are low. These papers show that the low interest rate environment of the early to mid 2000s influenced the banking system in the sense that it increased the level of risk assumed by banks. Also, it created the incentives for banks to find new ways of compensating for the low interest rates, as the securitization activity. Maddaloni and Peydro (2011) demonstrated that the influence of low interest rates on the softening of lending standards is amplified by securitization, since higher securitization leads to softer lending standards and higher bank risk.

The low interest rates paradox (Maddaloni and Peydro, 2011) suggests that when interest rates are low the credit and liquidity risk of banks increases and so does the likelihood of a financial crisis. If the crisis unfolds, the monetary authority lowers the interest rate in order to support the economy and the banking system and to avoid new credit turmoil. However, it might be precisely this attitude one of reasons that increases the likelihood of a new crisis.

This study aims at offering an image of the relationship between monetary policy and bank risk-taking in the context of the recent financial crisis. We believe this issue is of interest because this crisis is the most serious financial crisis since the Great Depression, with high economic and social costs. Moreover, although risk is an essential component of the economic system, excessive bank risk-taking has been a key determinant of the global financial crisis.

In our opinion, the risk-taking channel of monetary policy is of interest because it reflects the interaction between finance, behavioral finance and macroeconomics. It relates to finance because it captures the measurement and managing of risk. It relates to behavioral finance because it captures the effects of monetary policy on bank’s risk perceptions and incentives. In the end, it relates to macroeconomics because excessive bank risk-taking has effects on the general equilibrium, as the recent financial crisis demonstrates.

The remainder of this paper is organized as follows: the second section revises the key papers regarding the theoretical and empirical insights about the risk-taking channel of monetary policy, the third section presents the variables used in the analysis, while the fourth section explains the data collection process and the descriptive statistics of the data. In the fifth section we present the research methodology, while the sixth section summarizes the key results. The seventh sections concludes.
2 Literature Review

The aim of this section is to review the existing literature about the nexus between interest rate and bank risk-taking, focusing on the theories behind this relation and the empirical work that offers evidence on the existence of the risk-taking channel of monetary policy.

2.1 Theoretical foundations

The majority of the papers that study the impact of interest rates on bank risk have focused on the credit channel of monetary policy. This channel reflects the dual effect of monetary policy on the credit supply of banks. Firstly, through the balance-sheet channel, low interest rates lead to an increase of the collateral and cash-flows of borrowers. Potential borrowers become more creditworthy and this increases the supply of loans. Secondly, through the bank-lending channel, when interest rates are low, banks are faced with the threat of deposit withdrawals. So, they have to search for other financing sources, at a higher cost (Kashyap and Stein, 1994). This extra cost is defined by Bernanke and Gertler (1995) as the external finance premium. As a consequence, the supply of credit would be lowered.

The seminal paper of Borio and Zhu (2008) puts forward the idea that the transmission channel of monetary policy should take into account changes in banks’ risk-taking activity. The authors define this as the risk-taking channel of monetary policy. Also, they discuss three factors that support the existence of a risk-taking channel. First, changes of monetary policy affect the perception of risk and the risk position of banks’ portfolios. Second, they influence the pricing of assets and have an impact on valuations, income or cash-flows. Third, communication problems regarding the transparency of the decision of the monetary authority may also influence the risk-taking activities of banks.

Additionally, Rajan (2005) discusses the “search-for-yield” effect as an argument in favor of the risk-taking channel. He explains that when interest rates are low, the yields on risk-free assets are also low. So, banks will tend to invest in risky assets, which offer a higher yield. Moreover, the author argues that the “herding phenomena” (managers try to replicate the investment decisions of their peers thinking that in this way, they will not under perform them) amplifies this behavior.

2.2 Empirical considerations

The access of some researchers to micro-level bank data on the different categories of loans creates the possibility of analyzing the relationship in a deeper manner. Jimenez, Ongena, Peydro and Saurina (2008) analyze the impact of low
interest rates on credit risk, using disaggregated data on bank loans from Spain. They argue that there are three important factors that determine the impact of monetary policy on bank risk taking: the bank itself, the borrowers and the market characteristics. The findings suggest that in the short-term, low interest rates may reduce the total credit risk of banks, while in the medium term, it increase the credit risk of banks. Also, they found that small banks and commercial banks take more risk when interest rates are low.

Different from Jimenez et al. (2008), Ioannidou, Ongena and Peydro (2008) analyze the way in which this rate influence the risk and the price of new granted loans. Their study is conducted on individual loan data from Bolivia, from 1999 to 2003. The study shows that when interest rates are low, banks take more risk and this additional risk is not priced properly. What is more interesting, it is negatively priced.

In the context of monetary policy and bank risk-taking, we argue some thought should be given to the concept of “paradox of low monetary rates”. Maddaloni and Peydro (2011) argue that it happens after periods of low interest rates, when banks are encouraged to take more risk, increasing the possibility of a banking crisis. If the crisis starts, the monetary authority will lower the interest rates in order to support the banking system. But lowering interest rates might increase the probability of a future credit crisis. The main finding of their paper is that low monetary rates lead to a softening of the lending standards and short-term rates have a more significant impact on bank risk-taking than long-term rates. This result is also obtained by Diamond and Rajan (2006) and Adrian and Shin (2009).

Additionally, Maddaloni and Peydro (2011) put forward the idea that too low for too long interest rates were a key determinant of the current financial crisis, because they increased the level of risk assumed by banks. The authors discuss three important factors that amplified this effect: the deep reliance of commercial banks on short-term funding, weak supervision concerning bank capital and financial innovation that was largely used in the years before the crisis.

