

Veselinovič, Draško; Fabijan, Janez; Vadnjal, Jaka

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Draško Veselinovič *, ***Janez Fabijan *****,
Jaka Vadnjal ***

Does Credit Growth in the EMU Banking Sector Follow its Capital Adequacy?¹

Abstract: We put our hypothesis very straightforward, considering the euro area and the whole European Economic and Monetary Union (EMU) banking sector. The paper's central hypothesis that capital adequacy of the EMU banking sector influenced credit growth and activities in the nonfinancial sector was confirmed; however, not entirely in all respects expected. We proved that, in general, there was a dependency between banks' capital adequacy and loan growth in the euro area for the observed period Q1 1999 until Q1 2022; yet the correlation coefficient of 0.48 shows a middle positive relationship of variables. At the same time, more than 23% of loans' variability might be explained by variability in capital adequacy. All significance tests proved our results valid.

Nevertheless, we saw two very different and slightly controversial dynamics in loan growth and capital ratio during the observed period. Therefore, we were forced to separately continue with an analysis for both time frames: the period before the big financial and economic crisis (Q1 1999 - Q4 2008) and the period starting with the big financial and economic crisis (Q1 2009 - Q1 2022). The linear regression in the pre-crisis period was almost flat. In contrast, a simple linear regression during the crisis showed a relatively high negative correlation at around -0.6. Therefore, the sub-hypothesis that higher capital adequacy resulted in negative credit growth was supported for the crisis period. We believe that this paper offers the main origi-

** Slovenian Business and Research Association, Ljubljana, Slovenia and GEA College of Entrepreneurship, Ljubljana, Slovenia*

E-mail:

Drasko.veselinovic@gea-college.si

*** Nova Ljubljanska Banka d.d., Ljubljana, Slovenia and GEA College of Entrepreneurship, Ljubljana, Slovenia*

E-mail:

Janez.fabijan@gea-college.si

** GEA College of Entrepreneurship, Ljubljana, Slovenia and Swiss School of Business Management, Geneva, Switzerland*

E-mail:

Jaka.vadnjal@gea-college.si

¹ The statements expressed in article represent author views and not necessarily those of the institution where he is employed.

nality and scientific contribution for this particular finding within the data time series deployment.

Keywords: Banking Sector, credit activity growth, capital adequacy, financial crisis, non-performing loans, linear regression, EMU.

JEL Classification: G21

Introduction

We can certainly find different references in literature to the subject given in the title; however, this article puts it very directly and considers the euro area and the whole EMU banking sector. Therefore, this paper's central hypothesis is that capital adequacy of the EMU banking sector influenced credit growth and activities in the nonfinancial sector. We exclude households for many reasons; namely, there were some methodological problems with the data, as we explained more in detail in the methodology chapter, and especially as we also wanted to explore a direct connection between capital adequacy of the banking sector and the most productive and the most crucial sector of the economy which includes industry, services, etc. We wanted to claim that higher capital adequacy brought higher credit growth and credit activities, representing the paper's central hypothesis. Consequently, higher credit growth and higher credit activities bring higher GDP growth and development, which has been researched by many authors and is not the topic of our paper. The sub-hypothesis of the article is that in times of crisis, the relationship between the two is reversed. However, in any case, the time-series that we considered, as well as calculations, analyses and regressions showed us how the parameters we were looking at were changing according to the analysed time frame. Therefore, we broke the whole studied period from 1999-2022 into two sub-periods to make our testing of both hypotheses more exact and consequently stronger. The first period we analysed was from Q1 1999 until Q4 2008 and we called it the Period before the big financial and economic crisis, while we defined the second period from Q1 2009 until Q1 2022 and we named it the Period after the big financial and economic crisis. Going that path, we could furthermore analyse and test the connection between capital adequacy and credit growth/activities. Besides, we got more exact results.

To prove both hypotheses, we used the aggregated EU data from January 1, 1999, when the euro was introduced as a legal tender (banknotes and coins were issued later in 2002), until 2021, incl. also the beginning of 2022. This time frame includes two full crises – the Recession starting in 2008, and the COVID-19 induced crisis beginning in 2019 and touching on the Ukrainian crisis, starting in early

2022. We calculated the correlated relationships between both aggregated data sets and saw how strong they were. We also used references from other authors who have already tackled these questions. An interesting research question that would go very well along both set hypotheses was the problem of non-performing (NPL) loans. However, we did not go into detail there since that would take us away from the primary aim of this paper. Nevertheless, we might have used some partial NPL data to research and explain the main and sub-hypothesis.

The structure of the paper adequately represents our primary goals. We start with this introductory explanation putting forward the background and laying out the fundamental idea/problematics of the paper. Also, both hypotheses are set and explained together with the time component of the analysis. Afterwards, we went through the literature review and some interesting and important references regarding this paramount and, to a certain extent, controversial subject. The methodology and data used to do all our calculations represented quite an important part of the paper. One would presume that such data should be public and out there for anyone without any problem, but surprisingly this was not the case. Therefore, we had to emphasise these issues we have explained very thoroughly in this special chapter. To put together some usable and comparable data for the whole time series (Q1 1999 - Q1 2022), we had to do some calculations and use some assumptions that we explained in detail. Regression calculations followed. The paper ends with results and analysis, including the breakdown of the whole time series into two sub-series based on the findings of calculations and analysis.

Literature review and hypotheses

To ensure the safety and soundness of the global financial system and to reduce systemic risk, numerous policy measures and regulatory reforms have been brought forward. In parallel, several pieces of academic research have critically assessed these developments. Studies can be divided into three content groups: (i) causes of the crisis, (ii) policy and reform reactions, and (iii) analysis of the efficiency of these reforms (Meier, Gonzalez, & Kunze, 2021). Furthermore, some research findings (Konstantinos & Malandrakis, 2021) encourage further research on the topic of the contribution of global banks to the financial crisis propagation. The level of concentration is another viewpoint of the research and is usually related to the competitiveness of a banking system, which affects the development and health of the particular country's entire economic system (Anđelinović, Milec, & Dumičić, 2022).

The evolution of the market structure in European banking and the level of financial integration in the euro area show a high level of interaction with financial regulatory environment developments. There are several concerns regarding monetary policy and banking supervision. Also, the role of the Capital Markets Union proposal in respect of its important objective to increase the supply of credit from non-bank financial intermediaries to the economy of the European Union was not be neglected (Alexander, 2020).

The adjustment of bank activities to regulatory capital requests assumes that the increase in capital requirements affects the banks' balance sheet and bank lending policy to the non-financial sector. The high equity mark-up in the recapitalization processes due to asymmetric information about the bank's net worth makes it not very attractive to the existing and possible future shareholders to pay in additional capital. This increased bank lending barriers and led banks to invest in lower-risk assets which are also of lower profitability (Klinac & Ercegovic, 2018).

Agoraki, Kouretas, & Tsamis (2021) analyse the effects of performance of the Eurozone banking sector over the period 2007–2016 on determinants developed under the three pillars of the Basel II agreement: (i) capital stringency, (ii) official disciplinary power and (iii) private monitoring. They compare the periphery Eurozone countries (Greece, Italy, Portugal, Spain) with banks in core Eurozone economies (Germany, France). Banks financed with short-run capital market funding are more fragile. They find that banks in countries with more restrictive regulatory frameworks perform better and the better-performing banks have more equity.

