Banks Capital, Risks and Profitability at European Banks

by Giovanni Ferri[a], Valerio Pesic[b]

Abstract

Banks capital level is particularly relevant for prudential regulators, who view an adequate level of capital as a key – even if no longer a sufficient per se – condition to pursue financial stability of a single bank and of the whole banking system. However, determining the right threshold of capital needed to ensure the soundness and stability of the international banking system – finding a correct measure of risk without jeopardizing banking profitability – remains a tough issue to solve. Through this paper we show how regulatory arbitrage – occurring especially within Internal Rating Based (IRB) models – can be detrimental for the pursuit of a fair level playing field. More in particular, focusing on profitability distortions in a large sample of European banks, we find that reporting RWAs below our model prediction Granger-causes higher profitability among banks using IRB-Advanced approaches. Thus, we conclude that regulatory arbitrage via IRB model calibration significantly affects reported profits at European banks.

JEL Classification codes: G2; G21; G28.

Keywords: Banking; Regulatory arbitrage; Profitability; Risk Weighted Assets dispersion; IRB

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1. Introduction

A well established view in the economic banking literature asserts that “higher capital-asset ratio (CAR) is associated with a lower after-tax return on equity (ROE)” (Berger, 1995). The arguments behind this hypothesized negative relationship between capital and earnings have intuitive appeal and are consistent with “standard one-period models of perfect capital markets with symmetric information between a bank and its investors”. Higher capital ratios “reduce the risk on equity” and so “lower the equilibrium expected return on equity required by investors”. Also, higher CARs lower after-tax earnings by cutting the tax shield provided by the deductibility of interest payments.

Despite these arguments, over time empirical evidence in the economics literature found support also for the opposite view. There are various potential explanations for a positive capital-earnings relationship, once the assumptions of the one-period model of perfect and symmetric information are relaxed. Relaxing the one-period assumption allows “an increase in earnings to raise the capital ratio, provided that marginal earnings are not fully paid out in dividends”. Relaxing the perfect capital markets assumption allows “an increase in capital to raise expected earnings by reducing the expected costs of financial distress including bankruptcy”. Finally, relaxing the assumption of symmetric information allows for “a signaling equilibrium in which banks that expect to have better performance credibly transmit this information through higher capital” (Berger, 1995).

Banks capital level is particularly relevant for prudential regulators, who view an adequate level of capital as a key – even if no longer a sufficient per se – condition to pursue financial stability of a single bank and of the whole banking system. However, determining the right threshold of capital needed to ensure the soundness and stability of the international banking system – finding a correct measure of risk without jeopardizing banking profitability – remains a tough issue to solve.

Being aware that the level of capital necessary to comply to the regulatory framework can hinder the profitability of banks – by enlarging (exogenously) the denominator of their Return on Equity ratio (ROE) – supervisors constantly engaged, since the first version of the 1988 Basel Accord, to cushion the negative effects of regulatory requirements on banks profitability.

Over time, supervisors considered different tools to achieve that optimal threshold. They allowed (in the past) banks to include in regulatory capital resources other than common shares and retained earnings. They considered an increasing number of typologies of risks under the Risk Weighted Assets (RWA) formula, so to contemplate the evolution of banking activity and avoid regulatory obsolescence. They reviewed the modalities to compute capital requirements by different approaches, so to stimulate more sophisticated and relevant banks to invest in refined (and complex) methods of risk evaluation, supposedly achieving sounder risk management together with lower absorption of capital. Finally, within the last framework of Basel III, supervisors aimed to make banking sectors more resilient by increasing the quality and quantity of the regulatory capital base, enhancing the risk coverage of the capital framework, proposing a new leverage ratio to protect against model risk and measurement error, and finally introducing a number of macroprudential elements to dampen the procyclicality of the prudential supervisory system.

While there was wide consensus on the new framework, concerns emerged on the relevant efforts by the more sophisticated banks – which were in general those using most sources of funding other than common base – which could considerably impact their profitability profile. By this token, Basel III has been viewed as a possible new spur to improve these banks' capital profile, inciting more discretionary use of the regulatory framework to further reduce capital absorption (Basel Committee on Banking Supervision, 2011).

In the event, the potential bias is if the discretionary use of the regulatory framework moves from a "fair use" of the possibilities offered by regulators to new "enforcing interpretations" of regulatory discretion which might generate the suspicion of "regulatory arbitrage".

In this paper we investigate the potential nexus between regulatory arbitrage and profitability in a relatively large sample of European banks. Via a Granger analysis approach, we identify the effect that regulatory arbitrage can have at more sophisticated banks, the ones adopting Advanced IRB model, to save on capital and by this improve their level of profitability. The evidence supports our hypothesis. We also perform several robustness analyses confirming the main results.

The rest of the paper is structured as follows. The available literature is surveyed in Section 2. Section 3 presents our methodology and describes the data that we meticulously collected. In Section 4 we report and comment the results of our econometric estimates. Finally, in Section 5 we summarize and evaluate the main implications for regulators.

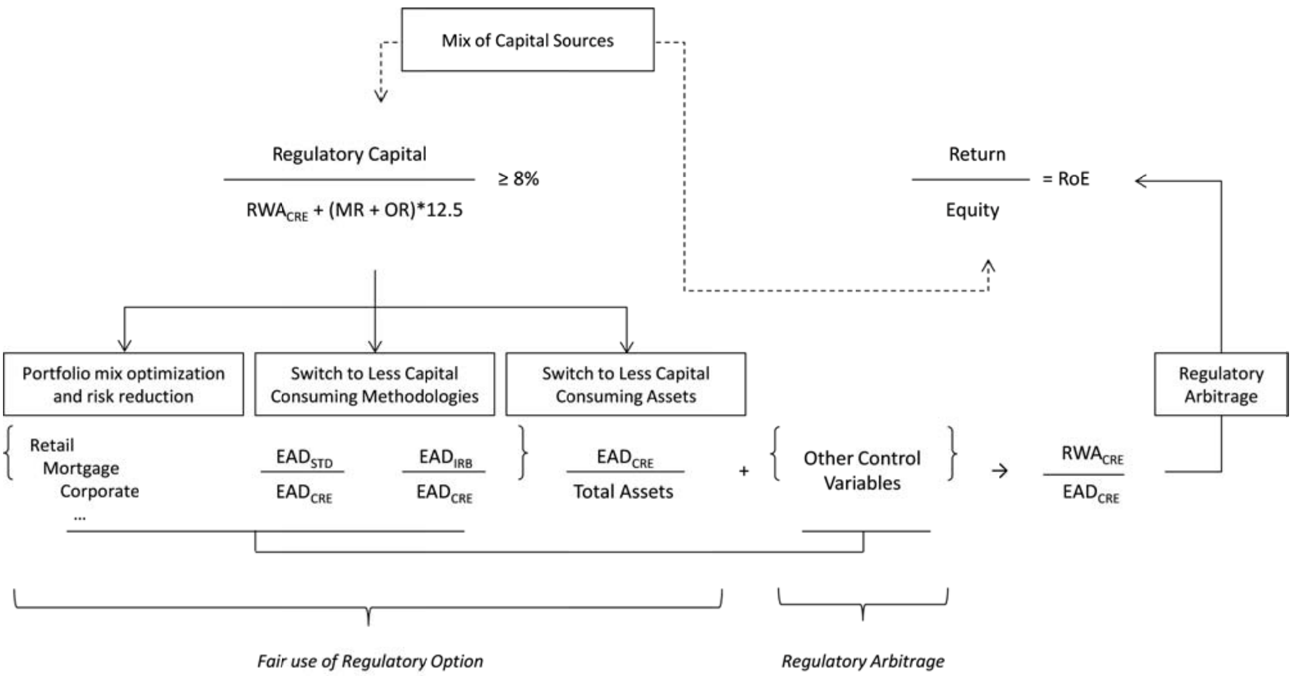
2. Balancing banking stability and banking profitability in the economics literature

Our paper tackles two streams of the economics banking literature. The first, and more recent, one considers the potential bias characterizing regulatory metrics (RWA dispersion) because of regulatory arbitrage, while the second, and more established, investigates the determinants of banks profitability and optimal capital structure.

Since the dispersion among RWAs has become evident even across banks operating in the same jurisdiction and with similar business specialization, supervisors recently started to investigate regulatory arbitrage taking place at banks via RWA calculations [EBA (2013a, 2013b, 2013c, 2014); Basel Committee on Banking Supervision (2013a, 2013b, 2013c); Banco de Espana (2010, 2011, 2012); Banca d'Italia (2012); National Bank of Belgium (2014); IMF (2012a, 2012b, 2015)].