Altunbas et al. (2010) show that a reduction of interest rate below a certain benchmark leads to a negative effect, encouraging banks to take more risk. In order to capture this discrepancy between real interest rates and benchmark levels of them, the authors use a Taylor rule in defining a proxy for the monetary policy stance. We employ the same strategy in our study. Firstly, we compute the country-specific benchmark level of interest rate using a Taylor rule. Secondly, we substract this benchmark from the actual short-term interest rate in order to determine the negative Taylor gaps, that show very low levels of interest rates.
One of the articles that we lean heavily on (Delis and Kouretas, 2011) analyzes the impact of the low interest rate environment of the early to mid 2000s on risk-taking incentives of banks. They found that low interest rate strongly increase bank risk-taking. When analyzing the relation between monetary policy and bank risk, they take into account the endogeneity of bank-level interest rates, but also of some of the control variables.

Empirical papers employ different proxies for measuring bank risk-taking and interest rates. For example, Delis and Kouretas (2011) measure bank risk-taking using two proxies, the risky assets, regarded as a broader proxy, and the non-performing loans (a measure for credit-risk). Monetary policy is proxied by four alternative measures: a short-term interest rate, a long-term rate, a bank-level lending rate and the central-bank rate. However, the conclusions of their analysis are based mostly on the results obtained using the bank-level lending rate.

By contrast, Maddaloni and Peydro (2011) use Taylor rule residuals in order to tackle the problem of endogenous monetary policy, in general and endogenous bank-level lending rate, in particular. The authors argue that positive Taylor residuals correspond to relatively high interest rates, while negative residuals imply what is called “very low” interest rates.

Altunbas et al. (2009) use Expected Default Frequencies and Loan Loss Provisions as alternative measures of bank risk-taking. The Z-score, which is inversely related to the probability of bank insolvency, is another proxy used in the literature for measuring bank risk-taking (Konishi and Yasuda, 2002; Laeven and Levine, 2008).

Overall, the empirical evidence shows a negative relation between low interest rates and bank risk-taking. In our paper, we analyze whether this relation is supported when using a different and unique sample of commercial banks. In addition to this, we study whether the financial crisis has influenced this relation and whether, during the crisis, low monetary policy have had an effect that reduced risk-taking of banks.

3 DATA

The aim of this paper is to analyze the nexus between the stance of monetary policy and bank risk taking in the context of the recent financial crisis. In order to achieve this goal, we first establish the variables used to identify the stance of the monetary policy and the bank risk-taking, but also some control variables that may influence this relation.
3.1 Dependent variables

The existing literature on the topic of our paper documents the use of some alternative measures for risk-taking. We measure the bank risk-taking through three different proxies.

First, we use the ratio of non-performing loans to total loans. It is used as a proxy for credit risk (Delis and Kouretas, 2011; Ioannidou et al., 2008; Ioannidou, 2005). It reflects the quality of the banks’ portfolios of loans. Low interest rates may determine a slight decrease in the level of non-performing loans on short-term for current debtors, because it may ease the interest burden of them. However, on medium and long-term, low interest rates may encourage banks to lower the lending standards and the screening activity and to give loans to some borrowers who would not be eligible otherwise. Hence, in the medium and long-term, the low interest rates may determine an increase of non-performing loans.

Second, we use the Z-score as a proxy for the risk of banks, seen from the perspective of its insolvency risk. We compute Z-score as Laeven and Levine (2008) do, because our sample consists in listed and unlisted banks, while Konishi and Yasuda (2004) only use listed banks. Z-score is computed as the ratio of the return on assets plus the capital-asset ratio to the standard deviation of assets returns. Z-score computed as above represents the inverse of the probability of insolvency: the higher the Z-score, the stable the bank. A low probability of insolvency or a high distance to insolvency points to less risk aversion and to a higher bank risk-taking. We use natural logarithm of this measure as a solution for its highly skewed distribution.

Third, we bring an innovation to our study and use loan loss provisions ratio as a measure for bank risk-taking. When loans become non-performing, banks are faced with the possibility of not recovering the principle and the interest, so they have to use a mechanism through which they create a kind of cushion that protects them against unexpected losses on loans. This mechanism is known as loan loss provisioning. A negative relation between interest rates and loan loss provisions signals a higher risk-taking assumed by banks in the presence of low interest rates.

3.2 Independent variables

Concerning the monetary policy stance, the majority of the existing studies use the three-month Euribor or the overnight interest rates for Eurozone (EONIA rate) as measures of short-term interest rates. They are the same for all countries in our sample and they vary only across time. In order to add variability to the interest rates variable, we employ the technique used in Maddaloni and Peydro (2011) and Altunbas et al. (2010) and proxy it using Taylor’s rule residuals. Concerning the
endogenous character of interest rates, we follow Delis and Kouretas’ (2011) argument and assume that the European Central Bank do not take into account the bank risk-taking in one particular country when establishing the monetary policy. Also, to support the exogenous character of monetary policy, Jimenez, Ongena, Peydro and Saurina (2008) argue that it is not monetary policy that is reacting to future risk, but banks are actually seeking it.

Turning back to the Taylor’s residuals, computing them requires some further notions. First, we need to know the estimated output (or the potential output). Many methods have been used in the literature for estimating the potential output and the output gap (Chagny and Dopke, 2011; Cerra and Saxena, 2000; Almeida and Felix, 2006) - from simple univariate techniques to multivariate structural techniques and stochastic filtering techniques. From all these methods, the Hodrick-Prescott filter approach is the most known and commonly used univariate method. It was proposed by Hodrick and Prescott (1997) and it consists in the de-trending of an economic time series. Basically, it separates the GDP time series into a permanent (smoothed) series which corresponds to the estimate of potential output and a cycle component which represents the difference between real GDP and potential GDP, namely the output gap. A detailed description of the technical features of this technique is beyond the scope of this paper and it is presented in the Appendix B. After estimating the potential output, we use the obtained values and run a regression of EONIA on inflation and GDP, according to Taylor’s rule. The regression is implemented for each country because the basic idea of this rule is that, even if countries in Eurozone have a common monetary policy, the macroeconomic conditions differ according to the specificity of each country. In this sense, besides the interest rate, the equation proposed by Taylor includes the GDP and inflation that vary between countries. The residuals from the regression measure the difference between the actual nominal short-term interest rate (EONIA in our case) and the rate computed through Taylor’s rule using equal weights on output and inflation and no interest rate smoothing. The mathematics of estimating Taylor’s gap can be found in the Appendix A.