Klinac, Pesa, & Bolfek (2019) researched the sample of 35 listed bank groups in the period from 2000 to 2016 which are market makers of the EU. The model shows that the required increase in capital position causes a decrease in credit activity in the non-financial sector. Potential growth of the revenue from non-credit risk operations cannot compensate for the reduced interest-based income as a consequence of increased capital requirements.

The imbalances that led to the Euro crisis were mostly caused by financial flows between the member states' diversity. Macroprudential tools may have unintended consequences for other member states' financial cycles. Contrarily, countercyclical instruments, like the Basel III capital buffer, are often set by independent agencies with responsibilities for national stabilization. Through interbank lending, macroprudential policies in core economies can have destabilizing spillover consequences on a financially dependent periphery (Badarau, Carias, & Figuet, 2020).

The study of the causes of the Greek banking system's collapse identified three categories. The first two include macroeconomic and bank-specific factors. The third category suggests other factors related to the financial crisis. The main cause was the accumulated deficits and imbalances of the economy which caused a debt crisis followed by a banking crisis (Magoutas, Chountalas, Manolopoulos, & Gelardos, 2022).

Credit channels of the monetary policy transmission have not been debated much in the context of the EMU and the increasing fragmentation of the European banking system. This is even more important after a decade of the debt crisis which some European countries have faced. The interconnectedness of credit channels in policy transmission analysed on a sample of eight European countries suggests that the household balance sheet channel, borrower cash flow channel and interest rate channel are the most divergent channels in the EMU (Petsalakis, Khalid, & Premaratne, 2021).

Large banks in Europe have been significantly affected as a result of the COVID-19 recession. Due to lower net interest income, their revenues fell by 5% in the first half of the year. Loan loss provisions more than tripled. Despite cutting costs, profits almost vanished. The leverage ratio decreased to 4.8% as a result of the lowered dividend payments, while the average core capital ratio climbed to 14%. Corporate lending has increased thanks to government guarantees. Banks increased the amount of money deposited with central banks, maintaining a solid liquidity position. This increased total assets together with purchases of government bonds (Schildbach & Schneider, 2020).

To study the financial stability of banks in this region in the face of the COVID-19 pandemic's ongoing negative effects, stress tests were performed to determine how much NPL growth over the next year will result in a breach of regulatory capital requirements in domestic sectors and individual bank groups. With a 12% increase in nonperforming loans, the banks were well-capitalized and able to meet capital requirements. Domestic banking sector resilience varies, and it is higher in non-EU countries. Smaller and non-public banks demonstrate a greater ability to preserve capital. Smaller and non-public banks have a greater ability to maintain the appropriate level of equity while larger banks are more profitable (Kozak, 2021).

The macroeconomic consequences of cross-border banking in monetary unions such as the Eurozone were investigated against the backdrop of the emergence of macroeconomic imbalances within the European Economic and Monetary Union. The rule-of-thumb lending standards based on the macroeconomic per-

formance of the monetary union's core region can have destabilizing spillover effects on the other region, resulting in higher macroeconomic volatility overall. This effect may be mitigated by macroprudential policies, particularly policies requiring banks to adopt less procyclical lending standards, which have proven effective in stabilizing output in both regions of the monetary union (Dräger & Proaño, 2020).

The 2008 economic downturn, followed by the sovereign debt crisis, demonstrated that the EMU's original design was unsustainable. Despite significant progress, no comprehensive reform has yet been implemented. It is suggested that a better balance between common shock absorption instruments and a greater role for markets as incentives for fiscal and financial discipline should be created. There is a need to develop a long-term resilience system, which includes the ability to respond and adapt. Deeper economic and financial unions, resilient structures, increased risk sharing, and reduced inherited risk can all be at the heart of EMU reform (Halmai, 2022).

There is evidence of a euro area financial cycle as well as high- and low-amplitude national financial cycles. Evidence of five empirical regularities is provided using a concordance and similarity analysis on business and financial cycles: (i) the aggregate euro area credit-to-GDP ratio exhibited procyclical behaviour in the years preceding the euro area recessions; (ii) financial cycles were less synchronized than business cycles; (iii) business cycle synchronization increased while financial cycle synchronization decreased; (iv) financial cycle desynchronization was more pronounced between high-amplitude and low-amplitude countries, particularly Germany; and (v) high-amplitude countries and Germany experienced divergence (Oman, 2019).

Following the 2008 financial crisis and the new measures inspired by the Basel III regulatory framework, US banks have strengthened their risk-absorption capacities while expanding their credit activities. During the post-2008 financial crisis period, capital ratios had a significant negative impact on lending growth for large European banks. Liquidity indicators have a positive impact on bank lending growth, highlighting the importance of taking into account the characteristics and behaviours of heterogeneous banks when implementing new regulatory policies (Naceur, Marton, & Roulet, 2018).

Bank equity has a significant impact on a bank's funding costs and lending growth. Greater retention of bank earnings and the resulting higher bank capital would have aided in the transmission of monetary policy aimed at easing financial conditions for borrowers. Monetary tightening has a smaller impact on banks with higher capitalization because they have easier access to uninsured fi-

nancing. If the banking system as a whole is undercapitalized, there may be some tension between the monetary policy imperative of expanding lending and the supervisory goal of ensuring individual bank soundness (Gambacorta & Shin, 2018).

The impact of the new Basel III capital and liquidity regulation on bank lending following the 2008 financial crisis using data from European commercial banks was examined by Roulet (2018). Capital ratios have a significant and negative impact on large European bank retail and other lending growth during the post-2008 financial crisis period of deleveraging and "credit crunch" in Europe. Furthermore, liquidity indicators have both positive and negative effects on bank lending growth, highlighting the importance of taking into account heterogeneous banks' characteristics and behaviours when implementing new regulatory policies (Roulet, 2018).

Since 2012, several central banks have implemented a negative interest rate policy to increase the supply and demand for bank loans. In a study of OECD banks from 2012 to 2016, the difference in lending change was examined in countries that adopted the negative interest rate policy versus those that did not. Lending was weaker in countries that implemented negative interest rate policies. This negative effect appears for smaller banks, more reliant on retail deposit funding, less well capitalized, had interest-based business models and operated in more competitive markets (Molyneux, Reghezza, Thornton, & Xie, 2020). In this context, communication has become a vital part of modern monetary policy, and its importance is even higher during a crisis when a central bank has to calm the markets down. During a period of very high economic uncertainty, there appears to be a large variance in the information content of different policymakers and styles of communication (Lehtimäki & Palmu, 2022).

The imposition of higher capital ratios is effective in reducing risk and improving bank efficiency and profitability, based on another study in OECD countries performed between 1999 and 2013. Although both risk-based and non-risk-based capital ratios improve bank efficiency and profitability, risk-based capital ratios do not reduce risk. The validity of the weighting methodologies used to determine risk-based capital ratios, along with the performance of regulatory monitoring, can be challenged. While Basel III requires banks to maintain higher liquidity and capital ratios, the study's findings suggest that forcing higher capital ratios may harm the performance and profitability of highly liquid banks (Bitar, Pukthuanthong, & Walker, 2018).