More recently, Mariathasane & Merrouche (2014) and Ferri & Pesic (2017) study the determinants of RWA dispersion by focusing on the effect that the adoption of IRB methodologies can play in reducing capital absorption, via Basel risk-weights manipulation. They both conclude that regulatory arbitrage likely materializes with internal ratings-based (IRB) model adoption, especially among weakly capitalized banks. Specifically, Mariathasane & Merrouche (2014) study the relationship between banks' approval for IRB methods under Basel II and the ratio of RWA to total assets. Instead, focusing on RWA/EAD, Ferri & Pesic (2017) are able to clean the risk weighted density from the roll-out effect generated by banks portfolio shift from Standard to IRB (Figure 1).

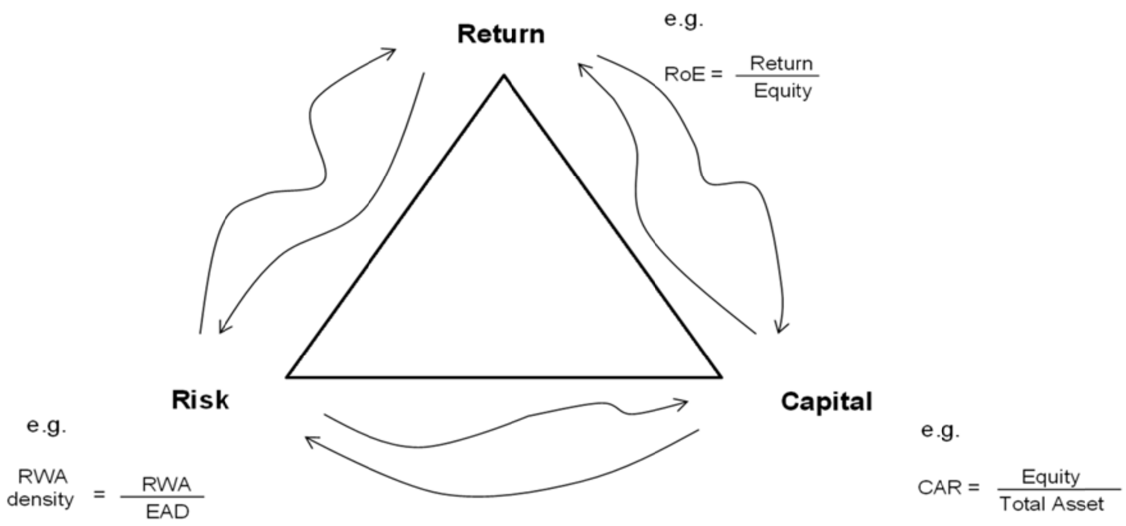
Figure 1 – The Regulatory Capital Framework Puzzle



Over time, significant efforts have been devoted to investigate both the determinants of banks profitability (Berger et al., 1995a; Albertazzi & Gambacorta, 2009; DeYoung & Rice, 2004; Fiordelisi & Molyneux, 2010) and banks capital level optimization decisions (Berger et al., 1995b; Blum, 1999; Estrella, 2004). In particular, the determinants of banks profitability emerge in the recent economics literature on bank business model investigating balance sheets characteristics (Altunbas et al., 2011), income and funding diversification (Demirgüc-Kunt and Huizinga, 2010; Köhler 2016), classification of financial institutions based on their asset and liability mix via cluster analysis (Ayadi et al., 2011) or factor analysis (Mergaerts & Vander Vennet, 2016).

It's difficult to consider those elements together because of their reciprocal nexus of causation (Berger, 1995; Berger & DeYoung, 1997), especially when prudential regulation exogenously impacts capital structure decisions by the management (Kim & Santomero, 1988; Repullo, 2004).

Figure 2 – Reciprocal Causality Between Risk, Profitability and Capital



Moving from that standpoint, in this paper we aim to investigate profitability distortions due to IRB model regulatory arbitrage at European banks, so to verify if potential savings of capital absorption generated by IRB model calibration significantly affect reported profits by these banks. Moreover, considering the relation between capital, profitability and risk, we aim to add a novel contribution on the causal relation between risk and profitability in bank organizations (Figure 2).

3. Methodology of analysis and database

3.1 Methodology of analysis

The main contributions of our econometric analysis are grounded in some features of the data we compiled. It is useful to describe these features. First, we have a quite large number of individual banks (239) and of total bank-year observations (1368) from 29 European countries, covering on average above 80% of total assets of European banks.[1] This supports the quality of our analyses and allows performing various robustness checks.

Second, our data covers a unique period. Specifically, we estimate effects from 2008 up to 2017, thus going well into the euro-crisis, which in various euro countries was much deeper than the sub-

[1] The countries included are: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom.

prime crisis. At the same time, our period is the one leading to the arrival of Basel III, when especially larger banks (maybe the ones relying more on IRB methods) should strive to save capital in achieving the new regulatory requirements, possibly engaging in regulatory arbitrage.

Third, we managed to collect bank data in jurisdictions using different RWA calculation methods. In particular, having many more European banks than previous studies, we can analyze whether and to what extent there is regulatory arbitrage in Europe, an area where regulatory cross-country differences exist but are certainly smaller than when comparing Europe with other world areas.

Fourth, we observe RWAs and EADs, so that we can possibly identify true regulatory arbitrage linked to IRB use to minimize capital requirements. Specifically, we describe how the progressive shift from Standard to IRB models can modify the capital absorption deriving from EADs. To that end, we split our dataset in line with average coverage of EAD portfolio by different methodologies (over 2008-2013). So, we distinguish the following sub-groups of banks in our dataset[2]:

- STANDARD BANKS – banks with EAD portfolio covered purely by the Standard approach;
- IRB BANKS – banks with EAD portfolio covered at least in part by the Foundation-IRB approach, without use of the Advanced-IRB approach;
- IRB ADVANCED BANKS – banks with EAD portfolio covered at least in part by the Advanced-IRB approach.

Comparing results for these different sub-groups will outline the intensity with which banks lower RWA absorption by moving their EADs from Standard to IRB models. This is also a germane contribution, as previous studies considered only IRB banks, disregarding the transition to IRB.

3.2 Dataset description

A preliminary step to our analysis implied a painstaking effort to gather data from individual banks' balance sheets and Pillar Three reports (see also Ferri and Pesic, 2017). Indeed, to the best of our knowledge, at the moment no reliable data on this is available in the commonly used databases for banks. We aimed to cover the most reliable number of European banks, encompassing a significant number of years, so to assess whether the crisis exacerbated the likelihood of regulatory arbitrage.

For each bank we have its Risk Weighted Assets (RWAs) and Exposures At Default (EADs), together with its percentage of EADs referred to, respectively, the Standard model, the Foundation IRB (F-IRB) model, and the Advanced-IRB (A-IRB) model.

To test whether and the extent to which there was "regulatory arbitrage" we focus on the most significant variables. These include potential predictors of the business specialization of a bank and a measure of its risk level.

[2] The approach we follow here builds on that used in Ferri and Pesic (2017).

We look for the relation between the level of risk of each bank, measured by the ratio RWA/EAD, its level of profitability, measured by ROE (ratio of Net Income/Equity), its level of capitalization, captured by the ratio of Equity/Total Asset. For robustness purposes we consider also alternative measures of profitability and risk, such as ROA (ratio of Net Income/Total Asset) and Standard Deviation of ROA. Both those measures confirm our evidence, highlighting that especially among the more sophisticated (Advanced IRB) banks profitability can be affected by regulatory arbitrage. Therefore, the most relevant bank level dependent variables we consider are:

- RWA/EAD – ratio between RWA and EAD, the risk weighted assets density, corresponding to regulatory measure of banks assets riskiness[3];
- ROE – ratio of Net Income to Equity, corresponding to our chief measure of bank profitability, representing the main objective of banks' management;
- EQUITY – ratio of equity to total assets. We define this ratio similarly to the *leverage ratio* of the Basel III capital framework, which is viewed as a safeguard against model risk and measurement error more effective than other ratios controlling for the level of bank capitalization – i.e. ratio between equity and EAD, or ratio between equity and RWA.

Other variables included in our analysis are:

- ROA – ratio of Net Income to Total Assets, representing our robustness measure of bank profitability, which we considers in order to control for the capability of bank's profitability without the effect of leverage achieved by potential arbitrage capital saving;
- SD(ROA) – standard deviation of ROA, representing our robustness of bank riskiness, which we calculated over a moving average of e years period;
- F-IRB - EAD portfolio coverage by Foundation-IRB methodology (F-IRB), which we view as the most common regulatory option aiming to reduce RWA/EAD (namely "roll out" effect);
- F-IRB SQ - squared of F-IRB, which we consider to control for then on-linearity of F-IRB effects on RWA density[4]

[3] Despite having collected data also on market and operational risks, we focus only on credit risks, still representing the most relevant component of European banks' overall risk, or at least of the banks oriented to lending activity. Moreover, despite having collected data of a high detailed quality with the distinguished ratio of RWAs density for the different regulatory approaches (Standard, IRB Foundation, IRB Advanced), we only focus on the total credit portfolio RWAs density, taking the percentage mix between standard and IRB approach as a determinant of RWAs dispersion.