The way of computing the measure used for the stance of monetary policy, namely the Taylor gaps, resembles the one used by Altunbas et al (2010) and Maddaloni and Peydro (2011). However, in our study we use only equal weights on output and inflation and no interest rate smoothing, while Altunbas et al. use three different versions of the Taylor’s rule.

Having in mind that the interest rate is not the only variable that can influence the risk-taking behavior of banks, we control for some bank-specific characteristics, as capitalization, profitability, size, efficiency and non-traditional
activities. Also, we control for banking regulation, taking into account three indices: capital stringency, official supervisory power index and market discipline, computed using Barth’s Database. The last category of control variables concerns the macroeconomic controls, like economic growth, importance and concentration.

3.3 Data collection and descriptive statistics

The bank-level data used for computing variables for the analysis was collected from Bankscope Database. Unlike Delis and Kouretas’ (2011) paper, we conduct our analysis on a sample of commercial banks only, because the majority of savings and cooperative banks have many missing values and they are self-eliminating from the sample. Also, we conduct the analysis on commercial banks only due to comparability reasons.

We analyze the sample of commercial banks during the period from 1999 to 2011. We organize it as a panel data in which each bank corresponds to a cross section and each year to the time dimension. The sample consists of commercial banks from EuroArea. Banks from each country are included in the sample starting with the year their country has joined the EuroArea. The panel consists in 571 banks and 13 years (period 1999 to 2011), a total of 6999 bank-year observations. In our data, 75.57% of observations are missing when using non-performing loans as the dependent variable, 42.78% are missing when using loan loss provisions and 42.51% when using Z-score. Despite that, we would rather prefer to use list-wise deletion because eliminating cases that have incomplete observations would significantly reduce the size of our sample.

The sample may be affected by some survivorship bias (because some of the banks might have failed at one moment in time and they are excluded from the sample). Also, we apply our own selection criteria of choosing the sample and the banks included in it. When downloading data from Bankscope, we searched for active commercial banks from EuroZone that have at least five years of available data and that have data for at least one of the following years: 2009, 2010 or 2011. Although Bankscope has the advantages of accounting for almost 90 percent of total banking assets in each country and also of presenting the data in standardized formats, it has the disadvantage of limitations in data availability.

As far as the missing data is concerned, considering that each available information is important for the purpose of the analysis, we do not eliminate banks that have missing observation. Instead, we would rather use the listwise deletion applied in the regression used to analyze the relationship between monetary policy and bank risk-taking. In order to tackle the problem of outliers and also the non-normal distribution, we use the outlier labeling rule (Hoaghin, Iglewicz and Tukey, 1986; Hoaghin and Iglewicz, 1987) as a method for detecting the outliers and we
apply the winsorizing method in order to eliminate them, because trimming would have led to a loss of information. A further explanation about the insights of the outlier labeling rule can be found in the Appendix C.

The descriptive statistics reported in Table 1 enable a better understanding of the variables that we include in the analysis.

Non-performing loans have a mean value of 4.34% of total loans for the period 1999-2011, with a maximum of 14.55% from total loans. Also, from a total of 6999 bank-year observations, only 2183 are available for analyzing the non-performing loans. Regarding the monetary policy, the dynamics of EONIA show a decrease of the mean values of the overnight interest rates in the period from 2008 to 2011. Taylor’s residuals, the proxy for monetary policy stance, have a negative mean value of -0.0091%, with a minimum of -5.76% for year 2011 in Estonia and a maximum of 4.81% for year 2009 in Ireland. The dynamics of the mean values of Taylor’s residuals for the period 1999 to 2011 show negative values for period 2003 to 2007 and for period 2009 to 2011. These negative values of Taylor’s residuals are associated with the concept of very low interest rates (Maddaloni and Peydro, 2011) and they represent the low interest rates which increase the level of bank risk-taking.

As far as the distance to insolvency is concerned, it has a mean value of 0.3784, with a minimum of -3.3126 and a maximum of 4.1637.

A further analysis on the dynamics of the mean values of the bank-level controls and macroeconomic indicators shows that year 2008 has brought considerable changes in the financial situation of banks, but also on the general economic environment. The profitability of commercial banks from Euro Area has mean values which increased in the period from 2002 until 2007, but they show a deep decrease starting from year 2007 to 2011. This evolution reflects the effects of the recent financial crisis on the banking system. Regarding the regulatory environment, the official supervisory power index exhibits an important increase in its mean values that demonstrates the increasing importance of the regulatory requirements for the banking system. Moreover, with a mean value of 1.7243, economic growth has a minimum value of -5.1713 and a maximum of 7.5467. The dynamics of the GDP growth rate show a deep decrease of its mean values. Starting from year 2007 until year 2010 it has registered negative values, corresponding to the recession caused by the financial crisis with extended effects on the general economic environment. After year 2010, it has begun to slightly increase.

The existing literature argues about the positive relation between the distance to insolvency (Z-score) and the bank risk-taking (Borio and Zhu, 2008).
This means that a negative correlation between interest rates and Z-score (in case of our study it has a value of -0.2361) corresponds to a negative relation between interest rates and bank risk-taking.