Loan loss provisions in the euro area are negatively proportionate to economic growth, implying that they are procyclical. At larger and better-capitalized banks, loan loss provisions seem to be more pro-cyclical. Loan loss provisions' procyclicality can explain nearly two of the variation in bank capital base over the business cycle. Application deployment of procyclicality in the euro area is approximately half that of other advanced economies. This imbalance reflects higher procyclicality in provisioning in the euro area countries before the euro adoption, along with divergent growth experiences in the euro area countries following the global financial crisis (Huizinga & Laeven, 2019).

Many conclusions were drawn from the study on the policy actions implemented in the euro area in response to the COVID-19 pandemic outbreak. First, the banks' capacity to extend credit would have been substantially hampered in the absence of the capital and funding cost relief. Second, the coordinated action by the monetary and regulatory authorities boosted the effects of the individual measures in preserving liquidity conditions and assisting with the flow of credit to the private sector. Third, without monetary and prudential measures, the epidemic would result in a much greater decrease in employment (Altavilla, Barbero, Boucinha, & Burlon, 2020).

It was discovered in a study of the factors involved in the matching of banks and firms in the loan market, as well as the implications of this matching for lending relationships, bank capital, and credit provision, that bank-dependent firms borrow from well-capitalized banks, whilst firms with access to the bond market borrow from banks with less capital. This partnership of bank-dependent firms with stable banks straightens cyclicity in aggregate credit provision and reduces the effect of bank shocks on the real economy (Schwert, 2018).

Thus, the following hypothesis was built based on the authors' experience and literature review:

H1: the capital adequacy of the EMU banking sector influenced credit growth and activities in the nonfinancial sector ((Klinac & Ercegovic, 2018)) (Agoraki, Kouretas, & Tsamis, 2021), (Gambacorta & Shin, 2018).

Again, following some literature findings and our rationalizing, we also built an alternative sub-hypothesis:

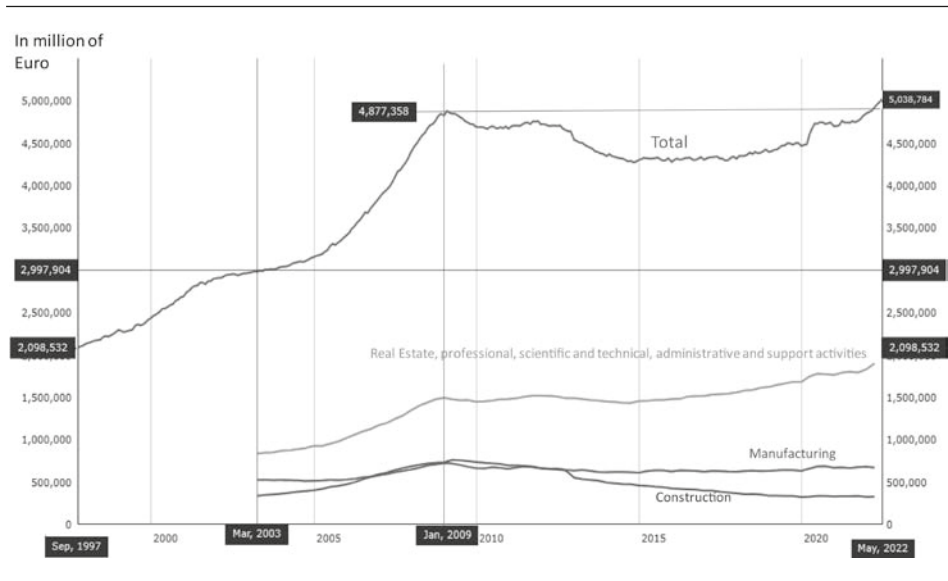
H1b: In times of crisis, the relationship between the two was reversed (Halmai, 2022); (Roulet, 2018); (Huizinga & Laeven, 2019).

Methodology and data management

"Picture shows more than thousands of words." Let us see Chart 1 which presents the dynamic of credit growth to non-financial companies granted by a monetary financial institution in the EMU, as if all 19 countries have been members and that the EMU has existed from the very beginning of the analysed period, from January 1999 to date. We believe learning from history is very much what the EMU is missing, obviously because of its short real history, to better anticipate and react towards economic cycles and crises.

To simplify and make it easier to remember many numbers, say by rounding, loan stock to enterprises rose 3 thousand billion euros in the observed period (September 1997 – May 2022). Looking at the trajectory of the line "Total" amount of loan in millions of euros in Chart 1 some very non-linear growth has been found. Already in January 2009, we can observe a pick of 5 thousand billion euros worth of loans, close to the final number at end of the observed period. We are all familiar that this peak emerged at the beginning (bankruptcy of Lehman Brothers on September 15, 2008) of the great financial and economic crisis with extreme negative GDP growth rates all over the member countries.

Chart 1: Estimated loans of MFI (S.122 + S.123) to NFC by economic activity (NACE)

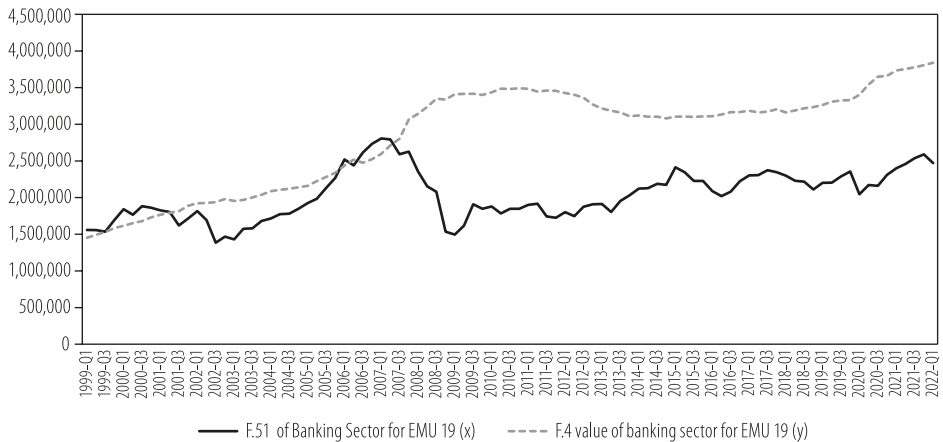


Source: (European Central Bank, 2022) https://sdw.ecb.europa.eu/browseChart.do?org.apache.struts.taglib.html.TOKEN=a94d83d0934a01a4a5bc3b34252dc82d&df=true&ec=&dc=&oc=&pb=&rc=&DATASET=0&removeItem=&removedItemList=&mergeFilter=&activeTab=BSI&showHide=&MAX_DOWNLOAD_SERIES=500&SERIES_MAX_NUM=50&node=bbn3598&legendRef=reference&legendPub=published&trans=N

The definition of loans from BSI – Balance Sheet Statistics in Chart 1 is broader than in Quarterly Sectoral Accounts Statistics, where we later in Chart 2 use F.4 financial instrument (loan) granted only to the domestic sector of the economy (S.1), whereas loans granted from domestic MFI (S.122 – Monetary Financial Institutions other than National Central Banks) to foreign NFI (S.211- Non-Financial Companies) are excluded. In financial sectoral accounts, sole data to foreign counterpart sector on the country level sector are still not available, and neither we can find such a data time series in Balance of Payments statistics (Eurostat Quarterly Financial Accounts).