[4] The key reason why one may envisage a non-linear relationship between the extent of F-IRB (and also of A-IRB) and RWA/EAD has to do with the behavior of supervisors and banks. In practice, supervisors might be lenient seeing reductions in RWA/EAD at a bank that is starting to shift its initial portfolio shares from Standard to F-IRB (or from F-IRB to A-IRB) but they might worry noticing analogous RWA/EAD reductions when that bank has already transferred a large part of its portfolio from Standard to F-IRB (or from F-IRB to A-IRB). Anticipating possible supervisors' reactions, banks already using F-IRB (or A-IRB) to a large extent might limit the reduction of RWA/EAD when shifting additional portfolio shares from Standard to F-IRB (or from F-IRB to A-IRB).

- A-IRB - EAD portfolio coverage by Advanced-IRB methodology (A-IRB), which we view as a further common regulatory option aiming to reduce RWA/EAD (namely "roll out" effect);
- A-IRB SQ - squared of A-IRB, which we consider to control for the non-linearity of A-IRB effects on RWA density;
- LOANS/LIABILITIES − ratio between net loans and total liabilities, viewed as a proxy of the leverage realized by each bank between borrowed funds and loans granted;
- SIZE− logarithm of total assets, to control for possible size related differences;
- LISTED − dummy variable − with value of 1 if the bank is listed and 0 otherwise − to control for the potential discipline exercised by capital markets;
- STATE AID − dummy variable which takes the value of 1 if the bank received any specific intervention during the period of our analysis;
- STRESS TEST – dummy variable which takes the value of 1 if the bank has been included in at least one of the EBA 2010 stress tests during the period of our analysis;
- NPL/LOANS – ratio of Impairment Charge to Net Loans, representing the cost for bank to write off the Non Performing Loans;
- ASSETS GROWTH – increase in total assets, perhaps negatively related to RWA/EAD since faster growing banks can more easily adjust their portfolio composition;
- Z-SCORE − measure of the bank's probability of insolvency (defined as in Hesse and Cihak, 2007), which we view as a variable potentially controlling for the bank's "true risk exposure";
- OFF/TA – ratio of Off-Balance Sheet Items to Total Assets, which we view as a variable potentially controlling for a bank's "true risk exposure". In this case, the variable can be considered like a regulatory option offered by regulation, even if we cannot exclude that it may be used as an instrument of regulatory arbitrage, especially by banks adopting the more sophisticated F-IRB and A-IRB methods;
- OTHER/TA – ratio of Other On-Balance Sheet Items considered in EAD portfolio to Total Assets, which we consider as a further variable potentially controlling for the bank's "true risk expo-sure". (We estimated this variable as the residual between EAD minus the OFF-Balance Sheet and Loans). Also here, the variable can be viewed as an option offered by regulation, even if we can-not exclude that it may be used as an instrument of regulatory arbitrage, especially by banks adopting the more sophisticated F-IRB and A-IRB approaches;
- RESOLVING INSOLVENCY - Resolving Insolvency Rank as obtained from the World Bank's dataset Doing Business. We con-sider this variable to control for the potential discipline exercised by the strength of the national legal system
- L.GDP GROWTH lagged increase in Country's GDP;

- OVERALL CREDIT STANDARD - national EAD portfolio coverage under Standard Methodology. We consider that variable to control for the potential discipline exercised by supervisors of the national legal system, as well as when the increase of banks utilizing IRB may lead to a relaxation of supervisory scrutiny.

Table 1 reports descriptive statistics on the most relevant variables considered in our analysis, reported by the Total Sample, Standard Banks, F-IRB Banks and A-IRB Banks.

– Table 1 about here –

Table 2 presents the Correlation Matrix among the variables. As expected, there some positive pairwise correlation upon some variables which we use as alternative measures within our robustness checks.

– Table 2 about here –

3.3 Features of Our Granger Causality Analysis

To test whether and the extent to which there was "regulatory arbitrage" and whether it intensified under lower level of capital and profitability, we focus on three fundamental variables, in the order measuring profitability, capital adequacy and risk. Since those variables are characterized by a not easy to disentangle problem of reciprocal causation, we decided to use (in line with some previous analyses) a Granger causality approach.

Granger-causality tests have been widely used to analyze inter-temporal relationships in the economic literature and in banking studies (e.g. Fiordelisi et al., 2011; Fiordelisi and Molyneux, 2010; Casu and Girardone, 2009; Williams, 2004; Berger and De Young 1997; Berger, 1995). In a Granger causality contest we know that if the reverse is not true and "lagged values of X help predict current values of Y in forecast formed lagged values of both X and Y, then X is said to Granger cause Y" (Thurman and Fisher, 1988): in such a way through this approach we aim to investigate this kind of "chickens and eggs" dilemma on the following variables: Risk = RWA/EAD; Profitability = Ratio of Net Income/Equity; Capitalization = Ratio of Equity/Total Asset.

In particular, to control for the intertemporal relationship among those three variables, we consider two lags and estimate an AR(2) process for the risk, profitability and capital variables. Therefore, following Fiordelisi et al. (2011), we assess Granger causality as the joint test of the null hypothesis that the two lags are equal to zero. With the AR(2) process, we analyze Granger causality as the joint test that the two lags of each of the determinants are distributed as chi-square with two degrees of freedom. If the probability is less than 10%, then the null hypothesis that X Granger causes Y is rejected at the 10% significance level. We also assess the 'long-run effect' of X on Y by testing the restriction that the sum of all lagged coefficients is zero: in this case, a rejection of the restriction implies that there is evidence of a long-run effect of X on Y.

Since the introduction of a lagged dependent variable among the predictors creates complications in the estimation as that variable is correlated with the disturbance, we use the Generalized Method of Moments (GMM) system estimators developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998). Specifically, after controlling for alternative methods, we consider the Sys-GMM Blundell and Bond (1998) model as most suitable to our purpose. For all specifications we apply the Windmeijer correction to reported standard errors, showing the results for Sargan/Hansen tests of over identifying restrictions and Arellano-Bond tests for autocorrelation of first and second order.

4. Empirical analysis

4.1. Results of the econometric analysis

Table 3 reports the results for the first Granger analysis we applied among the level of risk, profitability and capital on our sample of European banks. In this case, we consider ROE as our measure of profitability, which we aim to analyze since we argue it should benefit from the potential reduction of the level of capital, more than other measures such as ROA, Net Income, etc. To measure risk undertaken by each institution, we use RWA/EAD, the RWA density, which is also a prudential measure of risk, that is affected by potential bias, as the economics literature has started to highlight (Mariathasan & Merrouche, 2014, Ferri & Pesic, 2017). Finally, we capture the level of capitalization with EQUITY, defined as the ratio of Equity to Total Assets. We define this ratio similarly to the leverage ratio of the Basel III capital framework, instead of other definitions (e.g. ratios of Equity to RWA, Equity to EAD, Equity to Loans, etc.), since it represents a more effective safeguard against model risk and measurement error.

We perform our analysis on the total and on the following different sub-groups of banks: Total Sample, Standard Banks, F-IRB Banks, A-IRB Banks. In this way, we aim to consider the effects that could derive from the potential regulatory arbitrage generated by a bank's regulatory accounting choices. For the Total Sample (first section of Table 3) we seem to find no clear Granger-causal nexus, since each variable seems to cause only itself, perhaps confirming the goodness of the Sys-GMM model considered, as proposed by Blundell and Bond (1998). The second section reports the results for Standard Banks, where we find negative Granger-causality from Equity to RWA/EAD, which means that better capitalized banks undertake less risk. This evidence is not surprising, as it is often noticed that, e.g. smaller-sized banks are generally both more capitalized and less prone to undertake risks. The third and the forth sections refer to respectively F-IRB and A-IRB banks: for both sub-groups we find positive Granger-causality from ROE to RWA/EAD, suggesting that more profitable banks seem to engage in higher level of risk in terms of capital absorbing activities. At the same time, in F-IRB we find also negative Granger-causality from ROE to Equity, so that it appears that more profitable banks can also decide to reduce their level of capital, which, along Berger (1995), can be viewed as a sort of cushion against the uncertainty on future performance. The circumstance that the latter nexus is absent at A-IRB banks might depend on supervisors' severe scrutiny and push on these banks to increase their capital levels. The same type of reasoning might also explain the positive Granger-causal nexus from RWA/EAD to Equity. In all, especially for F-IRB and A-IRB banks, Table 4 results are neither particularly surprising nor counterintuitive but in line with the expectation of sounder and safer management of banks.