**Table 1 Descriptive Statistics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-performing loans</td>
<td>0.0434</td>
<td>0.0392</td>
<td>0.0000</td>
<td>0.1455</td>
<td>2183</td>
</tr>
<tr>
<td>Loan loss provisions</td>
<td>0.0038</td>
<td>0.0046</td>
<td>-0.0068</td>
<td>0.0131</td>
<td>5500</td>
</tr>
<tr>
<td>Z-score</td>
<td>0.3784</td>
<td>1.0938</td>
<td>-3.3126</td>
<td>4.1637</td>
<td>5448</td>
</tr>
<tr>
<td>EONIA</td>
<td>2.5542</td>
<td>1.2895</td>
<td>0.4377</td>
<td>4.3872</td>
<td>6999</td>
</tr>
<tr>
<td>Taylor gap</td>
<td>-0.0091</td>
<td>1.5090</td>
<td>-5.7627</td>
<td>4.8136</td>
<td>6999</td>
</tr>
<tr>
<td>Capitalization</td>
<td>0.0852</td>
<td>0.0505</td>
<td>-0.0414</td>
<td>0.1803</td>
<td>6344</td>
</tr>
<tr>
<td>Profitability</td>
<td>0.0086</td>
<td>0.0101</td>
<td>-0.0129</td>
<td>0.0307</td>
<td>6214</td>
</tr>
<tr>
<td>Size</td>
<td>14.4111</td>
<td>2.2530</td>
<td>7.6401</td>
<td>21.5128</td>
<td>6347</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.3769</td>
<td>0.2033</td>
<td>-0.1259</td>
<td>0.8664</td>
<td>5682</td>
</tr>
<tr>
<td>Non-traditional activities</td>
<td>0.1710</td>
<td>0.1648</td>
<td>-0.1054</td>
<td>0.5409</td>
<td>5505</td>
</tr>
<tr>
<td>Capital stringency</td>
<td>5.5711</td>
<td>1.5700</td>
<td>2.0000</td>
<td>8.0000</td>
<td>6999</td>
</tr>
<tr>
<td>Market discipline</td>
<td>5.5728</td>
<td>0.7010</td>
<td>4.0000</td>
<td>8.0000</td>
<td>6999</td>
</tr>
<tr>
<td>Supervisory power</td>
<td>9.8750</td>
<td>2.1807</td>
<td>5.0000</td>
<td>14.0000</td>
<td>6999</td>
</tr>
<tr>
<td>Economic Growth</td>
<td>1.7243</td>
<td>2.4668</td>
<td>-5.1713</td>
<td>7.5467</td>
<td>6999</td>
</tr>
<tr>
<td>Importance</td>
<td>131.8422</td>
<td>30.3308</td>
<td>55.6995</td>
<td>260.9600</td>
<td>6909</td>
</tr>
<tr>
<td>Concentration</td>
<td>41.5830</td>
<td>17.6378</td>
<td>18.9455</td>
<td>90.6350</td>
<td>6999</td>
</tr>
</tbody>
</table>

Source: own computations

This table reports the descriptive statistics used to analyze the sample of the analysis. The average value is described through the mean value. The maximum and minimum represent the highest value and the lowest value that a variable exhibits during the period of analysis. The number of observations refers to the number of complete observations existing in the sample after the listwise deletion of missing observations. The period of analysis is 1999 to 2011. The variables are as follows: non-performing loans is the ratio of non-performing loans to total loans, loan loss provisions is the ratio of loan-loss provisions to total assets, Z-score is the natural logarithm of the ratio of the sum between the return-on-assets and capital-asset ratio to the standard deviation of the return-on-assets, EONIA is the overnight interest rate for the EuroZone, Taylor gap represent the residuals from a regression of EONIA on GDP and inflation and no interest rate smoothing, capitalization is the ratio of equity to total assets, profitability is the ratio of profit before tax to total assets, Size is the natural logarithm of total assets, Efficiency is ratio of overheads to total interest income, Non-traditional activities is the ratio of off-balance sheet items to total assets, Capital stringency is the index of capital requirements,
Supervisory power is the index of the official power of the supervisor, Economic
growth represent the real GDP growth rate, Importance is the domestic credit
provided by the banking sector as a share of GDP and Concentration is computed
as the 5-bank concentration ratio.

4 Research methodology

The paradox of low monetary policy and the recent financial crisis have
convinced banks to pay more attention on the level of risk their actions incur. But
has the crisis changed the perception of risk by banks? The European Central
Banks has significantly lowered the interest rate and the EONIA decreased from
3.87% in 2008 to 0.71% in 2008, 0.44% in 2010 and it exhibits a slightly increase
to the level of 0.87% in 2011. The “very low interest rates”, measured through
Taylor residuals have registered negative mean values during the period from 2003
to 2007 and from 2009 to 2011. Have these low rates led to a further increase in
bank risk-taking? Or have banks become more conscious about the consequence of
their actions and tried not to take more risk when rates are low? In the end, has the
crisis influenced in some way the relationship between monetary policy and bank
risk-taking? These are the questions which triggered the existence of this study and
we will try to find an answer to them.

Taking into account the above discussion, we will investigate the following
research questions: Are low interest rates leading to higher bank risk-taking? Has
the crisis influenced this relation? During the crisis, has the low monetary policy an
effect that reduced bank risk-taking?

In this paper, we formulate three research hypotheses, as follows:

Hypothesis 1: Very low interest rates lead to higher bank risk-taking for
period 1999 to 2011, but also for period from 2008 to 2011. We will investigate
this hypothesis using an entity fixed-effects model on three different subsamples.

Hypothesis 2: The relation between low interest rates and bank risk-taking is
different before the financial crisis than after it. We will investigate this hypothesis
using a Chow test for structural breaks.

Hypothesis 3: The financial crisis has influenced the relationship between
interest rates and bank risk-taking for the period 1999 to 2011. We will analyze the
coefficient of the interest rate variable in interaction with the slope dummy variable
CRIS in order to investigate this hypothesis.

The analysis of the impact of interest rates on bank risk-taking raises two
econometrical problems (Delis and Kouretas, 2011). The first one is the
endogeneity of some of the control variables and the second one refers to the
dynamic nature of bank risk. Besides these two, the literature also discusses the
endogeneity of interest rates, but we argue that the use of Euro Zone interest rate mitigates this problem. The reason is that European Central Bank does not take into account the risk of each Euro Zone bank when establishing the unique monetary policy. Moreover, as Maddaloni and Peydro (2011) argue, the use of Taylor’s residuals might also mitigate this problem.