However, with the first set of data for the dependent variable, two additional dimensions might help on the level of defined aggregate analysis; member countries' distribution of loans and economic activity. Data allow using the combination of both. Chart 1 extracts lines of loans granted by Monetary Financial Institutions (MFI without Central Banks) to Non-Financial Companies (NFC) for "Real Estate, professional, scientific and technical, administrative and support activities", "Manufacturing" and "Construction" by which we can mostly explain the non-linear movements on the total amount of loans for the observed period. We obtain such data time series from March 2003 so that we can start testing hypotheses on the level of different industries and countries. This could be done at least from 2004, precisely from the time of extreme - exponential loan growth until the detected pick, when two-thirds of all net loan growth in the overall observed period of analysis had been granted to the non-financial sector of the euro area residents. Coming down to the country level, of course, only relative indicators such as growth rates could allow comparative analysis and also a better regressive analysis with capital adequacy expressed as a share in total (financial) liabilities. To test our hypothesis, we decided to start using longer time series of financial sectoral account statistics data from the very beginning.

Chart 2: Quarterly stock of loans (F.4) granted by Monetary Financial institutions to the domestic non-financial sector in the European Monetary Union and stock of equity (F.51) of Monetary Financial Institutions other than Central Bank in Total financial liabilities(x) for end of quarter data from Q1 1999 till Q1 2022 in millions of EUR



Source: (European Central Bank, 2022) and (European Commission, 2022)

Note: Eurostat Quarterly Financial Accounts, for F.4 concrete data set used see source (for F.51 change the value of dimension "Financial Instrument")

Line F.4 in Chart 2 for loans granted by MFI (other than National Central Banks) *only to domestic* Non-Financial Companies has a similar trajectory to line Total in Chart 1. Unfortunately, there is no possibility to add also data for the stock of loans (F.6) granted to foreign Non-Financial Companies. Compared to Chart 1, in Chart 2 a pick has been reached slightly later in mid of the financial and economic crisis (2010 Q3) and there is a sharp increase in loans granted by the beginning of the COVID-19 crisis (2020 Q1). There was only a small increase in the stock of loans after the first quarter of 2009. Apart from that, we have achieved now to produce a basis for consistent calculation of capital ratio back from Q3 2014 when a Single Supervisory Mechanism for the euro area has not existed yet, the Equity quarterly stock line - F.51.

Solving the lack of relevant data

Our hypothesis asks also for an independent variable – the level of capital available by the banking sector. After the biggest financial and economic crisis had finished, someone said "The data were there" for possible support to prevent the

unprecedented development we had seen. But we have discovered the opposite situation.

The Single Supervisory Mechanism has legally (*de jure*) started on 1 November 2013 but operationally (*de facto*) by European Central Bank one year later, on 1 November 2014. Consistent and harmonized data on the complete set of risk indicators are available only by the third quarter of 2014 under the umbrella of the European Banking Federation, providing data for all EU member countries. Before that, the time series do not exist in EBA Risk Dashboard. The Statistical Data Warehouse of the ECB can provide some rare data on yearly or half-yearly basis for some of the member states from 2007 onward, but with a great doubt of correctness and consistency on the numbers reported. It is obvious we cannot fill in the gaps to get clean quarterly risk indicators of capital adequacy (Total Capital Adequacy, CET1, etc..) even from 2007 on, having complete emptiness already from 2003 on as a highly important breakeven point in Chart 1.

Quarterly frequency is needed to allow a higher number of observations for the dependent variable (y) and to include seasonal movements with year-on-year indexes, on the level of economic activity breakdown. That fact turns us to the possible use of long time series of quarterly sectoral financial accounts as a proxy for capital risk indicators as the independent variable (x). But when we found the publicly available aggregated data for numerator and denominator to calculate risk indicator only for the entire MFI population including central banks, we were aware that such data were more suitable for judging the monetary policy than analysing supervisory policy. For the potential inclusion of monetary policy aspects in our analysis in later stages, we also have data on loan growth for other Non-Monetary Union member states, which did run open monetary policies.

Nevertheless, we found at Eurostat Quarterly Sectoral Accounts (QSA) time series similar data non-availability as at the EBA and the ECB. To solve this problem in QSA data we also used the Balance Sheet data of Central Banks – the ECB and NCBs' contributions to the Eurosystem statistical balance sheet (European Central Bank, 2022) or the so-called “BSI data” to deduct the capital of central banks in the numerator and to deduct the total liabilities of central banks in the denominator of capital risk indicator to calculate proxy (TCR - Total Capital Ratio) of capital ratio only for the banking sector. Since these are the liabilities side of balance sheet items there is not much deviation from total financial liabilities and total liabilities for central banks. We can run quality data control for the period when both time series exist.

In Chart 3 of the Linear Regression Model chapter, the above conceptual framework of our analysis has been presented coming out from solving the data availability problem. As we have already written, the ideal situation would be to have fully consistent EBA long-time series. But let us use the EBA definitions as the starting point to prepare a good and methodologically acceptable time series. On this data basis, we are testing a hypothesis in between dependent (y - loans growth) and independent variable (x - proxy to TCR of EBA). It would be possible in later stages of our analytical work to split the test of hypothesis by activity dimension for a dependent variable over the euro area countries, which could provide us with a pure supervisory perspective of our analysis.

Simple linear regression model (Population model)

The statistical method we use to analyse the relationship between banks' capital ratio (x) and loan growth to non-financial companies (y) is regression analysis.

$$y = \beta_0 + \beta_1 x + \varepsilon \quad (1)$$

Where: y = value of the dependent variable; x = value of the independent variable; β_0 = population's intercept; β_1 = Slope of the population regression line and, ε = error term, or residual (i.e., the difference between the actual y -value and the value of y predicted by the population model) (Groebner, Shannon, Fry, & Smith, 2008).

Based on our data availability over different dimensions we can produce a sample of a maximum of 93 observations (from Q1 1999 to Q1 2022), many estimated regression equations and each time test their significance. For a simple linear regression model (one independent variable) there are three equivalent statistical tests to be performed: i) test for significance of the correlation between x and y , ii) test for significance of the coefficient of determination, iii) test for significance of the regression slope coefficient.

In our study, the interception itself would show the number of outstanding loans in case of zero capital adequacy, which could only have some meaning on the individual entity level (individual bank e.g. in the resolution phase) but not very much on an aggregate level of our analysis.