– Table 3 about here –

In Table 3 the RWA density, as given by the ratio of RWA to EAD, as the measure of risks undertaken by a bank, is considered. Nevertheless, we know this measure can be influenced by several factors, which can be related to any characteristic of banks' business model, as well as to any problem arising from the use of regulatory metrics. For that reason, in order to control for the effect that this last component can determine for bank's profitability, we decide to split the RWAs density into a systematic component depending on the assets share a bank has shifted to IRB and its orthogonal component. To perform this objective we define a two-step methodology of analysis, with the first step regressing the RWA/EAD by its most relevant determinants (Table 4). Afterwards, the second step considers the predicted error component of the first regression, as alternative measure for the risks undertaken by banks, to be analyzed via Granger analysis together with the level of profitability and capitalization (Table 5).

In Table 4 we represent the goodness of the model utilized to predict the RWAs density, by considering all the most relevant component which can be related to the bank's specific characteristics or the macroeconomic system. By this perspective, it is possible to notice that the adoption of the IRB methodology, Foundation or Advance, as expected, determines the reduction of

RWAs density, although that relation appears to be not linear. Moreover, it is possible to notice the variable STRESS TEST to increase the RWA density, as the scrutiny by the EBA can have a influence in increasing it, whilst the level of Impairment Charge (NPL/LOANS) and ASSETS GROWTH contribute to reduce it. Finally, it is useful to consider, thank to very high significant of the lagged dependent variable, capturing persistence, the good capacity of the model to explain the RWA/EAD ratio, with a pseudo R2 which is about 0.90. For that reason we consider like the variables considered in that regression should explain adequately the dispersion of RWA among European banks, leaving in the error component the potential effects of other factors, such as model calibration or risk weight manipulation, which we consider as potential evidence of regulatory arbitrage.

– Table 4 about here –

In Table 5 we perform a Granger analysis, similar to Table 3, but considering the residual component obtained from Table 4, as a more correct measure of risks undertaken by each bank, together with variables previously analyzed, the profitability and the level of capital. By this perspective, Table 5 show a very interesting result, with the component RESIDUAL which seems to perform a different role when considering the Total Sample versus the A-IRB Banks. More in particular, whilst in the Total Sample we notice a positive Granger causality from RESIDUAL to ROE, suggesting that undertaking more risks (by increasing RWA density) increase the profitability at banks, in A-IRB the Granger causality becomes negative and significant at 5 %, suggesting that the reduction of RWA/EAD, as explained by the error component of the previous model of the determinants of RWA density, appears to explain the profitability in banks, where the more sophisticated A-IRB methodologies are utilized. Moreover, in Standard banks we find also negative Granger-causality from ROE to EQUITY, which appears to confirm the hypothesis that the more profitable banks can decide to reduce their level of capital. Finally, in F-IRB banks we notice a negative Granger causality from EQUITY to ROE, suggesting that high level of capital hamper the profitability of those banks, potentially enlarging the denominator of ROE ratio.

4.2. Robustness checks

We test the robustness of our main results via some different estimates. We first decide to perform an alternative Granger analysis, by considering the difference of RWA/EAD of each bank from the average of the Total Sample. We consider that variable, here defined as DIF RWA, as an alternative measure for RWA dispersion among our sample, to be analyzed together with the level of profitability and capitalization. By this perspective, Table 6 seems to mainly confirm the evidence obtained from Table 5, with the component of RWA dispersion, which positively Granger cause profitability at Standard Banks, whilst at A-IRB that relation continues to be negative. Therefore, it seems to be confirmed the hypothesis that more sophisticated banks, by adopting A-IRB methodologies, can be prone to ameliorate (by reducing) their risk weights and therefore realized an higher level of profitability. Table 6 shows also a negative Granger causality from ROE to EQUITY for Total Sample and F-IRB Banks, whilst a positive Granger causality from DIF RWA to EQUITY appears for F-IRB and A-IRB. We do not consider that last evidence as a potential weakness of our analysis, since EQUITY represents the ratio between Equity and Total Assets, so that it could depend from other strategies of the banks aiming at modifying their business model, rather than by the reduction of RWA.

– Table 6 about here –

Since the level of Equity could represent a fundamental discriminant for banks management behaviors, in our second robustness check we decided to split our sample into 2 groups, distinguishing the higher capitalized banks, which we represent like the ones with Equity upper the mean of the Total Sample, versus the lower capitalized banks, which are the ones with Equity lower the mean of the Total Sample. Then, we perform a Granger analysis similar to Table 5 for each of those sub-groups, with results which are reported respectively in Table 7a and 7b.

When considering the analysis performed upon the group of higher capitalized banks (Table 7a), we notice as the negative Granger causality from RESIDUAL to ROE in A-IRB Banks is preserved, confirming the hypothesis of regulatory arbitrage upon the more sophisticated banks. Moreover, here we notice a negative and high significant negative Granger causality from ROE to EQUITY for all the sub sample considered, with the exception of A-IRB banks. By this perspective, if we consider that during last years supervisors aimed to increase the quality and quantity of the regulatory capital base especially at larger banks, it seems to be confirmed the hypothesis that the more profitable banks can decide to reduce their level of capital. Table 7a exhibits also a positive Granger causality from EQUITY to RESIDUAL at Standard and F-IRB Banks, which can be consider in line with the expectation of sounder and safer management of banks. On the opposite, less intuitive appears to be the Granger causality from RESIDUAL to EQUITY at F-IRB banks, which otherwise should be interpreted as a result of any modification upon banks' business model composition.

– Table 7a about here –

In Table 7b we report the results obtained upon the sample of less capitalized banks. In this case, we notice a positive Granger causality from RESIDUAL to ROE, only for the Total Sample, whilst not any evidence of regulatory arbitrage seems to be present at F-IRB and A-IRB banks. Table 7b exhibits a negative Granger causality from EQUITY to ROE for the Total Sample and Standard banks, confirming that high level of capital can hamper the profitability of those banks, potentially enlarging the denominator of ROE ratio. On the opposite, in A-IRB banks we notice a negative Granger causality from EQUITY to RESIDUAL, which seems to be reasonable since the lower level of capital can reduce the capability of banks in undertaking risks. Finally, when looking at F-IRB banks we notice a negative Granger causality from ROE to RESIDUAL, which can be interpreted as a strategy implemented by the most profitable banks to reduce capital absorption, which can be interpreted within the negative Granger causality from ROE to EQUITY, confirming the hypothesis that also in less capitalized banks the aim at reducing the level of capital can persist.

– Table 8b about here –

In our third and last robustness check we perform a Granger analysis considering two alternative definition of profitability and risk. By this perspective, since the variable ROE and RWA dispersion should be influenced by the potential regulatory arbitrage occurring when utilizing the more sophisticated A-IRB methodology, in this analysis we consider ROA and its Standard Deviation (SD), as alternative measure of profitability and risk. Therefore, this Granger analysis performed upon the variables ROA, SD(ROA) and EQUITY can be interpreted as a robustness check of the previous analysis, without the influence of any regulatory "constraints". By this perspective, although for the Total Sample and Standard Banks we do not find any particular evidence (there is only a negative Granger causality from ROA to SD(ROA) in the Total Sample), some very interesting outcomes emerge upon the F-IRB and A-IRB banks. For both of them we notice a positive and significant Granger causality from SD(ROA) to ROA, meaning that the undertaking of risk leads to higher level of profitability. At the same time, Table 8 exhibits a positive and even stronger Granger causality from SD(ROA) to EQUITY, meaning that riskier banks decide to hold more capital, as potential protection against potential losses. Moreover, both at F-IRB and A-IRB banks is possible to notice a negative Granger causality from ROA to SD(ROA). Finally, in F-IRB banks is possible to notice a negative Granger causality from EQUITY to ROA, whilst a positive causality moves from ROA to EQUITY.

– Table 8 about here –

5. Conclusions

The capital requirement approach established with the Basel I Accord at the end of the 1980s was revised significantly at the end of the 1990s with the Basel II Accord. The main change consisted in allowing banks to set aside capital by distinguishing each asset's risk profile, a change that was also confirmed by the Basel III Accord. In practice, since Basel II banks were allowed to assign an ex ante risk class to each asset they held. Banks' assets can be broken down into two broad categories: Assets traded on markets and Other Assets. For market traded assets banks could rely on a market based assessment of the related risk. However, a large part if not the bulk of banks' assets is made of loans, for which market assessments are lacking. Here, Basel II ruled that banks could either rely on a primitive (STANDARD) approach or develop sophisticated Internal Risk Based models, along the IRB approach. In turn, a bank could adopt the IRB approach itself either in a less complex way (IRB Foundation) or in a more sophisticated way (IRB Advanced).

IRB methods – though to varying degrees between the Foundation and Advanced methods – allow banks to self determine the risk class of borrowers. Obviously, supervisors play a role in terms of providing validation to IRB models and lacking validation the banks would not be permitted to use those models. However, clearly each IRB bank enjoys some discretion in assigning risk classes and, thus, in determining risk weights against the loans it grants. This opens up the possibility for a bank to have some leeway in affecting its own Risk Weighted Assets (RWAs) and, through this, to influence its own capital requirements. Finally, if a bank can lower its own capital requirements it will also be in the condition to report higher levels of Return on Equity (RoE).