We divide the empirical strategy conducted in our study into two parts. The first one analyzes the nexus between interest rates and bank risk-taking without taking into account the presented econometrical problems, while the second one tackles the two problems.

The basic specification analyzed in this paper takes the following general form:

\[ r_i,t = \alpha_i,t + \beta_0 * r_i,t-1 + \beta_1 * ir_i,t + \delta * ir_i,t * CRIS_t + \beta_2 * bc_i,t + \beta_3 * r_g,t + \beta_4 * ec_t + u_i,t \]

In this equation, \( r_i,t \) represents the bank risk-taking, proxied by the three alternative measures: non-performing loans, loan loss provisions and Z-score, \( ir_i,t \) represents the monetary policy, measured by two alternative proxies: the Taylor gap and the long-term rate, \( bc_i,t \) corresponds to the vector of bank-level control variables, while \( r_g,t \) represents the vector of regulatory controls, \( ec_t \) is the vector of macroeconomic controls, and \( u_i,t \) is the error term. CRIS is a dummy variable and its purpose is to delimitate the period comprising the unfolding of the financial crisis. \( \gamma \) is the coefficient that measures the persistency of bank risk, while \( \delta \) is the coefficient that measures the impact of the financial crisis on the relationship between monetary policy and bank risk-taking. It represents the additional effect on the level of bank risk-taking that the crisis period (2008 to 2011) brings to the non-crisis period (1999 to 2007).

The basic specification we propose in our study differs from the one used by Delis and Kouretas (2011) and Maddaloni and Peydro (2011) because we take into account the effects of the financial crisis on the relationship between monetary policy and bank risk-taking. In other words, in the papers we lean on, \( \delta = 0 \). Our paper brings an innovation to the existing literature, by introducing the effects of the crisis in the general form of this relationship.

Firstly, we do not take into account the endogeneity of some control variables, the dynamic nature of risk, and the effects of the recent financial crisis. This is equivalent to the analysis of the basic specification under two restrictions: \( \gamma = 0 \) and \( \delta = 0 \). We study the resulting equation and control for some omitted-variables that may also influence the relation, like CEO compensation or bank governance. Hence, to control for unobserved variables that differ across banks, but
are constant over time and that may influence the impact of interest rates on bank risk-taking, we employ in the analysis an entity-fixed effects model.

To verify if the fixed effects model is indeed better than a random effects model, we apply a Hausman Test for correlated coefficients. The random-effects model requires a more stringent assumption because it can be employed if any unobserved omitted variables are uncorrelated with the included explanatory variables (Brooks, 2008). If the Hausman statistic proves to be statistically significant, we will reject the null hypothesis that the random effects model is the appropriate model. Hence, fixed effects model will be the model to use in our analysis. Furthermore, we test the null hypothesis that the bank fixed-effects are jointly zero using a Redundant Fixed Effects Test. The rejection of the null hypothesis will support the use of the fixed-effects panel model that allows for bank heterogeneity.

We will investigate the first and second hypotheses by analyzing the model on three different samples. The first sample is the full period from 1999 to 2011. The second sample is named “tranquil”, it refers to the period from 1999 to 2007. It is characterized by a stable period in the Euro Area, with growing GDP rates and expansion of the bank lending activity. The third sample is named “turmoil” and it corresponds to the period after the unfolding of the financial crisis, from 2008 to 2011. The results are subjected to a Chow test for structural breaks in order to investigate whether the relation between monetary policy and bank risk-taking is different before the crisis than after it. In this study we assume that a possible structural break occurs after the unfolding of the financial crisis, starting with the year 2008.

To investigate whether the impact of monetary policy on bank risk-taking is driven by the effects of the financial crisis, we use only one restriction in the basic specification: the $\gamma=0$. So, the CRIS dummy variable has a value of zero for the tranquil period and a value of one for the turmoil period.

Going further with the study, we analyze the effects of the impact of the crisis in the context of some endogenous control variables and dynamic nature of bank risk. This is equivalent with the analysis of the basic specification without any restriction.

According to Delis and Kouretras (2011), the bank risk-taking of the previous period may influence the bank risk of the current period. They argue that a reason for this may be the level of regulation. Capital requirements could lead to risky investments with effects over an extended period of time. Also, the bank risk tends to deviate from equilibrium because it might need a certain amount of time to adjust to the effects of macroeconomic shocks.
A dynamic model, including a lagged dependent variable, captures the persistent character of bank risk and provides unbiased results. The Generalized Method of Moments for dynamic panel data is such a model. Moreover, the GMM takes into account the endogeneity of capitalization, lagged profitability and efficiency. As proposed by Arellano and Bover (1995), this method uses the lags of the possible endogenous explanatory variables as instrumental variables.

The results are subjected to a Sargan Test for over-identified restrictions and we also conduct an AR(1) and AR(2) tests on the residuals of the regression in order to establish the validity of the number of lags used as instruments for the list of endogenous variables.

When using the distance to insolvency, measured through Z-score, as a dependent variable, we do not include profitability and capitalization as bank-level control variables in the equation used to analyze the relation between interest rates and the distance to insolvency. The reason is that Z-score is computed using precisely these two variables, so there is no need to control for these two.

5 EMPIRICAL RESULTS

The purpose of this section is to summarize the results of the analysis and comment on their economic interpretation. First, we use an entity fixed effects model to analyze the relationship between monetary policy and bank risk-taking. Afterwards we use the Generalized Method of Moments in order to tackle the econometric problems of this relation: the endogeneity of some control variables and the persistency of bank risk.

An important part of the research question consists in understanding the nexus that can be established between monetary policy and bank risk-taking. The first hypothesis that we investigate in this paper is the existence of a negative relation between interest rates and bank risk-taking. In order to investigate it, we divide the sample according to the purpose of this paper. The analysis on different subsamples enables the investigation of the second hypothesis, with the aim of establishing whether the relation is stable over the period of study.