In our analysis, we will statistically recreate the EMU as it exists from 1 January 1999 in its current composition (19 countries). On the level of aggregate calculations, we will assume the existence of a unified supervisory function reflected in

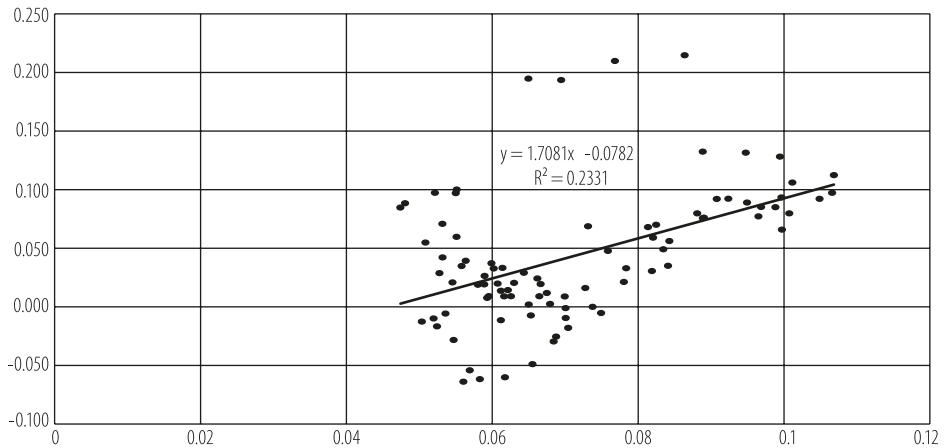
requirements towards banks through an average of capital ratio for 19 countries already before 1 November 2014. We produced a proxy for the total capital ratio for time series back by using Quarterly Sectoral Accounts and Balance Sheet statistics of Monetary Financial Institutions for EMU19 together and for individual member states. Further on, we also have Balance Sheet Statistics (Chart 1) where the definition of loans is broader as it does not only contain credit to domestic non-financial companies but also companies abroad (see BSI regulation by the ECB). But we can use BSI statistics to further analyse a phenomenon on the level of a combination of two dimensions: member states country and economic activity. Nevertheless, having in mind that BSI statistics represent a building block for final Financial Sectoral Accounts statistics that provide methodological consistency, we can find (Chart 2) that the growth of domestic loans (F.4 – the financial instrument by ESA 2010 using in QSA) also in non-financial sector accounts statistics amounted to more than 3,000 billion euros in the observed period and that the trajectory of loan curve is like the one in Chart 1, where BSI source of data is used. But this time we have also a long time series back of data for banks' capital ratios. Not including loans granted by a domestic bank to foreign companies would even help to a more clear and precise analysis of our hypothesis, having in mind our past studies on sectoral account analysis (Fabijan, 2019) when the most severe economic and financial crisis in many EMU member states (known as PIIGS) had its roots in external imbalances.

Results and analysis

This data availability has given to us a starting point to test our hypothesis. Can we reject the null hypothesis and claim that there was a significant linear dependency between banks' capital ratio (x) and loan growth to non-financial companies (y)? If so, then we can confirm our main thesis that the capital adequacy of the EMU banking sector influences credit growth and credit activities in the nonfinancial sector (excluding households).

Chart 3 shows us that in general there was a dependency on loan growth from capital adequacy in the euro area for the observed period Q1 1999 until Q1 2022. Yet the correlation coefficient of 0.48 shows the middle positive relationship of variables. More than 23% of loan variability might be explained by variability in capital adequacy. Not to forget, we hereby do not go into the quality of capital adequacy which is a strong perception of SSM from 2014 on, but we are aware that all current 19 member states had been building up their supervisory mechanisms before that, based on the common Basel Core Principles of Banking Supervision, starting in 1988.

Chart 3: Quarterly growth (y-o-y) of loans granted by Monetary Financial institutions to the non-financial sector in the European Monetary Union (y) concerning the share of the equity of Monetary Financial Institutions other than Central Bank in Total financial liabilities(x) for the end of quarter data from Q1 1999 until Q1 2022



Source: (European Central Bank, 2022) and (European Commission, 2022)

Note: Share of Capital is calculated as F.51 (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

In this line, we found an interesting distribution of observations in the scatterplot of Chart 3 where at a level of 6% (x-axis) of capital adequacy the highest density of observations with relatively negligible loans growth are placed, at around 2.5% (see the level of red regression line at 6% value for x variable) growth on quarterly y-o-y basis. As we know, Basle I requirement had started with 8% of own funds requirement, 6% for Tier and 2% for Tier 2. This ratio of 8% has been perpetuated to the current framework, defined in the EU by the CRR/CRD requirements. Nonetheless, the demand for uniform risk assessment as a basis for the calculation brought about a tightening of capital requirements. With this goal in mind, the qualitative requirements were adjusted over the years, and further types of risk had to be backed by capital. Risk-Weighted Assets, therefore, increased steadily over time. Consequently, more capital is required to comply with the relative capital adequacy of 8% (NORD/LB, 2017, pg. 14).

Estimated regression model (Sample Model)

Interestingly, in our scatter diagram for overall defined post-crisis period, observations close to 8% capital ratio, corresponding to around 5 to 6% of loan growths (y-axis). Furthermore, capital adequacy over 10 % allowed quarterly loan growth of around 9% (y-o-y). In general, we can provide a qualitative explanation to confirm our starting hypothesis. But can we statistical – quantitatively confirm its significance?

In our case (Chart 3):

$$\hat{y} = b_0 + b_1x \quad (2)$$

where: \hat{y} = Estimated, or predicted, y-value, x = Value of the independent variable, b_0 = Unbiased estimate of the regression intercept and, b_1 = Unbiased estimate of the regression slope (Groebner, Shannon, Fry, & Smith, 2008), is:

$$\hat{y} = -0,0782 + 1,7081x \quad (3)$$

A negative intercept on the level of 78 billion euros for the whole EMU is found as a logical explanation that there is no financial intermediary for banks without capital adequacy. More important here is the regression slope coefficient which tells us that for each additional unit of capital a 1.7% increase in loan growth is expected for the observed period on the level of the entire EMU.

Test statistics for significance of the Coefficient of determination

By squaring the correlation coefficient of 0.43 (Multiple R in Table 1 below), we can get a determination coefficient of 0.23 (R Square in Table 1) and test it as follows:

$$H_0: \rho^2 = 0, H_A: \rho^2 > 0, \alpha = 0.05 \quad (4)$$

is an *F*-test,

$$F = \frac{\frac{SSR}{1}}{\frac{SSE}{(n-2)}}, df = (D_1 = 1, D_2 = n - 2), = \frac{\frac{0,067941}{1}}{\frac{0,223488}{(89-2)}} = \frac{0,067941}{0,002568} = 26.45$$

(Table 1, columns: SS, MS and F, first two rows), (5)

where:

SSR = SUM of squares regression,

SSE = SUM of squares errors.

Because $F = 26.45 > \text{Significance } F$ (Table 1) we reject the null hypothesis and conclude the population coefficient of determination ρ^2 is greater than zero. This means the capital ratio explains a significant proportion of the variation in the loan's growth in the observed period.