In this paper, we started observing that RWAs dispersion across similar banks raises the concern of regulatory arbitrage via IRB models maneuvering. Two problematic distortions would then derive for regulators and supervisors. First, by this type of regulatory arbitrage a bank might appear more solid than it effectively is. Second, and here the concern is also for investors, that regulatory arbitrage would allow banks to report higher returns on equity than what would be appropriate.

We focused on profitability distortions due to IRB model regulatory arbitrage and used yearly data assembled for 239 European banks over 2008-2017. Moreover, we distinguished banks along their IRB regulatory choices: Standard banks – those using no IRB approach; IRB-F banks – those employing (some) IRB Foundation methods but no IRB Advanced methods; IRB-A – those using (some) IRB Advanced methods. Besides, in view of the fact that a bank's RWA density, profitability and capitalization may all be intertwined in relationships that are hard to disentangle, we used a Granger-causality approach. Prima facie, our results found no evidence of a causality running from RWA density to either RoE or capitalization. However, reality may be different. What if reported RWA densities embodied some regulatory arbitrage? It would then be desirable to estimate how a banks' RWA density deviates from its theoretical value. Along this reasoning, we took a two-step approach. First, we ran an ancillary regression on the key drivers of RWA density. And, then, in the Granger analysis, we replaced the RWA density with its own (orthogonal) residuals from the ancillary regression. It turned out that the error component of the RWA density negatively Granger-causes profitability at IRB-A banks. In other words, exactly among the banks that have the most leeway in self-determining their Basel risk weights – the IRB-A banks – we found that reporting lower RWA density than forecasted by the ancillary regression – which raises the suspicion of regulatory arbitrage – causes higher profitability. By and large, this result proved insensitive to a battery of robustness checks. Thus, we may conclude that regulatory arbitrage via IRB model calibration significantly affects reported profits at European banks.

The policy prescriptions one could derive from our analysis are rather simple. It is not advisable for regulators and supervisors to apply a "hands off" approach and let banks large degrees of freedom in operating their IRB models. Otherwise, the results could prove very costly to those investors lured in buying bank shares by overrated profitability and still have problems of bank stability. These concerns have already led to somewhat downplay the role of the RWA approach – e.g., think of the growing importance of alternative approaches such as Stress Testing and Assets Quality Evaluation. If, nevertheless, regulators and supervisors wish to keep the RWA approach, we can envisage that they will need to become much more proactive in terms of aggressive verification of the IRB models and, more generally, adopting a "hands on" approach to banking supervision.

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Annexes

Tab. 1 – Dispersion of Profitability and Other Variables

STATS	ROE	RWA/EAD	EQUITY	ROA	SD(ROA)	STANDARD	F-IRB	A-IRB	NPL LOANS	ASSETS GROWTH	LOANS/ LIABILITIES	SIZE	Z-SCORE	OFF/TA	OTHER/TA	LISTED	STATE AID	STRESS TEST	RESOLVING INSOLVENCY	GDP GROWTH	OVERALL CREDIT STANDARD
mean	2.84	46.30	7.01	0.27	0.54	63.56	16.79	19.69	5.12	3.86	70.22	17.43	40.25	14.06	34.40	0.37	0.15	0.25	66.92	0.00	50.35
p90	14.82	73.00	12.00	1.13	1.14	100.00	80.00	83.00	12.00	18.51	88.89	19.91	66.17	29.44	70.80	1.00	1.00	1.00	88.60	3.30	87.51
p75	10.11	59.00	9.00	0.62	0.44	100.00	0.00	38.00	7.00	7.85	79.45	18.76	41.01	18.83	44.70	1.00	0.00	0.00	83.30	1.81	76.83
p50	5.39	46.00	6.00	0.27	0.18	100.00	0.00	0.00	4.00	0.96	65.67	17.31	20.73	10.59	25.09	0.00	0.00	0.00	72.60	0.38	51.15
p25	1.44	33.00	4.00	0.06	0.08	24.00	0.00	0.00	1.00	-4.43	45.45	16.12	7.41	3.73	12.87	0.00	0.00	0.00	48.40	-1.59	25.13
p10	-16.71	18.00	2.00	-0.63	0.04	0.00	0.00	0.00	0.00	-11.82	25.38	15.25	2.37	0.28	-1.57	0.00	0.00	0.00	39.20	-4.39	14.12
sd	12.91	20.83	6.84	0.73	1.31	40.22	32.58	34.65	6.28	20.87	183.95	1.86	229.66	15.89	70.15	0.48	0.36	0.43	18.56	2.99	26.23
N	1339	1345	1341	1339	1086	1345	1345	1345	1345	1309	1252	1341	1335	1205	1198	1345	1345	1345	1339	1345	1345

MEAN (by BANKS)	ROE	RWA/EAD	EQUITY	ROA	SD(ROA)	STANDARD	F-IRB	A-IRB	NPL LOANS	ASSETS GROWTH	LOANS/ LIABILITIES	SIZE	Z-SCORE	OFF/TA	OTHER/TA	LISTED	STATE AID	STRESS TEST	RESOLVING INSOLVENCY	GDP GROWTH	OVERALL CREDIT STANDARD
Standard	2.95	52.34	8.35	0.30	0.67	100.00	0.00	0.00	5.71	5.76	83.27	16.46	50.36	12.97	41.32	0.36	0.11	0.08	61.13	-0.14	59.40
F-IRB	3.72	38.31	5.88	0.28	0.42	25.89	74.20	0.00	4.33	4.13	58.40	17.96	28.76	14.79	32.08	0.22	0.19	0.38	73.15	0.18	42.60
A-IRB	1.88	41.31	5.38	0.18	0.39	24.58	1.11	74.40	4.63	0.06	56.46	18.84	30.54	15.45	23.81	0.53	0.20	0.46	72.81	0.11	39.33

Tab. 2 – Correlation Matrix

	ROE	RWA/ EAD	EQUITY	ROA	SD(ROA)	STD	F-IRB	A-IRB	NPL LOANS	ASSETS GROWTH	LOANS/ LIABILITIES	SIZE	Z-SCORE	OFF/TA	OTHER/TA	LISTED	STATE AID	STRESS TEST	RESOL INSOL	GDP GROWTH	OVERALL STD
ROE	1.0000																				
RWA/ EAD	-0.1689	1.0000																			
EQUITY	0.1786	0.1566	1.0000																		
ROA	0.8876	-0.0517	0.3573	1.0000																	
SD(ROA)	-0.3176	0.0556	0.2379	-0.2546	1.0000																
STD	-0.0262	0.3068	0.1975	0.0034	0.1219	1.0000															
F-IRB	0.0557	-0.1864	-0.0815	0.0477	-0.0604	-0.5402	1.0000														
A-IRB	-0.0213	-0.1774	-0.1493	-0.0475	-0.0830	-0.6397	-0.3012	1.0000													
NPL LOANS	-0.3964	0.3584	0.0468	-0.3444	0.2900	0.1765	-0.0943	-0.1136	1.0000												
ASSETS GROWTH	0.2305	-0.0304	-0.0043	0.1936	-0.1819	0.1196	-0.0010	-0.1347	-0.0948	1.0000											
LOANS/ LIABILITIES	0.0458	-0.0240	0.7776	0.0951	0.2488	0.0977	-0.0417	-0.0726	-0.0234	-0.0168	1.0000										
SIZE	0.0137	-0.2564	-0.3591	-0.1099	-0.1994	-0.4848	0.0884	0.4689	-0.0944	-0.1083	-0.1763	1.0000									
Z-SCORE	0.0603	-0.0054	0.0460	0.0776	-0.0563	0.0407	-0.0267	-0.0217	-0.0534	0.0292	-0.0008	-0.0168	1.0000								
OFF/TA	0.0864	0.0691	0.0705	0.0987	-0.0409	-0.0692	0.0393	0.0423	-0.0176	0.0191	-0.0493	0.0587	-0.0316	1.0000							
OTHER/TA	0.0951	-0.3114	0.1713	0.1452	0.1254	0.1275	-0.0691	-0.0814	-0.0423	-0.0039	-0.0200	-0.1631	-0.0432	-0.2306	1.0000						
LISTED	-0.0215	0.2311	-0.0095	0.0129	-0.0064	0.0339	-0.1664	0.1138	0.1436	0.0236	-0.0205	0.1478	-0.0305	0.1085	-0.1647	1.0000					
STATE AID	-0.3188	0.1012	-0.1524	-0.3171	0.1872	-0.0946	0.0549	0.0570	0.2307	-0.1911	-0.0314	0.1601	-0.0695	-0.0019	-0.0804	0.0581	1.0000				
STRESS TEST	-0.0748	-0.0695	-0.1353	-0.1232	-0.0492	-0.3482	0.1608	0.2480	0.0699	-0.1136	-0.0549	0.5466	-0.0590	0.0221	-0.1087	0.2449	0.3141	1.0000			
RESOL INSOL	-0.0077	-0.2328	-0.2321	-0.1077	-0.1271	-0.2964	0.1243	0.2223	-0.1858	-0.0296	-0.0820	0.2919	-0.0486	-0.0184	0.0051	-0.1658	0.0676	0.1590	1.0000		
GDP GROWTH	0.1424	-0.1240	0.0254	0.1511	-0.0476	-0.0903	0.0425	0.0634	-0.1348	0.0280	-0.0173	0.0309	0.0383	-0.0141	0.0415	-0.0207	-0.0791	-0.0657	-0.0089	1.0000	
OVERALL STD	-0.1178	0.4158	0.1702	-0.0099	0.1414	0.3603	-0.1203	-0.2986	0.3576	0.0131	0.0039	-0.3966	-0.0729	0.1103	-0.0313	0.1169	0.0734	-0.0893	-0.5064	-0.1177	1.0000