The results summarized in Table 2 are obtained using the entity fixed effects model. The Hausman test and the Redundant Fixed Effects test support the use of cross-section fixed effects. The Chow test demonstrates that the parameters are not stable over time. Hence, we conclude that the relation between low interest rates and bank risk-taking is different before the financial crisis then after it.

Table 2 summarizes the results of this analysis, by using the three proxies for bank risk-taking (non-performing loans, loan loss provisions and z-score) and the Taylor’s residuals as proxies for interest rates. In all nine regressions, interest rates have a negative influence on the level of bank risk. This result is in line with the
previous empirical studies. For the full sample 1999-2011, low interest rates lead to higher non-performing loans and also to higher loan loss provisions. Hence, low interest rates lead to high credit risk for banks. The negative relation between Z-score and interest rates shows that low monetary policy lead to high bank stability, hence to a low probability of insolvency. Usually this low probability is associated with a high risk tolerance and a higher propensity for bank risk taking (Borio, 2008).

In Table 2 we also report the results of the analysis conducted on the two subsamples, the one characterized by a tranquil period and the one defined by the financial turmoil. Monetary policy, proxied by Taylor's residuals have a slightly significant impact, at 10% level, in case of loan loss provisions, but the impact is significant at 1% level in case of Z-score. Low interest rates determine high non-performing loans (although the impact is not significant) and high loan loss provisions.

After the unfolding of the financial crisis, for the subsample from 2008 to 2011, the results reported in columns 3, 6 and 9 show that the low interest rates increase the volume of non-performing loans. Banks reacted so that they increased the provisions for loan losses. In addition to this, very low interest rates seem to significantly increase the Z-score of banks, which induce an increase in the risk-taking behavior of commercial banks.

To summarize the results presented in Table 2, we reject the first null hypothesis at 5% level and conclude that very low levels of interest rates lead to higher bank risk-taking. Furthermore, we also reject the second null hypothesis about the stability of this relation. Hence, the relation between low monetary policy and bank risk-taking is not stable over time and the impact for the tranquil period 1999 to 2007 is different from the impact for the turmoil period 2008 to 2011.

Going further with the analysis, we want to investigate if the impact of monetary policy on bank risk taking is driven by the effects of the financial crisis and the extent to which this impact is statistically significant. Hence, Table 3 – columns 1, 3 and 5 - summarizes the results of the analysis with the inclusion of a dummy variable which takes the value of 1 for period from 2008 to 2011. The effect of the crisis is not significant for non-performing loans (column 1), but it is highly significant in case of loan loss provisions and Z-score (columns 3 and 5). The recent financial crisis brought a significant positive impact on the relation between interest rates and bank stability. However, the impact remains negative. Furthermore, the coefficient of the slope dummy variable CRIS and its significance show that the impact is lowered for the turmoil period, although it remains
negative. This can be interpreted as a slightly increase in the risk aversion of banks, caused by the effects of the financial crisis.

**Table 2** The impact of monetary policy on bank risk: Taylor gaps

<table>
<thead>
<tr>
<th>Dependent variable: Non-performing Loans</th>
<th>Dependent variable: Loan Loss Provisions</th>
<th>Dependent variable: Z-SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Sample</td>
<td>Tranquil</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>TGAP</td>
<td>-.0024***</td>
<td>-.0010</td>
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<tr>
<td>CAP</td>
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<td>.0516</td>
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<td>-.0072</td>
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<tr>
<td>OFFBS</td>
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<td>-.0416*</td>
</tr>
<tr>
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<td>-.0041*</td>
</tr>
<tr>
<td>MDFC</td>
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<td>-.0024</td>
</tr>
<tr>
<td>OFFPR</td>
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<td>.0020</td>
</tr>
<tr>
<td>EC_GROW_TH</td>
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<td>.0006</td>
</tr>
<tr>
<td>IMP</td>
<td>.0004*</td>
<td>.0002**</td>
</tr>
<tr>
<td>CONC</td>
<td>.0011*</td>
<td>-.0002</td>
</tr>
<tr>
<td>Entity FE</td>
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<td>Yes</td>
</tr>
<tr>
<td>Entity RE</td>
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<td>No</td>
</tr>
<tr>
<td>Hausman Test</td>
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<td>57.592</td>
</tr>
<tr>
<td>Observations</td>
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<td>876</td>
</tr>
<tr>
<td>R squared</td>
<td>.7737</td>
<td>.8071</td>
</tr>
<tr>
<td>Estimation</td>
<td>OLS</td>
<td>OLS</td>
</tr>
<tr>
<td>RSS</td>
<td>.6084</td>
<td>.1742</td>
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<tr>
<td>Chow Test</td>
<td>Rejects H0 of stability of parameters over time</td>
<td>Rejects H0 of stability of parameters over time</td>
</tr>
</tbody>
</table>

(*) Significant at 1% level, (**) Significant at 5% level, (***) Significant at 10% level

We analyze the relationship between monetary policy and bank risk-taking, using Taylor gap as measure for interest rate and three alternative measures for bank risk: non-performing loans (NPLTL), loan loss provisions (LLPTA) and Z-score. As controls we include the bank-specific controls, the regulatory controls and the macroeconomic controls. TGAP is the Taylor gap (computed using the
Taylor rule residuals and described in Appendix A), CAP stands for capitalization, PROF(-1) for lagged profitability, SIZE is the bank size, EFFIC stands for efficiency, OFFBS for off-balance sheet items, CAPRQ for capital requirements, OFFPR stands for official supervisory power index, MDISC for market discipline, EC_GROWTH is the economic growth, IMP stands for importance and CONC for concentration. Important to mention is the fact that in case of Z-score, we do not include profitability and capitalization as control variables, because they are used at computing this measure. The relation is analyzed on the three different subsamples using the entity fixed effects model. The Hausman Test examines whether we should use fixed effects or random effects. The Redundant Fixed Effects Test establishes the need of using fixed effects. The R-squared shows the goodness of fit of the model and the Chow test examines whether the relation is stable over time. *, ** and *** indicate significance at 1%, 5% and 10% level, correspondingly.

