1. THE RISK-TAKING CHANNEL OF MONETARY POLICY: DO MACROPRUDENTIAL REGULATION AND CENTRAL BANK INDEPENDENCE INFLUENCE THE TRANSMISSION OF INTEREST RATES?

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Abstract

This study focuses on the risk-taking channel of monetary policy and its interaction with a supervisory-independence channel for commercial banks from Central and Eastern Europe, during the 2005-2011 period. Our results support the existence of an inverse relationship between expansionary monetary policy and bank risk-taking, meaning that very low interest rates lead to higher bank risk-taking. Also, our results show that the tight macroprudential regulation framework mitigates the negative impact of low rates. Furthermore, we show that central bank independence exerts the same beneficial effect on the bank risk-taking channel because results show a dampening effect of central bank independence on the relation between expansionary monetary policy and bank risk-taking. Moreover, our results demonstrate that the risk-taking channel of monetary policy is even stronger in times of financial crisis.

Keywords: monetary policy, macroprudential regulation, financial crisis, bank risk, central bank independence

JEL Classification: E60, G01, G21, G28

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1. Introduction

The 2008 financial crisis put spotlight on the debate on whether the existence of very low interest rates and of an expansionary monetary environment lie beyond the accumulation of risks at the systemic level, being the key drivers for the outbreak of banking and financial crises. The risk-taking channel is a recently debated monetary policy transmission mechanism through which the monetary policy is transmitted to the banking system and, further on, to the whole economy. Since the seminal paper of Borio and Zhu (2012), who emphasize the theoretical insights regarding the existence of a risk-taking channel of monetary policy, many authors have tried to empirically demonstrate the existence of such a channel and to find an answer to whether this channel was, in part, responsible for the build-up of risks at the level of the banking systems around the world that triggered the outbreak of the 2008 financial crisis.

A prolonged period of very low interest rates may increase the risk-taking and, further on, the risk of a future financial crisis. In this point, macroprudential regulation may tighten its requirements in order to counteract the negative effects of expansionary monetary policy on financial risks.

This paper contributes to the debate on whether and how monetary policy and macroprudential regulation should be coordinated and, also, on whether and how central banks should take into account the financial stability objective and integrate it into the monetary policy framework aimed at achieving the price stability. Also, after the most recent financial crisis, there is one question that stands out and that is of interest for our paper. It is related to the "paradox of low interest rates" and the possibility that especially the very low level of policy rates was the main driver of the financial crisis. Moreover, the macro-regulatory changes that happened in the context of the financial events may have an impact on the transmission mechanism of monetary policy and this impact could be even stronger if we consider that many central banks, especially in emerging and middle-income countries, are also the macroprudential regulators and supervisors.

The objective of this paper is to examine whether macroprudential regulation and central bank independence influence the relation between monetary policy and bank risk-taking. Also, we investigate to what extent these variables mitigate the effect of the risk-taking channel of monetary policy.

Following the argument of Agur and Demertzis (2015), we want to empirically investigate focusing on the commercial banks from Central and Eastern European countries whether the macroprudential regulation dampens the negative effects of low interest rates on bank risk-taking, with or without offsetting the risk-taking channel. Also, considering the evidence which relates the central bank independence with the financial and banking stability (Klomp and de Haan, 2009; Doumpos *et al*., 2015) and given the literature that investigates the central bank transparency as a determinant of the bank risk-taking channel (Papadamou *et al*., 2015; Chen *et al*., 2017), we want to examine to what extent the central bank independence may also be a determinant for this monetary transmission channel.

The motivation that triggered our analysis is related to the fact that central banks around the world have chosen to adopt an expansionary monetary policy in order to sustain the banking system and economic growth. The levels of interest rates around the world is very low, in some countries interest rates hit the zero-lower bound and in other countries have recorded even negative values. Very low interest rates were used by central banks as an instrument to "save things" after the financial crisis, as a rescue measure. We believe that this extended

period of very low interest rates may be seen as an unconventional monetary policy used by central banks in the aftermath of the crisis. However, there are many papers and an extended literature which argue that especially this very low level of interest rates was the key driver behind the financial crisis, the main force that triggered it.

Our concern is whether the negative effects of low interest rates on bank risk-taking are influenced by the macro-regulatory changes or by the degree to which a central bank is more or less independent. Doumpos *et al*. (2015) argue that the influence of central bank independence and financial supervision structure on bank soundness represents a supervisory-independence channel. Taking this into account, we may say that our paper discusses the interaction between the risk-taking channel of monetary policy and this supervisory-independence channel. Moreover, as Agenor and Pereira da Silva (2014) reveal, a better understanding of the effects of macroprudential policy can be achieved through a better understanding of the monetary transmission mechanism. Also, they argue that macroprudential policy may influence the transmission of the monetary decisions. Our research question is important to policymakers because it might be helpful for them to know the determinants of monetary policy transmission, in order to design the most appropriate instruments for their policy goals and objectives.

Our paper is related to some recently debated topics in the literature after the 2008 financial crisis. The literature related to the risk-taking channel of monetary policy is still scarce (Borio and Zhu, 2012; De Moraes *et al*., 2016) and we believe that it deserves more attention, especially in the light of the most recent financial crisis and all the financial events that were triggered by it. To the best of our knowledge, this paper is the first to empirically examine the role of macroprudential policy and central bank independence in shaping the risk-taking channel of monetary policy.

The motivation of our study is threefold. First, although there more and more papers that analyse the bank risk-taking channel from different perspectives, the majority of these papers analyze the United States (Altunbas et al., 2014, de Moraes et al., 2016, Paligorova and Santos, 2017, Segev, 2020) or the Eurozone (Colletaz et al., 2018, Neuenkirch and Nöckel, 2018, Kabundi and De Simone, 2020). This is why we aim to offer an insight into the way that the risk-taking channel of monetary policy operates in Central and Eastern Europe and how macroprudentiality and central bank independence interferes in its functioning, making a contribution to the literature on the Central and Eastern Europe (Drakos et al., 2016, Brana et al., 2019). Second, being an analysis in the context of the global financial crisis, our study is motivated by the more and more evident need of monetary authorities to take into account the effects of macroprudential regulation on financial stability when designing the monetary policy. In the context of the global financial crisis, the expansionary monetary policy was used as an unconventional tool to support the banking and economic system. There in an increasing literature that prove evidence on the higher levels of bank risk-taking when faced with relaxed monetary policy (Delis and Kouretas, 2011, Borio and Zhu, 2012, Altunbas et al., 2014, Dell'Ariccia et al., 2014, Shehzad and de Haan, 2015, Paligorova and Santos, 2017, Colletaz et al., 2018, Neuenkirch and Nöckel, 2018, Brana et al., 2019, Kabundi and De Simone, 2020). Also, besides the use of expansionary monetary policy as an unconventional tool for mitigate the effects of the crisis, there was implemented a macroprudential regulatory framework that proves to influence the bank risk-taking, as showed in Claessens (2013), Agenor and Pereira da Silva (2014), Agur and Demertzis (2015), Cerutti et al. (2017). Third, the motivation of our study is triggered by the fact that there are many determinants of the relation between monetary policy and bank risk-taking, especially bank-level characteristics, as showed in the related literature, for example Buch

et al. (2014), Drakos et al. (2016). In this context, we want to investigate the potential interaction between the bank risk-taking channel and a supervisory-independence channel, as noted by Doumpos et al. (2015), meaning that central bank independence may shape the influence of monetary policy on bank risk-taking.