Tab. 3 – Granger causality for the relationship among banking profitability, risk-taking (RWA/EAD) and capital

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROE	RWA/EAD	EQUITY	ROE	RWA/EAD	EQUITY	ROE	RWA/EAD	EQUITY	ROE	RWA/EAD	EQUITY
L.ROE	0.4902***	0.6799	-2.8462	0.3325**	-0.7109	-2.1905	0.0128	17.3347***	-4.2784*	0.1015	31.1615**	-2.9073*
	0.135	*10.186*	*2.476*	*0.157*	*8.755*	*1.734*	*0.193*	*6.426*	*2.245*	*0.126*	*12.352*	*1.525*
L2.ROE	0.0779	-1.8416	-1.7035	0.1925	10.4932*	-0.3542	0.1985	-11.4854*	-4.1932*	0.1614	-9.4591	0.9949
	0.089	*4.223*	*1.662*	*0.118*	*5.887*	*2.433*	*0.124*	*5.899*	*2.228*	*0.118*	*7.854*	*0.936*
ROE Total	0.5681***	-1.1617	-4.5497	0.525*	9.7823	-2.5447	0.2113	5.8493***	-8.4716**	0.2629	21.7024**	-1.9124
	0.288	*8.667*	*9.967*	*1.456*	*7.939*	*9.462*	*6.763*	*7.939*	*9.462*	*6.763*	*0.992*	*3.252*
L.RWA/EAD	0.0018	0.9191***	0.086	0.0044	1.0319***	0.0867	0.0007	0.9172***	0.1039**	-0.0029	0.6525***	-0.0184
	0.004	*0.219*	*0.102*	*0.003*	*0.162*	*0.123*	*0.002*	*0.159*	*0.047*	*0.002*	*0.220*	*0.023*
L2.RWA/EAD	-0.0011	0.1212	-0.0881	-0.0043	-0.0556	-0.0909	0.0001	-0.0167	-0.0940**	0.0037*	0.0981	0.0522**
	0.003	*0.196*	*0.090*	*0.003*	*0.148*	*0.116*	*0.002*	*0.196*	*0.045*	*0.002*	*0.166*	*0.024*
RWA/EAD Total	0.0007	1.0403***	-0.0021	0.0001	0.9763***	-0.0042	0.0008	0.9005***	0.0099*	0.0008	0.7506***	0.0338*
	9.958	*0.288*	*14.384*	*8.929*	*0.200*	*9.981*	*5.284*	*0.200*	*9.981*	*5.284*	*0.152*	*4.232*
L.EQUITY	0.0037	0.7678*	1.1654***	0.0047	0.236	0.8643***	-0.014	-0.6522	0.9870***	0.0301*	0.5495	0.5161***
	0.008	*0.414*	*0.166*	*0.006*	*0.305*	*0.303*	*0.013*	*0.398*	*0.267*	*0.017*	*0.879*	*0.169*
L2.EQUITY	-0.0072	-0.8510**	-0.2245	-0.0056	-0.6330**	-0.0465	0.0072	0.6533	-0.1092	-0.0262*	-0.9235	0.3556***
	0.005	*0.346*	*0.154*	*0.005*	*0.271*	*0.234*	*0.009*	*0.411*	*0.210*	*0.014*	*0.706*	*0.113*
EQUITY Total	-0.0035	-0.0832	0.9409***	-0.0009	-0.397**	0.8178***	-0.0068	0.0011	0.8778***	0.0039	-0.374	0.8717***
	9.471	*6.175*	*0.288*	*9.982*	*2.500*	*0.200*	*7.483*	*2.500*	*0.200*	*7.483*	*6.187*	*0.152*
CONSTANT	0.0026	-2.5697	0.9361	0.0048	3.918	1.9464**	0.0321	1.9457	1.1122	-0.0444	10.2463*	-0.4542
	0.061	*4.234*	*0.843*	*0.074*	*5.086*	*0.832*	*0.072*	*2.758*	*0.991*	*0.091*	*5.585*	*1.150*
N	828	828	828	402	402	402	230	230	230	227	227	227
N(g)	236	236	236	122	122	122	66	66	66	73	73	73
AR1-p	0	0.0476	0.003	0.0042	0.002	0.0026	0.0407	0.0184	0.0019	0.0627	0.0684	0.0682
AR2-p	0.27	0.2885	0.0653	0.2972	0.6694	0.0029	0.8277	0.5962	0.2048	0.9715	0.172	0.4643
J	34	34	34	34	34	34	34	34	34	34	34	34
Hansen df	27	27	27	27	27	27	27	27	27	27	27	27
Hansen-p	0.0042	0.604	0.0692	0.1273	0.2591	0.0377	0.4194	0.5406	0.5388	0.3455	0.4688	0.1564

The variables ROE Total, RWA/EAD Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Tab. 4 – Ancillary regression controlling for the determinants of RWA/EAD

	RWA/EAD
L.RWA/EAD	0.9818***
	0.096
F-IRB	-0.1387***
	0.043
F-IRB SQ	0.0012***
	0.000
A-IRB	-0.1455**
	0.058
A-IRB SQ	0.0013**
	0.001
LOANS/LIABILITIES	0.0000
	0.002
SIZE	0.2043
	0.344
LISTED	-0.5570
	0.812
STATE AID	-0.5882
	0.720
STRESS TEST	1.3541**
	0.653
NPL/LOANS	-0.1640*
	0.088
ASSETS GROWTH	-0.0796***
	0.023
Z-SCORE	-0.0003
	0.000
OFF/TA	-0.0069
	0.013
OTHER/TA	-0.0131
	0.011
RESOLVING INSOLVENCY	-0.0198
	0.018
L.GDP GROWTH	0.1545
	0.160
OVERALL CREDIT STD	0.0056
	0.018
Tau2010	1.5350
	1.232
Tau2011	1.3494*
	0.741
Tau2012	-0.3632
	0.753
Tau2013	0.3550
	0.910
CONSTANT	-0.2514
	9.615
N	954
N(g)	225
AR2-p	0.3764
J	40
Hansen df	17
Hansen-p	0.6016
R2	0.9035

Tab. 5 – Granger causality for the relationship among banking profitability, risk-taking (RWA/EAD's residual) and capital