We study only the effects of the short-term interest rates (measured through Taylor residuals) on bank risk-taking, since the effects of long-term interest rates are not statistically significant for the sample of our analysis.

We have investigated the influence of interest rates on bank risk and to which extent this impact is driven by the effects of the crisis, but we still do not know if these results change when taking into account the potential endogeneity of some of the control variables and the dynamic nature of risk. Table 3 – columns 2, 4 and 6 - summarize the results of an analysis that tackles these two econometrical problems.

We apply the GMM technique to the basic specification with the aim of investigating if the relationship between monetary policy and bank risk is driven by the effects of the crisis. The results are presented in Table 3. When using this technique, the results are improved in the sense that they show significant influence in case of all three equations for Taylor gap. The Sargan test for over-identified restrictions cannot be rejected for all nine equations, so we conclude that the instruments used are valid. Also, the AR(1) and AR(2) tests are highly significant which is the reason why we did not include the first two lags of endogenous variables in the list of instruments. The results confirm what we observed using the other technique, that short-term interest rates influence the non-performing loans and loan loss provisions in a significant negative way. The explanatory power of the GMM method is higher.

Furthermore, the effects of the crisis bring an additional negative impact to this relation, which increases the magnitude of the coefficients for interest rates in the turmoil period. Hence, when interest rates are low, the non-performing loans
and loan loss provisions increase even more in the turmoil period than in the tranquil period. This corresponds to an increase in the bank risk in the presence of relaxed monetary policy due to the effects of the crisis. A very important result is reported in column 6, where low short-term interest rates, proxied by Taylor’s residuals, have an effect that decreases bank stability in the non-crisis period. This would mean lower bank risk-taking in the tranquil period. However, results show an additional negative impact in crisis period. This means a slightly increase of bank stability, followed by higher bank risk-taking. A better bank stability may be explained by the fact that, in crisis times, low interest rates give banks bigger margins.

Regarding the coefficient on the lagged dependent variable, in all three columns they are statistically different from 0, with values between 0 and 1, except for column 6, where it has a value of 1.1516. These results point to the fact that risk is characterized by a significant degree of persistency, according to the discussion proposed by Delis and Kouretas (2011). It means that the bank risk of the previous period influence the bank risk of the current period in a significant way.

As a conclusion, the results from Table 3 investigate the third null hypothesis that the crisis have had no effect on the relation between monetary policy and bank risk-taking. We can reject the null hypothesis at 5% level, so the effects of the crisis have a significant influence on the nexus between interest rates and bank risk-taking. Regarding this influence, we argue that the crisis have had an additional negative impact to the relation, so that the bank risk-taking have increased after the unfolding of the financial crisis.

Table 3 The influence of the crisis on the relation between monetary policy and bank risk-taking: Panel Technique and GMM estimation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>TGAP</td>
<td>-.0013</td>
<td>-.0017*</td>
<td>.0000</td>
</tr>
<tr>
<td>TGAP*CRIS</td>
<td>-.0015</td>
<td>-.0019*</td>
<td>-.0003*</td>
</tr>
<tr>
<td>DEP(-1)</td>
<td>.4749*</td>
<td>.0452****</td>
<td>1.1516*</td>
</tr>
<tr>
<td>CAP</td>
<td>-.0971*</td>
<td>-.0632*</td>
<td>.0166</td>
</tr>
<tr>
<td>PROF(-1)</td>
<td>-.7428*</td>
<td>-.2930*</td>
<td>-.0447*</td>
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<tr>
<td>SIZE</td>
<td>-.0132*</td>
<td>-.0122*</td>
<td>-.0006*</td>
</tr>
<tr>
<td>EFFIC</td>
<td>-.0121</td>
<td>-.0301*</td>
<td>-.0065*</td>
</tr>
<tr>
<td>OFFBS</td>
<td>-.0476*</td>
<td>-.0569*</td>
<td>-.0009***</td>
</tr>
<tr>
<td>CAPRQ</td>
<td>-.0044*</td>
<td>-.0006*</td>
<td>-.0001***</td>
</tr>
</tbody>
</table>

* denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.
We analyze the relationship between monetary and bank risk-taking, using Taylor Gap as measure for interest rate and three alternative measures for bank risk: non-performing loans (NPLTL), loan loss provisions (LLPTA) and Z-score. As controls we include the bank-specific controls, the regulatory controls and the macroeconomic controls. TGAP is the Taylor gap (computed using the Taylor rule residuals and described in Appendix A), CRIS is a dummy variable, DEP(-1) is the lagged dependent variable, CAP stands for capitalization, PROF(-1) is the lagged profitability, SIZE is the bank size, EFFIC stands for efficiency, OFFBS for off-balance sheet items, CAPRQ for capital requirements, OFFPR stands for official supervisory power index, MDISC for market discipline, EC_GROWTH is the economic growth, IMP stands for importance and CONC for concentration. In case of Z-score, we do not include profitability and capitalization as control variables, because they are used at computing this measure. The coefficient on the dummy variable “CRIS” captures the effect of the crisis. The relation is analyzed on the full sample 1999 to 2011, using first the entity fixed-effects model (column 1,3 and 5) and, second, the Generalized Method of Moments (columns 2, 4 and 6). The Hausman Test examines whether we should use fixed effects or random effects. The AR(1) and AR(2) tests investigates the existence of autocorrelation of order one and two and the table reports the p-values of these tests. Sargan statistic
The aim of this paper is to study the relationship between monetary policy and bank risk-taking, in the light of the recent financial crisis. Using a sample of commercial banks from the Euroarea, we conduct the analysis on two basic directions. The first one is to investigate the impact of interest rates on the risk-taking of commercial banks and the second one is to investigate to what extent this impact is driven by the effects of the crisis in the period 2008 to 2011. An important assumption that we made in this study is that the effects of the crisis can be extended over the period from 2008 to 2011. Hence, we introduce a dummy variable which capture these effects and take the value of 0 from 1999 to 2007 and the value of 1 afterwards.