As a contribution to the existing literature, firstly we contribute to the study of the determinants of the risk-taking channel of monetary policy, our paper adding insights into the literature that discusses the risk-taking channel of monetary policy. We confirm the existence of a risk-taking channel of monetary policy for the commercial banks in Central and Eastern European countries, while most of the previous studies focus on the Eurozone or the United States. Our results show that very low levels of interest rates (a more relaxed monetary policy) are associated with an increase in bank risk-taking. Second, we relate our paper with the existing debate regarding the interaction effects between monetary policy and macroprudential regulation. Third, we contribute to the existing literature on the effects of central bank independence on financial stability, by analyzing it as a determinant of the bank`s risk-taking channel.

The remainder of the paper is organized as follows: Section 2 summarizes the review of related literature. Section 3 presents the methodology. Section 4 describes the sample and data. Section 5 reports the empirical results. Section 6 concludes.

2. Literature Review

2.1. The Risk-taking Channel of Monetary Policy

In the light of the 2008 financial crisis, the attention of both policymakers and researchers was directed towards the transmission mechanism of monetary policy. Investigating the possible implications of monetary decisions on the financial stability added a new channel to the transmission mechanism, the so-called "risk-taking channel of monetary policy". Borio and Zhu (2012) were the first that theoretically defined the existence of such a channel that refers to the effects of changes in policy rates on the banks' risk-taking incentives. In the context of the theoretical background for the risk-taking channel, Dell'Ariccia and Marquez (2006) and Rajan (2006) argue that, when faced with very low levels of interest rates, banks may engage in high-risk, but high-profit activities, demonstrating the "search-for-yield" effect of low policy rates. Far from being fully explored and understood, the transmission of monetary policy through the risk-taking channel has triggered many empirical studies that aim at investigating its existence, functioning and determinants. In the same line of theoretical discussion about the risk-taking channel, Dell'Ariccia *et al*. (2014) argue that changes in policy rates may have an impact on the bank monitoring activity, as a proxy for bank risk-taking, in the sense that low interest rates may lower the bank monitoring and, hence, lead to an increase in bank risk. Furthermore, Dell'Ariccia *et al*. (2014) argue that policy rates, along with their impact on real interest rates, have implications for bank risk-taking and financial stability, supporting the existence of the risk-taking channel as a new component for the transmission channel of monetary policy.

Regarding the existence of a risk-taking channel of monetary policy, there are many authors that empirically investigate it. Analyzing both the Euro area and the United States, Maddaloni and Peydro (2011) show that low interest rates increase bank risk-taking, by lowering their lending standards. In addition to this, Delis and Kouretas (2011) using a sample of banks from Euro area for the period 2001-2008 find that low interest rates increase both the banks' risky assets and non-performing loans. However, the evidence of a risk-taking channel is

stronger for the short-term interest rates than for the long-term rates. Using data for both European Union and United States, Altunbas (2014) finds that the risk-taking channel of monetary policy is even more evident when we account for the prolonged periods of low interest rates. Moreover, Shehzad and de Haan (2015) find that banks that have granted risky loans before the financial crisis, have more non-performing loans after the crisis, in spite of the reduced policy rates. Furthermore, Paligorova and Santos (2017) find strong evidence for the United States in favor of the existence of a risk-taking channel of monetary policy, which implies that low policy rates lead to a reduction in lending standards and, hence, to a higher risk-taking. Similarly, de Moraes *et al*. (2016) discuss the issue of bank loss provisions from a macroprudential perspective, which treats them in the light of the risk-taking channel and show that an expansionary monetary policy improves bank's expectations and, as a result, they decrease the amount of loan loss provisions.

Another strand of papers goes beyond simply investigating the existence of a risk-taking channel of monetary policy and analyze the determinants of this transmission channel, by studying the factors that influence the impact of policy rates on banks' risk-taking behavior. For example, Buch *et al*. (2014) study the interest rates-risk nexus for the United States and their results show that low central bank rates lead to higher risk for the domestic banks, but to lower risk for the foreign-owned banks. Drakos *et al*. (2016) study the asymmetric impact of ownership on the risk-taking channel for a sample of banks from Central and Eastern Europe and, in contrast to Buch *et al*. (2014), they find increased risk-taking behavior for the foreign-owned banks, but weak evidence of this channel for the domestic banks. Moreover, Altunbas *et al*. (2012) investigate the bank characteristics as determinants of the risk-taking channel of monetary policy and find that highly capitalized and highly liquid banks were less affected by the 2008 financial crisis, although the effect is weaker for countries with too-low-for-too-long interest rates.

2.2. Interactions between Monetary and Macroprudential Regulation

The research interest in the area of transmission mechanism of the monetary policy towards bank risk and financial stability is closely linked to the debate regarding the integration of the financial stability objective into the monetary framework. The interaction between monetary policy and macroprudential regulation is a relatively new topic in the literature and its importance became more obvious after the financial crisis. As Agur and Demertzis (2015) argue, the monetary and macroprudential policy interact and low interest rates lead to more bank risk-taking and less financial stability. Furthermore, Ioannidou (2005) shows that there is an inverse relation between the monetary policy behavior and the supervisory behavior, which means that contractionary monetary policy is associated with less tight bank supervision. These results do not support Goodhart and Schoenmaker (1993) hypothesis that central bank may increase its intervention as a bank supervisor in order to support the monetary policy and its objectives. Furthermore, Jonsson and Kevin (2014) show that the impact of coordinating monetary and macroprudential policy depends on whether there is a demand or a supply shock that lead to fluctuations.

Claessens (2013) notes that the interactions between monetary and macroprudential policies arise when each policy may influence the final objective of the other policy and argues that it is important to analyze these measures, especially related to the unconventional monetary policy adopted after the financial crisis in major countries and the associated risk-taking that can be pursued in small economies. Similarly to Ueda and Valencia (2012), Claessens (2013) is in favour of the central bank having both the role of monetary authority and macroprudential policymaker and supervisor and argue that in the

case of some dysfunctionalities, monetary policy should compensate the macroprudential regulation and vice versa.

Beau *et al*. (2012) argue the existence of complementary effects between monetary policy and macroprudential regulation, since the latter could capture and deal with the financial imbalances that may appear in the monetary transmission to the real sector. Angelini *et al*. (2012) discuss the potential complementarities between monetary policy and macroprudential regulation and suggest that there are more beneficial interaction effects than possible conflicts and that the macroprudential policy should cooperate with other policies, especially with the monetary policy in order to limit risks and the possibility of future financial crisis. Also, IMF (2012) supports the idea of complementary, rather than conflictual, effects of the interaction between monetary and macroprudential policy and argues that tighter capital requirements do not influence the bank profitability and this, usually, diminishes the bank risk-taking. Agenor and Pereira da Silva (2014) using a theoretical model on the interaction between monetary and macroprudential policies argue that the use of tight macroprudential regulation to restrain banks from taking excessive risks is the only possibility for the middle-income countries when monetary policy is too expansionary and it cannot become contractionary.

Angelini *et al*. (2014) and Du and Miles (2014) also support the idea of using monetary policy and macroprudential regulation as complementing tools in times of financial shocks and argue that the interaction of these two policies could be beneficial for the banks' lending behavior. Agur and Demertzis (2015) study the interdependencies between monetary and macroprudential policy by taking into account the bank risk-taking channel and demonstrate that, theoretically, an increase in capital requirements lead to a decrease in the bank risk-taking, while an increase in bank leverage lead to a further increase in bank risk-taking. Contrary, Aiyar *et al*. (2014) analyze the possible interaction effects between monetary policy and macroprudential regulation in the United Kingdom and their results are against the existence of such an interaction.

2.3. Central Bank Independence and Its Impact on Financial Stability

Turning to the discussion on the determinants of bank risk-taking, our paper aims at filling a gap in the literature and analyzes the impact of central bank independence on the bank risk-taking channel. To the best of our knowledge, there is no paper to analyze the central bank independence as a determinant of the bank risk-taking channel. The majority of the papers in the literature on central bank independence analyze its effects on inflation and price stability[3].