For a simple regression model, the test for ρ^2 is equivalent to the test for the population correlation coefficient ρ^2 . In table 1 we see that the t -test statistic for the correlation coefficient was $t = 5.142 = F = 26.45$. Thus, the tests are equivalent. They will provide the same conclusions about the relationship between the x and y variables.

Test statistics for significance of the slope

We have already introduced the first two necessarily tests for the simple linear regression model. The third one deals specifically with the significance of the regression slope coefficient. The null and alternative hypotheses to be tested are:

$$H_0: \beta_1 = 0, H_A: \beta_1 \neq 0 \quad \alpha = 0.05 \quad (6)$$

is a t -test,

$$t = \frac{b_1 - \beta_1}{s_{b_1}}, \quad df = n - 2, \quad = \frac{1.7081 - 0}{0.332141} = 5.14 \text{ (Table 1, row X Variable 1),}$$

where:

b_1 = Sample regression slope coefficient,

β_1 = Hypothesized slope (usually $\beta_1 = 0$)

$s_{b_1} = \frac{s_\varepsilon}{\sqrt{\sum(x - \text{pop. } x)^2}}$ = Estimator of the standard error of the slope, where

s_ε = *Sample standard error*.

Because $5.14 > 2.37$ (Upper 95%, Table 1, second row), we should reject the null hypothesis and conclude that the true slope is not 0. Thus, the simple linear relationship that utilizes the capital ratio variable is useful in explaining the variation in the growth of banking loans to non-financial companies.

Table 1: Summary output for Chart 3 (Entire period: Q1 1999 till Q1 2022)

Regression Statistics	
Multiple R	0,48283726
R Square	0,23313182
Adjusted R Square	0,224317243
Standard Error	0,050683702
Observations	89

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0,067941753	0,067941753	26,44844168	1,65072E-06
Residual	87	0,223488877	0,002568838		
Total	88	0,291430631			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-0,078165568	0,024295533	-3,217281479	0,00181829	-0,12645557	-0,029875566
X Variable 1	1,708138893	0,332141496	5,142804845	1,65072E-06	1,047971705	2,36830608

Source: QSA, Eurostat Quarterly Financial Accounts. Share of Capital is calculated as $F.51$ (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

Well, generally our starting hypothesis is confirmed, but let us turn to Chart 1 where we observed two very different stories of the dynamics in loan growth in the observed period, as well as back to Chart 3 where the same is also true for capital ratio. To this knowledge we are forced to separately continue with simple linear regression for both time frames: i) the period before the big financial and economic crisis (Q1 1999 - Q4 2008) and ii) the period starting with the big financial and economic crisis (Q1 2009 – Q1 2022). We have enough observations for both parts of our analysis.

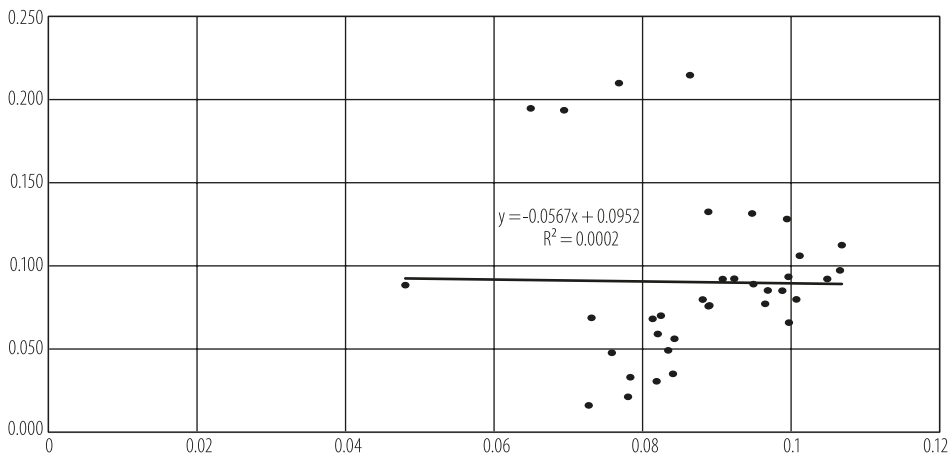
Period before the big financial and economic crisis (Pre-crisis period: Q1 1999 - Q4 2008)

As we already know (see Chart 1), this is the period of extreme loan outstanding amount growth on the level of the entire EMU19, particularly from 2004 until the Lehman Brothers collapse. Scatterplot (Chart 4) draws 36 observations with extremely high variabilities or outliers, on one side extremely high quarterly loan growths (even over 20% on a year-to-year basis, started approximately a year before the Lehman Brothers collapse) and on the other hand extremely low or almost no loans growths, so that the regression line in-between is almost flat or even with a slight downturn direction, negative dependency of banking loans activity to capital adequacy. We did compose an artificial data time series back for the EMU to be fully aware that the SSM did not exist yet and that supervisory function depends on each member state alone, based on developing Basel stand-

ards and principles. However, there is a call to potential new member countries for pre-harmonization activities with demanding convergence criteria. Having in mind also that none of the three significance tests can reject the null hypothesis as stated in the previous case, which means that, in general, we can confirm the non-existence of dependency on loan growth from capital adequacy in the pre-crisis period, we can reject the alternative hypothesis with even small negative dependency, as simple linear regression model (sample Model for pre-crisis period Q1 1999 – Q4 2008) shows:

$$\hat{y} = -0.0782 + 1.7081x \quad (7)$$

Chart 4: Quarterly growth (y-on-y) of loans granted by Monetary Financial institutions to the non-financial sector in the European Monetary Union (y) concerning the share of equity of Monetary Financial Institutions other than Central Bank in Total financial liabilities(x) for end of quarter data from Q1 1999 until Q4 2008



Source: (European Central Bank, 2022) and (European Commission, 2022)

Note: Share of Capital is calculated as F.51 (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics.

Coming out of such test results we are forced to deepen? our “supervisory” analysis on the level of individual member states and take into consideration Chart 1 and the concentration of loans growth in certain sectors of economic activity. We can use some more detailed BSI data combined by both dimensions, available from the end of the first quarter 2003 onwards.

Linear regression for the pre-crisis period in Chart 4 is almost flat on the high level of close to 10% loan growth. Based on our previous quarterly sectoral accounts analysis for Slovenia (Fabijan, 2019a) we can search for causes and reasonable explanations for malfunctioning of supervisory function or/and mal risk management/corporate governance in banking as well as in the non-financial sector. Knowing the problems of the so-called peripheral countries or PIIGS (Portugal, Ireland, Italy, Greek and Spain), a kind of cluster analysis might be a good methodological approach.