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY
L.ROE	0.6297***	0.0040	-0.0070	0.1775	0.0491	0.0068	0.1750	0.0691	-0.0494	0.2009	0.1068	-0.0250
	0.172	*0.110*	*0.027*	*0.223*	*0.085*	*0.020*	*0.234*	*0.121*	*0.039*	*0.140*	*0.118*	*0.016*
L2.ROE	0.0854	-0.0133	-0.0214	0.3380**	0.0150	-0.0379**	0.2423**	-0.0345	-0.0375	0.2549*	0.0051	0.0029
	0.094	*0.053*	*0.016*	*0.162*	*0.062*	*0.016*	*0.123*	*0.058*	*0.025*	*0.133*	*0.054*	*0.009*
ROE Total	0.7151***	-0.0093	-0.0284	0.5155**	0.0641	-0.0311**	0.4173	0.0346	-0.0869	0.4558**	0.1119	-0.0221
	0.227	*4.583*	*6.957*	*2.806*	*6.625*	*3.161*	*3.835*	*5.608*	*4.541*	*1.838*	*5.961*	*5.775*
L.RESIDUAL	0.1584	-0.4916*	0.0112	0.6772*	-0.1324	0.0374	-0.4300	-0.3392	0.0267	-0.5639**	-0.6757***	-0.0207
	0.454	*0.271*	*0.092*	*0.348*	*0.182*	*0.054*	*0.500*	*0.364*	*0.062*	*0.236*	*0.219*	*0.017*
L2.RESIDUAL	0.2303**	-0.0495	0.0088	0.1917	0.0259	0.0169	0.2295	-0.0581	0.0173	0.1083	-0.0385	-0.0109
	0.115	*0.063*	*0.012*	*0.132*	*0.062*	*0.018*	*0.175*	*0.130*	*0.019*	*0.125*	*0.117*	*0.019*
RESIDUAL Total	0.3887*	-0.5411	0.0200	0.8689	-0.1065	0.0543	-0.2005	-0.3973	0.0440	-0.4556**	-0.7142***	-0.0316
	6.171	*8.114*	*9.886*	*4.819*	*7.272*	*7.642*	*5.820*	*5.811*	*5.987*	*2.288*	*0.352*	*6.221*
L.EQUITY	-0.3638	0.9486	0.5574	-0.1008	0.4046	0.3736*	-2.5449**	-0.0568	0.6749***	-0.4025	-0.1631	0.3809
	0.917	*0.613*	*0.386*	*0.533*	*0.264*	*0.221*	*1.186*	*0.635*	*0.236*	*1.321*	*1.284*	*0.241*
L2.EQUITY	0.0284	-0.7009	0.4284	0.2167	-0.2667	0.6001***	2.2019*	0.4397	0.2567*	0.1658	-0.5562	0.4737***
	0.768	*0.681*	*0.375*	*0.465*	*0.307*	*0.232*	*1.206*	*0.614*	*0.144*	*1.144*	*0.970*	*0.172*
EQUITY Total	-0.3354	0.2477	0.9858***	0.1159	0.1379	0.9737***	-0.343*	0.3829	0.9316***	-0.2367	-0.7193	0.8546***
	10.957	*7.958*	*0.227*	*5.111*	*5.983*	*0.153*	*3.487*	*5.494*	*0.122*	*4.134*	*5.110*	*0.124*
CONSTANT	1.7342	-1.6609	0.4277*	-1.9845	-1.6309	0.3439	3.1717	-1.8094	1.1806	1.7670	4.3937	1.2056*
	2.317	*1.449*	*0.253*	*3.235*	*1.168*	*0.278*	*4.829*	*2.804*	*0.777*	*3.078*	*2.884*	*0.718*
N	515	515	515	235	235	235	148	148	148	155	155	155
N(g)	198	198	198	96	96	96	56	56	56	65	65	65
AR1-p	0.0111	0.8133	0.503	0.2803	0.0457	0.9737	0.0721	0.93	0.6601	0.0477	0.5493	0.0613
AR2-p	.	.	.	.	.	.	.	.	.	.	.	.
J	27	27	27	27	27	27	27	27	27	27	27	27
Hansen df	20	20	20	20	20	20	20	20	20	20	20	20
Hansen-p	0.1284	0.4021	0.0088	0.8083	0.2042	0.1649	0.3176	0.7129	0.9157	0.4424	0.7038	0.0632

The variables ROE Total, RESIDUAL Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Tab. 6 – Granger causality for the relationship among banking profitability, risk-taking (DIF_RWA) and capital

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROE	DIF_RWA	EQUITY	ROE	DIF_RWA	EQUITY	ROE	DIF_RWA	EQUITY	ROE	DIF_RWA	EQUITY
L.ROE	0.4940***	-8.8469	-2.8378	0.2883	-5.3315	-3.4757	0.0856	15.1512**	-3.9419*	0.0068	17.7516	-1.0068
	0.143	*8.856*	*2.209*	*0.186*	*9.285*	*2.326*	*0.212*	*7.670*	*2.278*	*0.164*	*11.849*	*1.964*
L2.ROE	0.0873	1.0011	-1.3783	0.2342*	11.6576**	0.7498	0.1578	-9.4557	-4.0924*	0.2102*	-7.1727	0.1346
	0.085	*3.960*	*1.938*	*0.135*	*5.627*	*3.130*	*0.122*	*5.882*	*2.307*	*0.110*	*6.915*	*0.903*
ROE Total	0.5813***	-7.8458	-4.2161**	0.5225***	6.3261	-2.7259	0.2434	5.6955**	-8.0343*	0.217	10.5789	-0.8722
	0.288	*14.075*	*5.953*	*1.400*	*6.353*	*7.235*	*7.369*	*6.353*	*7.235*	*4.614*	*7.044*	*4.939*
L.DIF_RWA	0.0048	0.7120**	0.1598	0.0065**	1.0394***	0.1251	0.0006	0.8717***	0.1240**	-0.0039**	0.6418***	0.0084
	0.004	*0.325*	*0.158*	*0.003*	*0.160*	*0.135*	*0.003*	*0.211*	*0.057*	*0.002*	*0.200*	*0.031*
L2.DIF_RWA	-0.0043	0.2433	-0.1298	-0.0065**	-0.0695	-0.1193	-0.0003	0.0316	-0.1046*	0.0027	0.0811	0.0560**
	0.004	*0.281*	*0.136*	*0.003*	*0.146*	*0.128*	*0.003*	*0.253*	*0.055*	*0.002*	*0.143*	*0.027*
DIF_RWA Total	0.0005	0.9553***	0.03	0.0002*	0.9699***	0.0058	0.0003	0.9033***	0.0194*	-0.0012*	0.7229***	0.0644*
	14.361	*0.288*	*14.280*	*5.464*	*0.200*	*9.581*	*2.436*	*0.200*	*9.581*	*3.451*	*0.213*	*4.398*
L.EQUITY	-0.0009	1.1432**	1.0574***	0.0013	0.2714	0.8397***	-0.0108	-0.3542	0.9641***	0.0224*	1.3523	0.4558***
	0.010	*0.518*	*0.219*	*0.006*	*0.274*	*0.297*	*0.013*	*0.367*	*0.253*	*0.012*	*1.076*	*0.169*
L2.EQUITY	-0.0017	-1.0955***	-0.1305	-0.0018	-0.6163**	-0.0021	0.004	0.3026	-0.0966	-0.0158	-1.4097	0.3520***
	0.006	*0.408*	*0.191*	*0.005*	*0.278*	*0.240*	*0.009*	*0.384*	*0.184*	*0.010*	*0.947*	*0.099*
EQUITY Total	-0.0026	0.0477**	0.9269***	-0.0005	-0.3449*	0.8376***	-0.0068	-0.0516	0.8675***	0.0066	-0.0574	0.8078***
	11.236	*4.571*	*0.288*	*4.802*	*4.444*	*0.200*	*6.910*	*4.444*	*0.200*	*5.976*	*6.872*	*0.150*
Constant	0.0238	0.0572	0.7935	-0.0043	3.7085*	1.3689**	0.0678	-1.1337	1.5531*	-0.0207	-1.4356	1.6292*
	0.039	*1.802*	*0.485*	*0.037*	*2.018*	*0.604*	*0.046*	*2.280*	*0.849*	*0.041*	*2.540*	*0.850*
N	828	828	828	402	402	402	230	230	230	226	226	226
N(g)	236	236	236	122	122	122	66	66	66	73	73	73
AR1-p	0	0.0476	0.003	0.0042	0.002	0.0026	0.0407	0.0184	0.0019	0.0627	0.0684	0.0682
AR2-p	0.27	0.2885	0.0653	0.2972	0.6694	0.0029	0.8277	0.5962	0.2048	0.9715	0.172	0.4643
J	34	34	34	34	34	34	34	34	34	34	34	34
Hansen df	27	27	27	27	27	27	27	27	27	27	27	27
Hansen-p	0.0042	0.604	0.0692	0.1273	0.2591	0.0377	0.4194	0.5406	0.5388	0.3455	0.4688	0.1564

The variables ROE Total, DIF_RWA Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Tab. 7a– Granger causality for the relationship among banking profitability, risk-taking (RWA/EAD's residual) and capital –more capitalized banks