With respect to the possible influence of central bank independence on bank risk-taking and financial stability, Klomp and de Haan (2009) results support the idea that greater CBI means less financial instability. Authors argue that greater independency means that a central bank can inform the financial sector if there is any problem and could ask financial institutions to take actions in order to solve that problem. Similarly, Doumpos *et al*. (2015) show that central bank independence is positively related to bank stability and, in case of smaller banks, this effect is amplified by the crisis.

[3] Crowe and Meade (2008) emphasize the beneficial role of increased CBI in achieving the price stability objective of a central bank. See Cuckierman (2008) and de Hann and Eijffinger (2016) for an up-to-date survey literature about the central bank independence.

Another strand of papers analyze the involvement of central banks in macro-supervision and whether it would be optimal for a central bank to have both the monetary authority and the macroprudential supervisor role. Masciandro and Volpicella (2015) discuss the extent to which central banks should involve in macroprudential responsibilities. As the authors note, there are some advantages derived from the role of central banks as macro supervisors, especially related to the increased amount of information that central banks could have at their dispossals when making policy decisions. However, the authors suggest that assigning monetary authority as macroprudential autority could have some potential disadvantages, because central banks could become overly powerful. Also, another potential disadvantage is related to the fact that having two policy objectives, central banks couls use the wrong instruments for addressing each goal. Their results show that higher central bank independence is inversely related to the involvement in macrosupervision.

3. Data and Methodology

3.1. Dataset and Variables

We conduct a micro-level analysis in order to capture the effects of monetary policy in interaction with macroprudential regulation and central bank independence on bank risk-taking. We construct our sample by taking into account the sampling methodology developed in Andrieș and Brown (2017) and Andrieș *et al*. (2016). Our sample consists of active commercial banks from 14 countries of Central and Eastern Europe[4]. We conduct our analysis on a time-period of 7 years, from 2005 to 2011. When we construct our sample, we take into account limitations related to the availability of macroprudential regulation and central bank independence data. Also, we choose to focus on this time period because the aim of our paper is to investigate the role of macroprudentiality and central bank independence in the transmission of low interest rates in the context of the financial crisis. This is the reason why we select a time period that emphasizes the period before crisis, the crisis period, but also the after-crisis period. Finally, our sample has 132 listed and unlisted banks with a total of 924 bank-year observations. As far as our analysis is concerned, we do not take into account whether a bank is or not listed because we use only accounting information available on Bankscope database in order to compute our variables. Also, our main dependent variable, Z-score, has the advantage of not being influenced by whether the banks are listed or not (Lepetit and Strobel, 2013). This is the reason why we use a mixt sample that consists of 40 listed banks, while the others 92 banks are unlisted to the market.

The data used for the bank-level variables is taken from Bankscope database, while for the macroeconomic variables we used information available in the IMF Database. Also, data for constructing the macro-prudential policy is taken from the database published in Vandenbussche et al. (2015). Moreover, data for bank regulation is taken from Barth et al. (2013), while for central bank independence we use the data available in Bodea and Hicks (2014).

When discussing about the bank risk-taking there are different views in the literature. As Borio and Zhu (2012) and de Moraes *et al*. (2016) argue, there is an expectational component in the level of bank risk-taking, which makes its measurement to be seen from a behavioral perspective. Common practice in the related literature is to proxy it by using the

[4] *Albania, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Serbia, Slovakia, Slovenia, and Ukraine.*

bank Z-score or the shares of non-performing loans and loan loss provisions (or reserves). However, there are other authors, such as Dell'Ariccia *et al.* (2014), who use bank monitoring as a measure that is inversely related to bank risk-taking. All these variables capture the bank behavior when engaging in risky or less risky activities, depending on their business objectives.

We investigate our hypotheses using three alternative dependent variables, which are largely used in the related literature analyzing the bank risk-taking. As Lepetit and Strobel (2013) note, this measure is extensively used in the literature that analyses bank risk or even financial stability, having the main advantage of being easy to calculate based on accounting information only. We compute or Z-score by taking into account the following formula:

$$Z - score = \frac{Return - on - assets\ (ROA) + Capital - Asset\ ratio(CAR)}{Standard\ deviation\ of\ ROA}$$

When calculating the standard deviation of ROA we take into account a 3-years rolling window. Besides being largely used in the related literature, Z-score is appropriate to use in our analysis because our sample consists of both listed and unlisted banks and this proxy does not require market-based information in order to be computed. In spite of its drawback of assuming the ROA is normally distributed, as showed in Lapteacru (2016), there are a number of studies that support the effectiveness of Z-score in predicting the bank distress and, also, the bank risk-taking (Lepetit and Strobel, 2015, Chiaramonte, Croci and Poli, 2015, Mare, Moreira and Rossi, 2016, Boungou, 2020). Furthermore, as Brana, Campmas and Lapteacru (2019) point out, in comparison with the share of loan loss provisions or the share of non-performing loans, Z-score has the advantage of being a risk-based measure.

We include in our analysis the natural logarithm of Z-score, as was previously used in Demirgüç-Kunt *et al*. (2008), Laeven and Levine (2009) and Doumpos *et al*. (2015). Higher levels of bank *Z-score* means better bank stability and soundness and lower risk-taking (Borio and Zhu, 2012). To this point forward, we use *Z-score* to refer to the ln (1+Z-score) included in the analysis. Also, we use *the ratio of non-performing loans* (*NPL*) and *the ratio of loan-loss provisions* (*LLP*) as alternative proxies for bank risk-taking. The bank risk-taking is positively associated with the levels of non-performing loans and loan loss provisions, because more non-performing loans is a signal that the bank has increased levels of credit risk.

Our main independent variable is the monetary policy. We proxy the stance of monetary policy by using two alternative variables: *Taylor gap* and *Real short-term interest rate*. We estimate a Taylor rule for the money market interest rates existing in the 2005-2011 period in the 14 countries from our sample. We argue that the monetary policy stance is given by the *Taylor gap*, namely the gap between the actual nominal interest rates and the optimal rate estimated through the Taylor rule. In order to obtain the values for the Taylor gaps we apply to our database three steps. First, we compute the potential GDP by using the Hoddrick-Prescott filtering technique on the actual GDP series for each country in the sample. This technique splits the series into two components: the trend component and the cyclic component. The values obtained for the trend component are the values associated with the potential GDP[5]. The second step is to estimate an OLS technique on the following equation:

[5] *Estimating output gap using the Hodrick-Prescott filtering technique is also used in de Moraes et al. (2016).*

$$ir_t = \alpha + \beta_1(Inflation_t - Inflation^*) + \beta_2(GDP\ growth - potential\ GDP)$$

In our equation, the target inflation is *Inflation** = 2% and $\beta_1 = \beta_2 = 0.5$ which means that we use a Taylor rule with equal weights on output and inflation. The third step is to save the residuals from the above-estimated equation, and they represent the values of the *Taylor gap* (*MonPol*). As Maddaloni and Peydro (2011) argue, negative values of the *Taylor gap* are associated with very low interest rates. The second alternative proxy for the monetary policy stance is *the Real short-term interest rate* (*Real STIR*). *Real STIR* is measured as the difference between the nominal short-term interest rate and the inflation rate.

To investigate the influence of macroprudential policy on the risk-taking channel of monetary policy, similarly to Andrieș *et al*. (2016), we use the *Macroprudential index* (*MaPP index)*. *Macroprudential index* is a cumulative index that captures the strength of the macroprudential regulation and comprises information on the following five components: capital and risk-weights measures, provisioning measures, liquidity measures, eligibility measures and whether the country is part of Basel III or not. The data for its construction is taken from the Vandenbussche *et al*. (2016) database. We interpret an increase in the *MaPP index* as a tightening of macroprudential regulation, while a decrease in the index is interpreted as a loosening of macroprudential policy. More details regarding the compositions and construction of the *MaPP index* can be found in Appendix 1.