Table 2: Summary output for Chart 4 (Pre-crisis period)

SUMMARY OUTPUT

Regression Statistics						
Multiple R		0,368520178				
R Square		0,135807121				
Adjusted R Square		0,118862163				
Standard Error		0,035586571				
Observations		53				

ANOVA						
	df	SS	MS	F	Significance F	
Regression	1	0,010149726	0,010149726	8,0146034	0,006624011	
Residual	51	0,064586604	0,001266404			
Total	52	0,07473633				

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0,141035789	0,045815326	3,07835394	0,003346695	0,049057684	0,233013894
X Variable 1	-2,131331743	0,75285274	-2,831007489	0,006624011	-3,642746685	-0,619916802

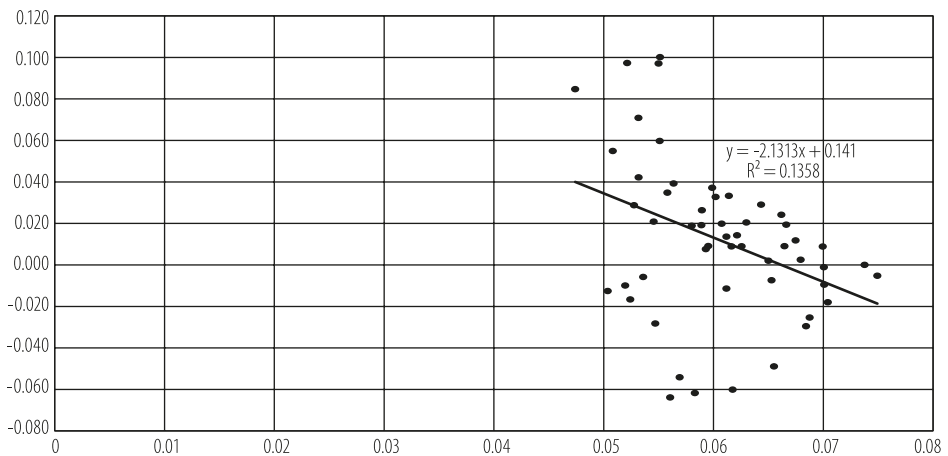
Source: QSA, Eurostat Quarterly Financial Accounts. Share of Capital is calculated as $F.51$ (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

The period after the big financial and economic crisis (Post-crisis period: Q1/2009 to Q1/2022)

Many member states faced rehabilitation of their banking system during the crisis period, starting in 2009. Defaulted and no longer paid loans and bonds were written off and this led to considerable losses in the balance sheets, investors' trust in the financial markets and the trust that banks placed in each other both suffered. The consequences were an outflow of liquidity and unfavourable funding conditions as well as a lack of fresh liquidity (NORD/LB, 2017, pg. 24). There was a general need for recapitalization of the banking system and state aid, with bail-in operations. The EMU has been working on the harmonization of recovery and resolution planning mechanisms.

For the crisis and the entire post-crisis period, from the end of the first quarter of 2009 until the end of the first quarter of 2022, in Chart 5 we find a simple linear regression model expresses a high negative correlation which could be explained by the huge need for recapitalization of banks and restructuring of non-performing loans (NPL) rather than new financing activities. These findings seem to be entirely consistent with findings of some recent research by Roulet (2018).

Chart 5: Quarterly growth (y-o-y) of loans granted by Monetary Financial institutions to the non-financial sector in the European Monetary Union (y) concerning the share of the equity of Monetary Financial Institutions other than Central Bank in Total financial liabilities(x) for the end of quarter data from Q1 2009 until Q1 2022



Source: (European Central Bank, 2022) and (European Commission, 2022)

Note: Share of Capital is calculated as F.51 (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics.

Table 3: Summary output for Chart 5 (Post-crisis period)

SUMMARY OUTPUT

<i>Regression Statistics</i>					
Multiple R		0,368520178			
R Square		0,135807121			
Adjusted R Square		0,118862163			
Standard Error		0,035586571			
Observations		53			

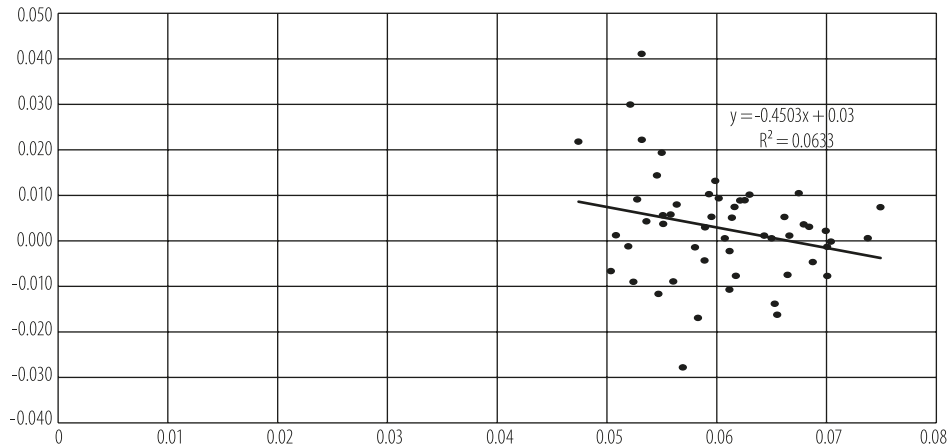
ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0,010149726	0,010149726	8,0146034	0,006624011
Residual	51	0,064586604	0,001266404		
Total	52	0,07473633			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	0,141035789	0,045815326	3,07835394	0,003346695	0,049057684	0,233013894
X Variable 1	-2,131331743	0,75285274	-2,831007489	0,006624011	-3,642746685	-0,619916802

Source: QSA, Eurostat Quarterly Financial Accounts. Share of Capital is calculated as $F.51$ (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

With F-test, we can confirm the significance of the negative relationship between loan growth (y) and capital ratio (x) for the entire period, but we cannot confirm or reject the null hypothesis for the regression slope coefficient, which is indeed rather high at minus 2.13. By recalculating loan growth as a quarterly chain index we reach a higher density of observations in a range of $\pm 10\%$ growth, compared to Chart 5 and consequently a lower negative slope of the linear regression curve in Chart 6. The density of pairs (x,y) now indicates lower variability.

Chart 6: Quarterly growth (chain index) of loans granted by Monetary Financial institutions to the non-financial sector in the European Monetary Union (y) concerning the share of the equity of Monetary Financial Institutions other than Central Bank in Total financial liabilities(x) for end of quarter data from Q1 2009 until Q1 2022



Source: (European Central Bank, 2022) and (European Commission, 2022)

Note: Share of Capital is calculated as F.51 (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics.

Table 4: Summary output for Chart 6 (Post-crisis period, chain index for loan growth)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,251689095
R Square	0,063347401
Adjusted R Square	0,044981663
Standard Error	0,01146071
Observations	53

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0,000453047	0,000453047	3,449216313	0,069060814
Residual	51	0,006698741	0,000131348		
Total	52	0,007151788			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0,029966531	0,014754896	2,030955068	0,047487955	0,000344841	0,059588221
X Variable 1	-0,450293444	0,24245738	-1,857206589	0,069060814	-0,937046946	0,036460058

Source: QSA, Eurostat Quarterly Financial Accounts. Share of Capital is calculated as F.51 (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

Also, t-test statistics can now confirm (see Chart 6 and Summary output, t- Stat for X Variable 1 is lower than lower 95 % bound and therefore we can reject the null hypothesis) non-null or negative slope regression coefficient for the entire period.