The overall findings of our analysis point to a negative relation between monetary policy and bank risk-taking, which supports the existence of a risk-taking channel of monetary policy. Our results are in line with the empirical literature on this topic. Maddaloni and Peydro (2011) found that low interest rates soften lending standards, while Ioannidou et al. (2008) argue that relaxing monetary conditions increase the risk appetite of banks. Also, Jimenez et al. (2008) and Delis and Kouretas (2010) show that low monetary policy leads to higher bank risk-taking.

Our study brings novelty to the existent empirical literature by studying this relationship in the context of the recent financial crisis and investigating the existence of the risk-taking channel in times of crisis. The effects of the crisis, extended on period 2008 to 2011, have a significant influence on the impact of interest rates on bank risk taking. The conclusion regarding the nature and the meaning of this impact is quite ambiguous. In case of non-performing loans and loan loss provisions used as dependent variables, low interest rates lead to higher credit risk. Furthermore, in case of Z-score, low monetary policy lead to higher bank risk taking in the turmoil period when using the entity fixed effects model, but to lower bank risk taking when using Generalized Method of Moments. As far as the significance of results is concerned, it is improves when using the latter estimation method.

Our study has some limitations. The results may be sensible to the level of missing data and the data might be affected by the selection bias, since the selection criteria are a subjective decision. Also, the results of this paper are valid for commercial banks only because data for the majority of savings and cooperative...
banks in EuroZone is unavailable. Another limit of this study regards the definition of the time frame for the tranquil and turmoil period, since this is also our subjective choice. Finally, the results may be sensible to the measures used as proxies for bank risk-taking, but also to the choice of using Hodrick-Prescott filtering technique in computing Taylor gaps, used to proxy the monetary policy stance.

The main contribution of our paper is the investigation of the existence of a risk-taking channel of monetary policy in the context of the financial crisis. It is of interest for both the regulators and policymakers because we consider that the new monetary framework (which makes extensive use of very low interest rates, hitting the zero-lower bound, and unconventional monetary measures) and its effects can be better understood only if we have a deep understanding of the way the traditional or conventional monetary policy works and the mechanisms through which it is transmitted to the wider economy. Also, studying the effects of low interest rates may help in preventing a future credit crisis.

ACKNOWLEDGEMENT

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REFERENCES


**APPENDIX**

**A – Taylor rule**

Taylor (1993) proposed a rule which could be used by monetary authorities in policymaking decisions and which argue that it is preferable for central banks to set the interest rates taking into account economic conditions in their own country.

We use Taylor rule in order to compute a proxy that can capture the stance of monetary policy. Basically, Taylor’s equation establishes a benchmark for interest rate that can be thought of as the appropriate policy interest rate, from a macroeconomic perspective. The deviation of the real interest rate from this benchmark level is known as Taylor Gap and represents the proxy used in this paper for the stance of monetary policy. We use the standard Taylor rule, with equal weights on output and inflation and no interest rate smoothing. The equation for Taylor rule is formulated as follows:

\[
i_t = \alpha + \beta_\pi (\pi_t - \pi^*) + \beta_y (y_t - y_t^*) \tag{A1}\]

\[
A(1)
\]
where $i_t$ represents the real interest rate at moment $t$, $\beta_\pi$ is equal to $\beta_y$ and they have a value of 0.5, $\pi^*$ is the target level of inflation and it has a value of 2% for EuroArea, $y_t^*$ represents the target level of GDP or the potential output and it has unobservable values, so they are estimated values. $\pi_t$ is the inflation rate and $y_t$ is the real GDP growth rate.

After estimating the potential output, we run a regression of real interest rate on GDP and inflation according to Taylor’s equation. The regression is ran for each country in the panel and the residuals obtained from each regression capture the relative stance of monetary policy for each country and they are the Taylor gaps used in the analysis conducted in this paper.

**B – Hodrick-Prescott filtering technique**

We use this approach as an estimating method for computing potential output, used in Taylor’s equation. We have chosen this method because of its advantage of being the most known and commonly used univariate method for estimating potential output and output gap. It is a simple smoothing procedure and it is probably the most popular way of de-trending economic time series in the last recent years.

The potential output (or the trend output) is obtained by minimizing a combination of the gap between actual output ($y$), the trend output ($y^*$) and the rate of change in the trend output for the whole sample of observation, $T$. The equation used by this technique is formulated as follows:

$$\text{Min } \sum_{t=0}^{T}(y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T-1} [(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)]^2$$  \hspace{1cm} (B1)

where $\lambda$ represent the degree of smoothness of the trend. We use the value of 100 for $\lambda$, as proposed by Hodrick and Prescott (1997).

Basically, Hodrick-Prescott filtering technique divide the real GDP growth rate time series into a trend component (the estimate for potential output) and a cycle component (the difference between actual value of output and potential output, or the output gap).

**C – Outlier Labeling Rule (Hoaglin, Iglewicz and Tuckey, 1986; Hoaglin and Iglewicz, 1987)**

We compute the value of the first and the third percentile ($Q_1$ and $Q_3$). The lower bound for the outlier is computed using $Q_1-g*(Q_3-Q_1)$, while the upper bound is computed using $Q_3+g*(Q_3-Q_1)$, where $g$ is the multiplier and it takes the value of 2.2, as proposed by Hoaglin and Iglewicz (1987). The values that are outside these two bounds are considered outliers. We tackle them by using winsorizing method, since trimming would have led to a loss of data, which is a drawback that we want to avoid, taking into account the relative high level of missing data in our sample.