Moreover, we construct another index, *Bank Regulation*, which is a composite index of bank regulation computed using data from Barth *et al*. (2013) database. To construct our index, we take into account the following indices developed by Barth *et al*. (2013) using the answers to the Bank Regulation and Supervision Survey, conducted by the World Bank: overall restrictions on bank activities (answer ranges from 4 to 16), capital regulation index (answer ranges from 0 to 10), official supervisory power (answer ranges from 0 to 15), independence of supervisory authority – overall, private monitoring index (answer ranges from 0 to 12) and external governance index (answer ranges from 0 to 19). We normalize each of these six components, by dividing each value to the maximum value of each component. In the end, we take the average and the final *Bank Regulation index* ranges from 0 to 1, with a maximum value of 1 indicating tight bank regulation.

To capture the effect of macroprudential regulation on the bank risk-taking channel, we include in our analysis the following two dummy variables: *Tight Macroprudential regulation* (*D_MaPP)* which takes the value of 1 for over-the-median levels of *MaPP index* (and 0 otherwise) and *Tight regulation* (*D_Regulation)* which takes the value of 1 for over the median levels of *Bank Regulation index* (and 0 otherwise).

Moreover, to investigate the influence of central bank independence on the risk-taking channel of monetary policy, we use two alternative indicators. The first index is the *Central Bank Independence index* (*CBI index)* constructed by Bodea and Hicks (2014) based on the index developed by Cukierman *et al*. (1992). The second variable used to proxy the central bank independence is the *Independence of Supervisory Authority (D_ISA)* developed by Barth *et al*. (2013). *Independence of Supervisory Authority index* is a dummy variable that captures the answer to the following question: "Can individual supervisory staff be held personally liable for damages to a bank caused by their actions or omissions committed in the good faith exercise of their duties?".

To capture the effect of central bank independence on the risk-taking channel we use the following two dummy variables: *Higher CB independence (D_CBI)* which takes the value of 1 for over the median levels of the CBI index and *Independence of Supervisory Authority*

*(*D_ISA) which takes the value of 1 if the answer to the related question is affirmative and 0 otherwise.

Furthermore, to investigate the influence of the financial crisis on the risk-taking channel of monetary policy, similarly to Doumpos *et al*. (2015) we construct a dummy variable, *Crisis* (*D_CRISIS*), which takes the value of 1 for countries and time periods which are associated with a systemic banking crisis, as defined by Laeven and Valencia (2012).

The risk-taking channel of monetary policy is analyzed in the related literature using two categories of control variables: bank-level controls and macroeconomic controls (Delis and Kouretas, 2011; Drakos *et al*., 2016; Chen *et al*., 2017). As for bank characteristics, we include in our study *the bank capitalization (CAP), the share of liquid assets to total assets (LIQUID), the share of non-interest income (NNINC), the share of non-deposit funding (NODEP)* and *the bank size (SIZE)*. Also, to control for macroeconomic determinants, we include in our analysis the *five-bank concentration ratio (CONC), the level of banking intermediation (FINTERM)* and *the economic growth (EC_GROWTH)*. All macro-level variables are lagged by one year. We report in Appendix 2 further details regarding the definition of the variables included in the analysis.

The data used for the bank-level variables is taken from Bankscope database, while for the macroeconomic variables we used information available in the IMF database. Also, data for constructing the macroprudential policy is taken from the database published in Vandenbussche *et al.* (2015). Moreover, data for bank regulation is taken from Barth *et al*. (2013), while for central bank independence we use the data available in Bodea and Hicks (2014).

Table 1

Descriptive Statistics

Variable	Description	Mean	Median	Max	Min	Std. dev.	Obs.
Z-score	Bank Z-Score	3.91	3.84	12.54	-0.65	2.20	646
NPL	Non-performing loans	1.63	1.75	4.08	-2.12	1.20	681
LLP	Loan Loss Provisions	1.95	0.94	19.08	-1.04	2.98	881
MonPol	Taylor gap	0.63	0.64	8.72	-7.84	3.14	826
Real STIR	Real Short-term Interest Rate	-0.79	-0.48	6.96	-11.52	3.63	826
MaPP	Macroprudential Index	0.24	0.23	0.47	0.06	0.12	792
CBI	Central Bank Independence	0.82	0.81	0.89	0.71	0.06	679
Regulation	Bank Regulation	0.79	0.80	1.00	0.56	0.11	830
CAP	Capitalization	11.28	10.01	55.29	-6.73	6.03	911
LIQUID	Liquidity	0.22	0.19	0.73	0.02	0.14	911
NNINC	Non-interest income	0.36	0.35	0.89	-0.07	0.16	911
NODEP	Non-deposit funding share	0.33	0.30	0.92	0.02	0.22	911
SIZE	Bank size	14.65	14.72	17.37	10.62	1.38	911
CONC	Concentration	59.39	58.28	99.64	26.16	16.07	924
INTERM	Bank intermediation	2.82	4.00	12.23	-17.95	5.54	924
EC_GROWTH	Economic growth	56.54	53.01	105.08	14.78	20.53	894

Source: Own computations.

Descriptive statistics of our data, reported in Table 1, show that the *macroprudential index* has a mean of 0.24, with a maximum of 0.47 and a minimum of 0.06, while the monetary policy stance proxied through the *Taylor Gap* has a mean of 0.63, with a maximum of 8.72 and a minimum of -7.84.

Table 2

Correlation Matrix

	ZSCORE	NPL	LLP	MonPol	Real STIR	MaPP	CBI
ZSCORE	1.00	-0.42	-0.61	0.03	0.11	0.02	-0.15
NPL	-0.42	1.00	0.54	0.16	0.10	0.09	0.08
LLP	-0.61	0.54	1.00	0.10	-0.05	-0.02	-0.02
MonPol	0.03	0.16	0.10	1.00	0.95	0.24	0.27
Real STIR	0.11	0.10	-0.05	0.95	1.00	0.21	0.31
MaPP	0.02	0.09	-0.02	0.24	0.21	1.00	0.25
CBI	-0.15	0.08	-0.02	0.27	0.31	0.25	1.00

Source: Own computations.

The correlation matrix reported in Table 2 shows a positive correlation between the monetary policy stance and all the three dependent variables. However, in the regression analysis, when we control for different determinants of bank risk-taking, we expect to obtain a positive impact of monetary policy on bank risk and a negative impact on non-performing loans and loan-loss provisions. Turning to Table 2, the correlation is positive between the macroprudential index MaPP and the variable that captures the bank stability (Z-score) and the share of non-performing loans (NPL), but it is negative between the macroprudential regulation and loan loss provisions (LLP).

3.2. The Empirical Setup

We analyze our research question using the risk-taking channel framework. This means that we use the basic model that it is used in the literature in order to capture the effects of low interest rates on bank risk-taking. In order to investigate our hypotheses, we use the following equation:

$$BRT_{t,i,j} = \alpha + \gamma * BRT_{t-1,i,j} + \beta_1 * MonPol_{t-1,j} + \delta_1 * MonPol_{t-1,j} * Dummy_{t-1,j} + \beta_3 * Bk\_ctrl_{t,i,j} + \beta_4 * Ec\_ctrl_{t-1,j} + \varepsilon_{i,j,t} \quad (2)$$

In equation (2) $BRT_{t,i,j}$ is the variable that capture the bank risk and stability for each bank i, in country j, at time t. MonPol is a vector of the two variables that capture the monetary policy stance (Taylor Gap and Real short-term interest rate), while Dummy is a vector of the five variables used to capture the determinants of the bank risk-taking channel (D_MaPP, D_Regulation, D_CBI, D_ISA, D_CRISIS). Moreover, $Bk\_ctrl_{t,i,j}$ is a vector of bank-specific controls, while $Ec\_ctrl_{t-1,j}$ is a vector of macroeconomic controls. β_1 $\delta_1$is the coefficient of our interest and it captures the interaction effect between the two types of policies, more precisely, it captures the additional effect of macroprudential regulation in a low interest rates environment. In order to interpret the cumulative effect of macroprudential regulation in a low interest environment we interpret the sum of coefficients β_1+δ_1.