It is an interesting question of what is a more precise level of negative co-relationship? We can use the following formula to calculate a confidence interval for the value of β_1 , the value of the slope coefficient for the overall population:

$$\text{Confidence interval for } \beta_1: b_1 \pm t_{1-\alpha/2, n-2} * se(b_1) \quad (8)$$

where: b_1 = Slope coefficient shown in the regression table 5; $t_{1-\alpha/2, n-2}$ = The t critical value for confidence level $1-\alpha$ with $n-2$ degrees of freedom where n is the total number of observations in our dataset and, $se(b_1)$ = The standard error of b_1 shown in the regression table 5.

From Summary Output in Chart 5 and Chart 6, we calculate a 95% confidence interval for the slope regression coefficient.

Table 5: Confidence interval for the slope for y value in two different indexes

Chart 5 – quarterly (y-on-y) loan growth	Chart 6 – quarterly (chain index) loan growth
95% C.I. for β_1 : $-2.13 \pm t_{.975, 53-2} * .572$	95% C.I. for β_1 : $-0.45 \pm 2.0086, 53-2 * .242$
95% C.I. for β_1 : $2.13 \pm 2.0086 * .572$	95% C.I. for β_1 : $-0.45 \pm 2.0086, 53-2 * .242$
95% C.I. for β_1 : $[-0.0924, -3.1168]$	95% C.I. for β_1 : $[0.3778, -0.5962]$

Source: QSA, Eurostat Quarterly Financial Accounts. Share of Capital is calculated as F_{51} (Equity)/ F (Total financial liabilities) for MFI excluding Central Banks (S.121) from numerator and denominator by using BSI, ECB Balance Sheet Statistics. Quarterly loan growth y-on-y basis calculation reduces available observations from 93 to 89.

Since the confidence interval for Chart 5 does not contain the value 0, we can conclude that there is a statistically significant association, and we took a lower bound (-0,0924) for the slope coefficient interval from Chart 5. Somehow with more additional observations, and a letter passing the test of significance for slope at less variability of loans data points (y) in Chart 6, we might expect a real range of slope regression coefficient for population somewhere to -0.6 for the post-crisis period in general. We narrowed the confidence interval from Chart 5 (standard deviation for $Y = 0,038$) in Chart 6 (standard deviation for $Y = 0,012$) by calculating the chain index instead of the y-o-y index. We took the upper bound for slope coefficients interval from Chart 6 (-0,5962).

However, in our future analysis, we need to stay with the calculation of the year-on-year loan growth to include seasonal movement as a particularly important characteristic for some sectors of economic activities which had the highest impact on dividing our entire period of analysis into two very diversified periods in Chart 1.

Discussion and implications

In this article, the reader can find the very first data set for total capital adequacy – the longest time series for the euro area countries simulated as existed in the current EMU19 constitution from the beginning of the time European Monetary Union was founded, by 1st January 1999. We used EUROSTAT financial accounts statistic by the combination of the ECB monetary financial institutions statistics to deploy a proxy to the total capital adequacy ratio for any of the member states and EMU as a whole. Both institutions used the same backwards time series simulation technics for policy analysis. Why are we sure this data is reliable and useful in comparison to today's EBA risk indicators available only from the existence of the SSM, by 1 November 2014, after the biggest financial and economic crisis?

Firstly, looking into the development of supervisory function from its fundamentals, from Herstatt risk in 1974 (NORD/LB, 2017) on and see Chart 3 linear regression for 89 quarterly observations of pairs of dependent and independent variables, the density of actual points offsets and confirm Basel standard development. If we only extract 6%, 8% and 10% capital adequacies of the independent variable (x) with relevant growths of loans granted by MFI to NFI as dependent variables (y) we can generally confirm that the Basel Committee and Banking Supervision (BCBS) based standards and principles regulation framework has been accepted in general and followed by all current member countries, taking data on the whole EMU level (19) back from the first quarter of 1999.

Secondly, the article divides two periods based on what ECB shows in Chart1, as a powerful stimulation source for our article, for the long-term time series of loan growth, granted to NFI by MFI. Generally, starting (basic) hypothesis is confirmed which means that the simple linear relationship that utilizes the capital ratio variable is useful in explaining the variation in the growth of banking loans to non-financial companies on an aggregated euro area level. Here we used all MFI without national central banks and ECB on the side of capital adequacy ratio calculation. For both pre-crisis and post-crisis periods we discovered a controversial situation in testing the basic hypothesis.

Someone would expect that both parts of the sub-hypothesis simply decomposed the general positive co-relationships in the overall observed period (Q1 1999 – Q1 2022). But already Chart 1 can lead us to the possibility that we have two clusters of XY pairs with totally different characteristics for not only the dependent variable but also what our analysis of capital ratio later shows, in respect to an independent variable.

Not one of the three significance tests has been confirmed in the pre-crisis period. On a general aggregated level, not of course on a particular country level, we found almost no dependency alarmed on malfunctioning of supervision on one side and/or mal risk management/corporate governance on the other side until the Lehman Brothers event. And more, by calculating the chain index for loan growth instead of the year-on-year index we lowered the variability of the data set for loan growth used in the post-crisis period and came to reject the hypothesis for the post-crisis period and the negative dependency is confirmed, which shows the extreme need to building up adequate capital capacities and strong Single Supervisory Mechanism rather than the existence of need for banking financing of NFI in the post-crisis period. With explained statistical techniques we even defined a negative confidence interval for the correlation slope coefficient for the post-crisis period (-0,1 to -0,6) in general at the Euro area level.

All in all, the euro area, from its early period to date has been recognized as a normal monetary area where banking capital adequacy takes an important role in creating financial conditions for the non-financial sector, but the natural development towards the idea of banking union as one of European Union policy pillars has been forced by the most severe world economic and financial crisis so far, marked as the Lehman Brothers collapse on 15 September 2008. Extreme differences in development in both periods compared to general expectations (basic hypothesis) confirmed the more political than economic characteristics of the EMU development. From crisis to crisis, the EU and the EMU are building their economic policy institutional framework.

The article already forecasts some ambitions for further analysis in a few directions: (i) country–sectoral distribution analysis, with the potential inclusion of the household sector component analysis, (ii) NPL resolution framework, and (iii) the need to test the SSM with Monetary Policy Concepts (e.g. Quantitative Easing) in the whole period of analysis. The latest is particularly important to further touch upon the following crises: COVID-19, the Ukrainian-Russian crisis, and finally, since we used quarterly sectoral accounts data and with the big gap between financial and real sector accounts, what is today predicted as the next or coming big distortion crisis.

If we assume that the financial liabilities of MFI mainly offsets the bookkeeping of the main financial instrument on the assets side – loans, then we might expect almost perfect regression or effectiveness of the transmission mechanism for the EMU. By providing additional time series for loan variables and capital adequacy variables for other Non – Euro Area Countries and keeping the capital and financial liabilities of National Central Banks in the numerator and denominator of the capital ratio, we can also add a monetary policy perspective to our analysis. Of course, for the independent variable we can also use here data on the level of economic activity for testing (hypothesis) on monetary policy effectiveness (e.g. Quantitative Easing in great Financial and Economic crisis) of the ECB on different Euro Area Economies (PIIGS countries versus other members, solo for Slovenia, etc.).

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