First, we investigate the existence of a risk-taking channel of monetary policy for the banks in the CEE countries, by considering that δ_1 = 0 in our model. This means that we focus on the coefficient β_1 which captures the impact of very low interest rates on bank risk-taking. In

this first step, we investigate the first research hypothesis. Second, we focus on the role of macroprudential policy and central bank independence in shaping the risk-taking channel of monetary policy. In this sense, δ_1 is the coefficient of our interest and it captures the interaction effect between the monetary policy and macroprudential regulation, monetary policy and central bank independence, monetary policy and the crisis, alternatively. In other words, we consider that δ_1 captures the amplification or dampening effect of macroprudential regulation and central bank independence on the risk-taking channel of monetary policy. In this second step, we investigate the second and third research hypotheses.

Third, we conduct an in-depth analysis with the aim of investigating whether the role of macroprudential regulation and central bank independence in shaping the risk-taking channel of monetary policy is different depending on bank size, capitalization and ownership. To do so, we split the sample into two sub-samples by taking into account the median level of each variable. For example, to investigate whether the relation is different for large or small banks, we split the sample according to the above-the-median level of bank size and the over-the-median level of it.

We analyze our model using the General Method of Moments estimation method, because it accounts for the endogeneity of monetary policy and some bank-level controls and it also accounts for the dynamic nature of bank risk. This estimation method is frequently used in the literature regarding the risk-taking channel (Delis and Kouretas, 2011; Chen *et al.*, 2017).

4. Results

4.1. Base Results

In this section, we discuss the results obtained for our analysis. Our results are in line with the existing literature that analyzes the nexus between low interest rates and bank risk-taking, although the majority of these papers analyze the United States or the Eurozone. This is one of the main contribution of our paper since we study the risk-taking channel of monetary policy for Central and Eastern Europe and contribute to the existing studies on this area (Drakos et al., 2016, Brana et al., 2019).

Table 3 reports the results for our baseline estimation. Essentially, they point to a negative relation between the monetary policy and bank risk-taking. When we evaluate the impact of a low interest rates environment on the bank stability, we observe that both the Taylor residuals (MonPol) and the real interest rates (Real STIR) have positive and statistically significant coefficients (see columns 1 and 4). This means that low interest rates lead to lower bank stability and, hence, to a higher bank risk-taking. Our results are consistent with prior works, such as Drakos *et al*. (2016) and Chen *et al*. (2017). Moreover, with respect to the impact of an expansionary monetary policy on bank risk-taking measured through the shares of non-performing loans and loan loss provisions, our results show a negative and statistically significant relation for both the Taylor residuals and real short-term interest rates. This demonstrates that a reduction in interest rates is associated with more non-performing loans (as a share of total loans) and higher loan loss provisions (as a share of total loans). From this point of view, our results are in line with Agoraki *et al*. (2011), Shehzad and de Haan (2015) and Chen *et al*. (2017).

Table 3

The Relation between Monetary Policy and Bank Risk-taking

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Dependent	0.206*	0.541*	0.374*	0.224*	0.555*	0.371*
	(0.07)	(0.01)	(0.01)	(0.07)	(0.01)	(0.01)
Taylor gap	**0.109***	**-0.069***	**-0.440***			
	(0.03)	**(0.00)**	**(0.02)**			
Real STIR				**0.089***	**-0.060***	**-0.465***
				(0.02)	**(0.00)**	**(0.02)**
Capitalization	-0.025	0.026*	-0.190*	-0.019	0.026*	-0.182*
	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)	(0.01)
Liquidity	-3.514**	-0.146	4.937*	-2.902**	-0.175	4.274*
	(1.49)	(0.13)	(0.69)	(1.41)	(0.14)	(0.59)
Non-interest income	3.220*	1.200*	3.117*	3.240*	1.072*	2.527*
	(1.18)	(0.15)	(0.12)	(1.13)	(0.14)	(0.16)
Non-deposits funding	-1.496	0.044	0.530	-1.141	-0.212**	-0.479
	(1.12)	(0.09)	(0.39)	(1.09)	(0.09)	(0.38)
Size	0.923***	-0.422*	-3.643*	0.842***	-0.268*	-2.472*
	(0.50)	(0.06)	(0.23)	(0.48)	(0.06)	(0.24)
Concentration	-0.186*	0.024*	0.241*	-0.166*	0.017*	0.189*
	(0.03)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Bank intermediation	-0.097*	0.049*	0.201*	-0.083*	0.045*	0.164*
	(0.02)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Economic growth	0.009	-0.005*	0.001	0.002	0.000	0.006
	(0.02)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
AR(1) p-value	0.01	0.00	0.00	0.00	0.00	0.00
AR(2) p-value	0.03	0.21	0.19	0.03	0.23	0.35
Hansen Test (p-value)	0.32	0.39	0.08	0.34	0.38	0.11
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	323	365	528	323	365	528
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculation. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

In other words, the results reported in Table 3 support the existence of a risk-taking channel of monetary policy for the 14 countries in Central and Eastern Europe over the 2005-2011 period. These results are in line with the majority of the literature discussing the risk-taking channel of monetary policy, such as Ioannidou *et al*. (2014). Also, the results are in line with most recent studies regarding the evidence of bank risk-taking channel, as the study of Segev (2020) who demonstrates the existence of such a channel for the Unites States by using loan-level data, or the study of Neuenkirch and Nöckel (2018) who provide evidence on the negative relation between low interest rates and bank risk-taking for the Eurozone. Controlling for bank characteristics, we observe that bank size is positively associated with bank Z-score, but negatively associated with non-performing loans and loan loss provisions. This result is in line with Agoraki et al. (2011) and Delis and Kouretas (2011) and it means that bigger banks exhibit lower levels of bank risk-taking, since they can benefit from better risk management schemes. Moreover, our results are in line with the more recent research of Colletaz et al. (2018) who show that the risk-taking channel of monetary policy is important

to the systemic level also because an extended period of expansionary monetary policy may contribute to increasing the systemic risk. This argument is also supported by the results of Kabundi and De Simone (2020).

Moreover, the positive coefficient of non-interest income in all columns of Table 3 shows that banks with higher income diversification are more stable, but they also have more non-performing loans and loan loss provisions; hence, higher bank risk-taking. Furthermore, banks that are located in countries with a high concentrated and well-developed banking system exhibit higher bank risk-taking. The argument is supported by the negative coefficients of both concentration and financial development in the relation with Z-score and the positive coefficients of these variables in the relation with non-performing loans and loan loss provisions. Turning to the strand of literature that examines the role of competition and concentration in the transmission of monetary policy, our results confirms the views expressed in Dell'Ariccia *et al*. (2014), Brissimis *et al*. (2014), Jimenez *et al*. (2014).

4.2. The Risk-taking Channel: Crisis and Non-crisis Period

In this section, we present the results of the analysis that captures the impact of financial crisis on the risk-taking channel of monetary policy for the countries included in our analysis. We report these results in Table 4. We observe that a systemic crisis amplifies the effect of low interest rates on the bank risk-taking. The positive coefficient of the interaction term in column 1 shows that, in times of crisis, an expansionary monetary policy leads to higher bank risk-taking (more non-performing loans and more loan loss provisions).

Table 4

The Impact of Crisis on the Risk-taking Channel of Monetary Policy

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Dependent	0.256*	0.522*	0.446*	0.232*	0.554*	0.427*
	(0.07)	(0.01)	(0.01)	(0.06)	(0.01)	(0.01)
Taylor gap	**0.042**	**-0.030***	**-0.136***			
	(0.04)	**(0.00)**	**(0.02)**			
Taylor gap *Crisis	**0.133***	**-0.077***	**-0.832***			
	(0.05)	**(0.00)**	**(0.03)**			
Real STIR				**0.061*****	**-0.038***	**-0.194***
				(0.04)	**(0.00)**	**(0.01)**
Real STIR*Crisis				**0.044**	**-0.034***	**-0.523***
				(0.04)	**(0.00)**	**(0.02)**
Capitalization	-0.008	0.025*	-0.228*	-0.012	0.026*	-0.206*
	(0.02)	(0.00)	(0.01)	(0.03)	(0.00)	(0.01)
Liquidity	-1.606	-0.513*	3.106*	-2.268	-0.534	0.403
	(1.63)	(0.11)	(0.69)	(1.50)	(0.12)	(0.61)
Non-interest income	3.877*	1.117*	1.960*	3.463*	1.048	1.859*
	(1.25)	(0.12)	(0.15)	(1.19)	(0.14)	(0.12)
Non-deposits funding	-1.766	0.139	1.951*	-1.182	-0.145	-0.261
	(1.09)	(0.10)	(0.33)	(1.09)	(0.10)	(0.36)
Size	1.026***	-0.459*	-3.523*	0.906***	-0.283***	-2.489*
	(0.58)	(0.05)	(0.22)	(0.52)	(0.06)	(0.19)
Concentration	-0.171*	0.014*	0.186*	-0.158*	0.014*	0.142*
	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)	(0.01)
Bank intermediation	-0.085*	0.047*	0.161*	-0.076*	0.042*	0.119*
	(0.02)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
	(1)	(2)	(3)	(4)	(5)	(6)
Economic growth	0.006	-0.005*	-0.015**	0.000	0.002*	0.033*
	(0.02)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
AR(1) p-value	0.00	0.00	0.00	0.01	0.00	0.00
AR(2) p-value	0.05	0.23	0.98	0.01	0.18	0.29
Hansen Test (p-value)	0.42	0.27	0.16	0.34	0.30	0.10
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	323	365	528	323	365	528
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculation. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

This result holds for both Taylor residuals and real short-term interest rates, as proxies for the monetary policy stance. As discussed in Chen *et al*. (2017), periods of financial and banking crisis may result in higher risk-taking and our results are in line with this argument. Also, our results are in line with papers that show evidence of worsening risk-taking levels after the outbreak of the financial crisis, for countries that experience "too long" periods of expansionary monetary policy before 2008 (Dell'Ariccia and Marquez, 2006; Maddaloni and Peydro, 2010). However, this result is in contrast with Agur and Demertzis (2015), who argue that lowering interest rates in times of crisis may reduce the risk-taking incentives.

4.3. The Interaction between Monetary Policy and Macro Prudential Regulation

In this sub-section, we investigate to which extent the tightening of macroprudential policy amplifies or dampens the risk-taking channel of monetary policy. Essentially, the results reported in Table 5 are in favor of a dampening effect of tighter macroprudential policy in the relation between low interest rates and bank risk-taking.

To be more accurate, the negative and statistically significant coefficient of the interaction term in columns 1 and 4 of Table 5 shows that low interest in a tight macroprudential framework leads to higher bank stability and, hence, to lower bank risk-taking. Furthermore, the positive and statistically significant coefficients in columns 2, 3, 5, and 6 of Table 5 show that an eased stance for the monetary policy under a tight macroprudential regulation lowers both the share of non-performing loans and the share of loan loss provisions, pointing to lower bank risk-taking. However, when considering the cumulative effect of low interest rates on bank risk-taking, we observe that tighter macroprudential regulation helps at diminishing the negative impact of low interest rates on bank risk-taking, but it does not offset it.

These results are in line with Agur and Demertzis (2015) regarding their argument on the interaction between monetary and macroprudential policies, showing that macro-regulation does not fully "neutralize" the risk-taking channel of monetary policy. Also, our results confirm the ones discussed in Cerutti *et al*. (2017) with respect to the ability of macroprudential regulation to overcome the financial crises.

Moreover, our results are in line with the empirical evidence that supports complementing, rather than contrasting effects of the interaction between monetary policy and macroprudential regulation (Beau *et al*., 2012; IMF, 2013; Angelini *et al*., 2012; Angelini *et al*., 2014; Agur and Demertzis, 2015).

Table 5

The Impact of Tight Macroprudential Regulation on the Risk-taking Channel of Monetary Policy

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Dependent	0.291*	0.586*	0.336*	0.313*	0.604*	0.351*
	(0.08)	(0.01)	(0.01)	(0.08)	(0.01)	(0.01)
Taylor gap	**0.273***	**-0.113***	**-1.005***			
	(0.07)	**(0.01)**	**(0.05)**			
Taylor gap * Tight Macroprudential regulation	**-0.210***	**0.060***	**0.766***			
	(0.07)	**(0.01)**	**(0.05)**			
Real STIR				**0.176***	**-0.097***	**-0.787****
				(0.04)	**(0.01)**	**(0.03)**
Real STIR* Tight Macroprudential regulation				**-0.121***	**0.048***	**0.522****
				(0.05)	**(0.01)**	**(0.03)**
Capitalization	-0.039	0.029*	-0.102*	-0.033	0.030*	-0.113*
	(0.03)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Liquidity	-3.958*	0.027	6.605*	-3.412**	-0.112	5.317
	(1.49)	(0.14)	(0.81)	(1.48)	(0.13)	(0.66)
Non-interest income	2.960*	1.124*	4.180*	2.990*	1.001	3.431
	(1.18)	(0.16)	(0.23)	(1.11)	(0.16)	(0.20)
Non-deposits funding	-1.269	-0.059	-1.523*	-0.621	-0.267	-2.991
	(1.16)	(0.12)	(0.42)	(1.15)	(0.14)	(0.47)
Size	0.613	-0.238*	-1.342*	0.408	-0.054***	-0.327
	(0.55)	(0.05)	(0.23)	(0.56)	(0.07)	(0.23)
Concentration	-0.188*	0.033*	0.267*	-0.164*	0.023*	0.189*
	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)	(0.01)
Bank intermediation	-0.087*	0.046*	0.170*	-0.075*	0.039*	0.130*
	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)	(0.01)
Economic growth	0.015	-0.004***	-0.038*	0.006	-0.001*	-0.021*
	(0.02)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
AR(1) p-value	0.00	0.00	0.00	0.00	0.00	0.00
AR(2) p-value	0.15	0.46	0.92	0.05	0.24	0.49
Hansen Test (p-value)	0.37	0.39	0.10	0.37	0.30	0.08
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	323	365	528	323	365	528
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculation. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

However, different from the mentioned literature, our results represent a contribution to the empirical evidence of beneficial effects of this interaction on the banks' risk-taking. All in all, the results reported in Table 5 confirm our second hypothesis, implying that the macroprudential regulation dampens the risk-taking channel of monetary policy by reducing the negative impact of low interest rates on banks' risk incentives.

4.4. The Role of Central Bank Independence in Shaping the Risk-taking Channel

When we evaluate the role of central bank independence in influencing the risk-taking channel of monetary policy, we confirm our hypothesis that CBI has a beneficial impact on the relation between monetary policy and bank risk-taking.

Table 6

The Impact of Central Bank Independence on the Risk-taking Channel of Monetary Policy

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Dependent	0.371*	0.548*	-0.159*	0.349*	0.564*	-0.134*
	(0.06)	(0.01)	(0.02)	(0.06)	(0.01)	(0.01)
Taylor gap	**0.237***	**-0.074***	**-0.745***			
	(0.05)	**(0.00)**	**(0.03)**			
Taylor gap * Higher CBI	**-0.276***	**0.024***	**0.384***			
	(0.05)	**(0.00)**	**(0.06)**			
Real STIR				**0.155***	**-0.051***	**-0.663***
				(0.02)	**(0.00)**	**(0.02)**
Real STIR* Higher CBI				**-0.168***	**0.005**	**0.316***
				(0.04)	**(0.00)**	**(0.03)**
Capitalization	-0.104*	0.016*	-0.296*	-0.088*	0.017*	-0.253*
	(0.04)	(0.00)	(0.03)	(0.02)	(0.00)	(0.01)
Liquidity	-6.582*	-1.060*	-0.468	-6.110*	-1.144*	-0.936***
	(1.59)	(0.15)	(1.01)	(1.07)	(0.16)	(0.54)
Non-interest income	3.617*	0.819*	-0.548	3.018*	0.787*	-1.225**
	(1.28)	(0.12)	(0.64)	(1.04)	(0.10)	(0.54)
Non-deposits funding	-2.074***	-0.182**	-0.717**	-0.755	-0.317*	-2.624*
	(1.18)	(0.07)	(0.31)	(1.04)	(0.07)	(0.21)
Size	-0.331	-0.481*	-2.053*	-0.351	-0.424*	-0.695*
	(0.66)	(0.04)	(0.38)	(0.43)	(0.05)	(0.24)
Concentration	-0.163*	0.026*	0.072*	-0.138*	0.022*	0.036*
	(0.02)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Bank intermediation	-0.090*	0.043*	0.145*	-0.050**	0.040*	0.108*
	(0.03)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Economic growth	0.019	-0.006*	-0.205*	0.016	0.001	-0.159*
	(0.02)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
AR(1) p-value	0.00	0.00	0.00	0.00	0.00	0.00
AR(2) p-value	0.10	0.47	0.02	0.12	0.58	0.05
Hansen Test (p-value)	0.51	0.33	0.24	0.32	0.40	0.12
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	265	332	461	265	332	461
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculations. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

As in case of macroprudential regulation, the results in Table 6 show that higher central bank independence dampens the impact of low interest rates on both bank stability (bank Z-score) and credit risk (NPL and LLP), reducing the risk-taking incentives of banks when confronted with an expansionary stance of monetary policy.

Our results confirm the ones obtained in Fratzcher *et al*. (2016) related to an improvement of bank stability in the presence of strengthen supervisory independence. Also, results are in line with Klomp and de Haan (2009), who showed that higher central bank independence reduces the financial instability. Moreover, our results support the positive impact of central bank independence on bank soundness, as shown in Doumpos *et al*. (2015). As a contribution to the mentioned papers, our study shows the beneficial effect of tighter macroprudential regulation in shaping the risk-taking channel of monetary policy. Turning to our hypotheses, the results reported in Table 6 confirm our third hypothesis that central bank independence dampens the risk-taking channel of monetary policy, by reducing the negative effects of low interest rates on banks' risk incentives.

4.5. Sub-sample Analysis

As explained in the methodology section, we also consider an in-depth analysis to investigate whether there are potential differential effects when discussing the role of macroprudential regulation and central bank independence, as determinants of the risk-taking channel of monetary policy. To do this, we split the sample according to the level of bank capitalization, the bank size and the status of foreign or domestic-owned bank. Our results reported in Table 7 show a statistically significant differential impact only in case of the role of macroprudential regulation in the relation between monetary policy and bank risk-taking for high-capitalized versus low-capitalized banks.

The results reported in Table 7 show that, in case of low-capitalized banks, tighter macroprudential regulation amplifies the risk-taking channel of monetary policy, leading to higher bank risk-taking in the presence of low interest rates. These results are in line with a more recent study of Brana et al. (2019) and Boungou (2020) who show that bank-specific characteristics influence the transmission of interest-rates towards bank risk-taking. However, when evaluating the differential impact of macro-regulation, central bank independence and systemic crisis on the risk-taking channel, the results show that there is no difference among banks according to their size and ownership.

Table 7

The Impact of Bank Capitalization on the Risk-taking Channel of Monetary Policy

	High-capitalized banks			Low-capitalized banks		
Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
Lagged Dependent	0.299*	0.450*	0.341*	0.197*	0.539*	-0.086*
	(0.05)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Taylor gap	**0.152***	**-0.103***	**-0.826***	**0.346***	**-0.055***	**-0.219***
	(0.04)	**(0.01)**	**(0.03)**	**(0.05)**	**(0.01)**	**(0.02)**
Taylor gap * Tight Macroprudential regulation	**-0.065*****	**0.056***	**0.570***	**-0.229***	**-0.015****	**-0.149***
	(0.04)	**(0.01)**	**(0.03)**	**(0.04)**	**(0.01)**	**(0.02)**
Capitalization	-0.035***	0.056*	-0.008	0.426*	-0.011	-0.341*
	(0.02)	(0.01)	(0.01)	(0.04)	(0.01)	(0.01)
Liquidity	-4.179*	-0.863*	5.410*	1.298	-0.449*	-0.712***
	(0.00)	(0.25)	(0.56)	(0.89)	(0.18)	(0.41)
Non-interest income	1.265*	1.334*	4.428*	2.263*	1.363*	0.514**
	(0.01)	(0.14)	(0.18)	(0.54)	(0.17)	(0.26)
Non-deposits funding	-2.218*	-0.713*	-2.431*	-0.704	0.185	-0.146
	(0.00)	(0.27)	(0.18)	(0.45)	(0.37)	(0.24)

	High-capitalized banks			Low-capitalized banks		
Size	0.427	0.245	-0.447*	4.203*	-0.928*	-1.249*
	(0.23)	(0.17)	(0.17)	(0.32)	(0.12)	(0.11)
Concentration	-0.123*	-0.011*	0.224*	-0.061*	-0.008	0.012***
	(0.00)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Bank intermediation	-0.015	0.032*	0.135*	-0.083*	0.052*	0.106*
	(0.30)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
Economic growth	0.059*	-0.023*	-0.022*	0.017*	-0.001	-0.112*
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
AR(1) p-value	0.00	NA	NA	0.27	NA	0.00
AR(2) p-value	0.15	NA	0.97	NA	0.69	0.49
Hansen test (p-value)	0.31	0.36	0.53	0.51	0.54	0.45
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	195	197	288	128	165	240
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculations. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

4.6. Robustness Checks

In what follows, we present the results obtained using alternative proxies for measuring the macro-regulation and central bank independence. One possible caveat of our analysis is the use of a cumulative index to proxy the macroprudential bank regulation (Andrieș *et al*., 2016). To overcome this limitation, we use an alternative measure of bank regulation, an index that is computed using data from Barth *et al.* (2013). This composite index translates into a dummy variable, Regulation, which takes the value of 1 if it is higher than the median value of the index and 0, otherwise.

Table 8 presents the results using this alternative measure. In line with those obtained using the MaPP index, the results show that bank regulation reduces the effect of monetary policy on bank risk, by dampening the risk-taking incentives of banks. However, different from the previous results, looking at columns 1 and 4, we observe that bank regulation has the power to revert the sign of the relation between monetary policy and the Z-score. The negative cumulative effect shows that low interest rates lead to higher bank stability. This supports the idea that, especially in times of crisis, higher bank regulation can improve the stability of banks. This argument is supported by the discussion in Agur and Demertzis (2015).

We also consider an alternative proxy for central bank independence. To do this we use the independence of supervisory authority index, developed in Barth *et al.* (2013). When considering this index as an alternative proxy for central bank independence, we take into account the fact that the majority of central banks are also the macroprudential supervisors.

Table 8

The Impact of Tight Bank Regulation on the Risk-taking Channel of Monetary Policy

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
Lagged Dependent	0.066	0.550*	-0.067**	0.087***	0.552*	-0.047**
	(0.05)	(0.01)	(0.03)	(0.05)	(0.01)	(0.02)
Taylor gap	**0.145***	**-0.083***	**-0.492***			
	(0.03)	**(0.00)**	**(0.04)**			
Taylor gap * Tight Regulation	**-0.229***	**0.029***	**0.155***			
	(0.05)	**(0.00)**	**(0.04)**			

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
Real STIR				**0.112***	**-0.062***	**-0.467***
				(0.03)	**(0.00)**	**(0.03)**
Real STIR* Tight Regulation				**-0.139****	**-0.003**	**0.081****
				(0.06)	**(0.01)**	**(0.04)**
Capitalization	-0.024	0.016*	-0.228*	-0.016	0.016*	-0.220*
	(0.02)	(0.00)	(0.03)	(0.02)	(0.12)	(0.03)
Liquidity	-1.536	-0.252**	1.143	-1.928	-0.302*	0.457
	(1,.14)	(0.11)	(0.82)	(1.16)	(0.15)	(0.74)
Non-interest income	-0.702	1.274*	0.012	-0.007	1.148*	-0.009
	(0.91)	(0.16)	(0.64)	(0.91)	(0.14)	(0.61)
Non-deposits funding	-0.878	-0.091	0.922*	-0.703	-0.384*	-0.189
	(0.93)	(0.10)	(0.34)	(0.89)	(0.06)	(0.31)
Size	1.029*	-0.295*	-2.719*	1.019*	-0.171*	-2.059*
	(0.36)	(0.06)	(0.34)	(0.36)	(0.00)	(0.32)
Concentration	-0.109*	0.024*	0.103*	-0.112*	0.015*	0.067*
	(0.02)	(0.00)	(0.02)	(0.03)	(0.00)	(0.01)
Bank intermediation	-0.085*	0.050*	0.156*	-0.086*	0.045*	0.133*
	(0.02)	(0.00)	(0.01)	(0.02)	(0.00)	(0.01)
Economic growth	-0.009	-0.003**	-0.108*	-0.008	-0.001	-0.090*
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
AR(1) p-value	0.01	0.00	0.00	0.00	0.00	0.00
AR(2) p-value	0.07	0.40	0.00	0.11	0.40	0.02
Hansen Test (p-value)	0.13	0.44	0.29	0.11	0.45	0.19
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	281	343	481	281	343	481
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculations. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

Table 9 shows the results obtained using this alternative proxy. The coefficient of the interaction term supports the evidence obtained using the MaPP index, confirming that the independence of supervisory authority dampens the negative impact of low interest rates on bank risk-taking. Finally, our results confirm our third hypothesis saying that the central bank independence reduces the risk-taking incentives induced by very low levels of interest rates.

Table 9

The Impact of Independence of Supervisory Authority on the Risk-taking Channel of Monetary Policy

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
Lagged Dependent	0.035	0.491*	-0.147*	0.047	0.524*	-0.141*
	(0.06)	(0.01)	(0.03)	(0.05)	(0.01)	(0.02)
Taylor gap	**0.118***	**-0.097***	**-0.959***			
	(0.05)	**(0.00)**	**(0.06)**			
Taylor gap * Independence of supervisory authority	**-0.073**	**0.048***	**0.784***			
	(0.06)	**(0.00)**	**(0.06)**			
Real STIR				**0.077****	**-0.059***	**-0.681***
				(0.03)	**(0.00)**	**(0.04)**

Dependent variable:	Z-score	NPL	LLP	Z-score	NPL	LLP
Real STIR* Independence of supervisory authority				**-0.013 (0.05)**	**-0.002 (0.00)**	**0.460* (0.04)**
Capitalization	-0.031 (0.02)	0.030* (0.00)	-0.276* (0.03)	-0.034 (0.02)	0.031* (0.00)	-0.297* (0.03)
Liquidity	-2.869** (1.30)	-0.133 (0.12)	-1.736** (0.94)	-3.151* (1.17)	-0.090 (0.09)	-3.292* (1.07)
Non-interest income	0.832 (1.11)	1.480* (0.14)	-1.799* (0.52)	0.597 (0.96)	1.266* (0.12)	-2.909* (0.50)
Non-deposits funding	0.250 (0.97)	-0.534* (0.12)	1.451* (0.47)	0.448 (0.94)	-0.684* (0.12)	0.246 (0.48)
Size	0.875** (0.39)	-0.332* (0.07)	-4.320* (0.34)	0.607 (0.41)	-0.175** (0.07)	-4.007* (0.33)
Concentration	-0.146* (0.03)	0.019* (0.00)	0.028** (0.02)	-0.141* (0.03)	0.020* (0.00)	0.006 (0.01)
Bank intermediation	-0.103* (0.02)	0.054* (0.00)	0.163* (0.01)	-0.094* (0.02)	0.049* (0.00)	0.137* (0.01)
Economic growth	-0.005 (0.01)	-0.001 (0.00)	-0.095* (0.01)	-0.005 (0.01)	0.001 (0.00)	-0.070* (0.01)
AR(1) p-value	0.00	0.00	0.00	0.00	0.00	0.00
AR(2) p-value	0.16	0.21	0.27	0.18	0.17	0.09
Hansen Test (p-value)	0.17	0.37	0.18	0.20	0.36	0.23
Technique	GMM	GMM	GMM	GMM	GMM	GMM
No. of observations	270	317	448	270	317	448
Cluster level	banks	banks	banks	banks	banks	banks

Source: Authors calculations. *, ** and *** indicate significance at 1%, 5% and 10% level, respectively.

5. Conclusions

This paper is about the risk-taking channel of monetary policy and the role of macroprudential regulation and central bank independence in amplifying or reducing the effects of low interest rates on banks' risk incentives. Our results confirm the existence of a risk-taking channel of monetary policy for countries of Central and Eastern Europe during the 2005-2011 period. Furthermore, the result is even more powerful in times of financial and banking crisis. Moreover, we find significant evidence that monetary policy interacts with both macroprudential regulation and central bank independence in shaping its transmission to the risk-taking incentives of banks. In line with previous works on the role of macroprudential regulation and central bank independence, our results show that tight macroprudential regulation dampens the negative impact of low interest rates on bank risk-taking. The same is true for central bank independence, since banks located in countries with higher CBI index experience reduced risk-taking incentives in the presence of low interest rates. Since bank risk-taking may be a proxy of financial stability, our results support the idea that central bank independence could reduce the financial instability.

Our analysis is important for the macro-regulators when establishing the macroprudential rules, because they have to take into account the effects of the interaction between monetary policy and macroprudential regulation and the impact of this interaction on the bank risk-taking and, furthermore, on the financial stability. In spite of the above contributions, the

research regarding the coordination of monetary policy and macroprudential regulation and their interaction effects is still in its early stages and there are many extensions to our analysis that could broaden the understanding of this issue. Future research could investigate whether the risk-taking channel of monetary policy is different in countries where the central bank is responsible for macro-supervision than in countries where it has only the monetary policy responsibility. Moreover, it would be interesting to investigate the interaction effects of monetary policy and macroprudential regulation on the bank risk-taking in the period after the financial crisis, by expanding the analyzed time period after the year 2011. This possible direction of future research becomes more important in the light of the results obtained by more recent studies (Boungou, 2020 and Ngambou Djatche, 2019) which reconsider the risk-taking channel of monetary policy by analyzing it on an extended period of time after the financial crisis.

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