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY
L.ROE	-0.0720	-0.1312	0.0627	-0.2362	0.1023	-0.0055	0.4236***	-0.0406	0.1190***	0.1140	0.1653	-0.0198
	0.132	*0.134*	*0.071*	*0.283*	*0.121*	*0.024*	*0.161*	*0.159*	*0.039*	*0.256*	*0.147*	*0.046*
L2.ROE	0.1089	0.0983	-0.0847*	0.1522	-0.1240	-0.0471**	-0.0219	0.1052	-0.1212**	0.2356	0.0470	-0.0224
	0.158	*0.064*	*0.043*	*0.377*	*0.124*	*0.023*	*0.210*	*0.085*	*0.051*	*0.148*	*0.155*	*0.017*
ROE Total	0.0369	-0.0329	-0.022**	-0.0840	-0.0217	-0.0526**	0.4017***	0.0646	-0.0022***	0.3496**	0.2123	-0.0422
	6.674	*7.438*	*3.050*	*4.219*	*5.373*	*1.152*	*0.091*	*4.360*	*0.878*	*1.480*	*4.223*	*2.969*
L.RESIDUAL	-0.1546	-0.3885***	-0.0158	0.0682	0.1835	0.0990	-0.1956	-0.6463***	0.0408	-0.4640**	-0.6041***	0.0169
	0.290	*0.142*	*0.081*	*0.488*	*0.271*	*0.095*	*0.227*	*0.126*	*0.077*	*0.201*	*0.203*	*0.034*
L2.RESIDUAL	-0.0328	-0.0916	0.0084	0.1031	0.0044	0.0099	-0.2713	-0.1472	-0.0726*	-0.0068	-0.0611	-0.0001
	0.095	*0.058*	*0.022*	*0.135*	*0.073*	*0.019*	*0.171*	*0.216*	*0.040*	*0.196*	*0.083*	*0.031*
RESIDUAL Total	-0.1874	-0.4801***	-0.0074	0.1713	0.1879	0.1089	-0.4669	-0.7935***	-0.0322**	-0.4708*	-0.6151**	0.0168
	5.619	*1.278*	*4.122*	*4.796*	*5.301*	*5.480*	*3.919*	*0.091*	*1.514*	*1.929*	*0.912*	*2.724*
L.EQUITY	0.7011	0.0068	0.4941	0.2924	0.3698***	0.2418**	-0.1997	-1.3751***	1.2049***	0.2113	0.4500	0.3540***
	0.759	*0.427*	*0.400*	*0.402*	*0.101*	*0.099*	*1.272*	*0.459*	*0.216*	*0.973*	*0.889*	*0.136*
L2.EQUITY	-0.2759	0.1500	0.5521	0.2149	-0.2068	0.7688***	0.2538	1.4225	-0.3378	-0.4574	-0.4152	0.4669***
	0.755	*0.370*	*0.374*	*0.376*	*0.183*	*0.108*	*1.834*	*0.903*	*0.379*	*0.817*	*0.717*	*0.135*
EQUITY Total	0.4252	0.1568	1.0462***	0.5073	0.1630***	1.0106***	0.0541	0.0474***	-0.21731***	-0.2461	0.0348	0.8209***
	5.976	*7.560*	*0.162*	*4.530*	*0.291*	*0.110*	*1.136*	*0.705*	*0.091*	*4.181*	*3.064*	*0.085*
CONSTANT	1.7342	-1.6609	0.4277*	-1.9845	-1.6309	0.3439	3.1717	-1.8094	1.1806	1.7670	4.3937	1.2056*
	2.317	*1.449*	*0.253*	*3.235*	*1.168*	*0.278*	*4.829*	*2.804*	*0.777*	*3.078*	*2.884*	*0.718*
N	261	261	261	121	121	121	82	82	82	72	72	72
N(g)	101	101	101	49	49	49	32	32	32	32	32	32
AR1-p	0.1758	0.2508	0.1696	0.6842	0.2366	0.8745	0.0282	0.5793	0.0294	0.0458	0.8928	0.1629
AR2-p	.	.	.	.	.	.	.	.	.	.	.	.
J	27	27	27	27	27	27	27	27	27	27	27	27
Hansen df	20	20	20	20	20	20	20	20	20	20	20	20
Hansen-p	0.5956	0.4434	0.4895	0.6787	0.6973	0.3679	0.404	0.6377	0.5646	0.4412	0.2526	0.3362

The variables ROE Total, RESIDUAL Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Tab. 7b– Granger causality for the relationship among banking profitability, risk-taking (RWA/EAD's residual) and capital –less capitalized banks

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY	ROE	RESIDUAL	EQUITY
L.ROE	0.6182***	-0.0565	-0.0461*	0.3801**	-0.0194	-0.0170	0.1276	0.1117	-0.0368**	0.3237**	0.1604	-0.0201*
	0.176	*0.101*	*0.025*	*0.156*	*0.091*	*0.020*	*0.173*	*0.139*	*0.018*	*0.136*	*0.116*	*0.012*
L2.ROE	0.1905*	0.0072	0.0093	0.3397**	0.0455	-0.0174	0.4673***	-0.2121**	-0.0052	0.1708	0.0488	0.0108
	0.113	*0.067*	*0.016*	*0.153*	*0.062*	*0.017*	*0.157*	*0.106*	*0.017*	*0.170*	*0.073*	*0.009*
ROE Total	0.8087***	-0.0493	-0.0368	0.0404***	0.0261	-0.0344	0.5949***	-0.0951**	-0.0420*	0.4945**	0.2092	-0.0093
	0.159	*5.688*	*5.904*	*0.107*	*4.539*	*5.122*	*0.081*	*1.705*	*2.042*	*1.119*	*4.241*	*3.316*
L.RESIDUAL	-0.3274	-0.3167	-0.1096*	-0.0133	-0.2200	0.0255	-0.9420	0.3631	-0.0632	0.0671	-0.7272***	0.0156
	0.466	*0.342*	*0.064*	*0.236*	*0.138*	*0.048*	*0.633*	*0.366*	*0.051*	*0.238*	*0.219*	*0.028*
L2.RESIDUAL	0.3352*	0.0918	-0.0129	0.1221	0.1340	0.0147	0.4568	-0.0161	0.0220	0.4605*	-0.1916	0.0125
	0.191	*0.119*	*0.023*	*0.182*	*0.086*	*0.032*	*0.300*	*0.120*	*0.017*	*0.277*	*0.173*	*0.021*
RESIDUAL Total	0.0078**	-0.2249	-0.1225	0.1088	-0.086*	0.0402	-0.4852	0.3470	-0.0412	0.5276	-0.9188***	0.0281
	2.143	*7.955*	*6.524*	*4.321*	*1.348*	*3.858*	*3.290*	*3.990*	*2.838*	*3.845*	*0.481*	*3.835*
L.EQUITY	-4.0288**	2.0188	0.8906**	-0.3454	0.1201	0.7913***	-3.5290	0.4256	0.2539*	0.3560	-2.9580	1.2117***
	1.865	*1.345*	*0.367*	*1.738*	*1.077*	*0.255*	*2.461*	*0.998*	*0.141*	*4.250*	*2.833*	*0.222*
L2.EQUITY	0.0800	-1.0804	-0.1832	-2.1050*	0.2199	-0.0907	0.8075	0.6421	0.1650	-0.5504	-1.5200	-0.3161
	1.331	*1.223*	*0.296*	*1.188*	*0.959*	*0.263*	*1.639*	*0.817*	*0.147*	*4.742*	*2.787*	*0.274*
EQUITY Total	-3.9488**	0.9384	0.7074***	-2.4504*	0.3400	0.7006***	-2.7215	1.0677	0.4189	-0.1944	-4.478**	0.8956***
	1.815	*7.396*	*0.159*	*3.071*	*3.842*	*0.107*	*3.781*	*4.057*	*3.157*	*0.822*	*1.309*	*0.091*
CONSTANT	19.0391***	-5.0954	1.7226**	11.9833	-2.1820	1.9353*	9.0554	-3.8523	2.7487***	-1.4119	23.0412***	0.7286
	6.812	*5.251*	*0.860*	*9.660*	*3.928*	*1.077*	*8.199*	*3.770*	*0.967*	*10.111*	*7.754*	*0.825*
N	254	254	254	114	114	114	66	66	66	83	83	83
N(g)	97	97	97	47	47	47	24	24	24	33	33	33
AR1-p	0.0612	0.3864	0.3601	0.4119	0.1258	0.6705	0.0929	0.207	0.7425	0.0623	0.5318	0.0125
AR2-p	.	.	.	.	.	.	.	.	.	.	.	.
J	27	27	27	27	27	27	27	27	27	27	27	27
Hansen df	20	20	20	20	20	20	20	20	20	20	20	20
Hansen-p	0.6522	0.5548	0.181	0.3926	0.9236	0.4093	0.8208	0.6126	0.5581	0.3007	0.3467	0.405

The variables ROE Total, RESIDUAL Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Tab. 8 – Granger causality for the relationship among banking profitability (ROA), risk-taking (SD(ROA)) and capital

	Total Sample			STD Banks			FIRB Banks			AIRB Banks		
	ROA	SD(ROA)	EQUITY	ROA	SD(ROA)	EQUITY	ROA	SD(ROA)	EQUITY	ROA	SD(ROA)	EQUITY
L.ROA	0.4902*	-0.5730*	-0.4019	0.3963	-0.0747	1.6281	0.5573**	0.0887	1.0099	0.0253	-0.0032	-0.6284
	0.278	*0.338*	*0.954*	*0.254*	*0.414*	*1.215*	*0.271*	*0.180*	*0.842*	*0.164*	*0.132*	*0.419*
L2.ROA	0.0079	-0.2440*	-0.2051	-0.0012	-0.6644	-0.7637	0.4027*	-0.3973**	0.5887*	0.4036***	-0.3320**	0.4603*
	0.162	*0.135*	*0.527*	*0.118*	*0.555*	*0.690*	*0.232*	*0.188*	*0.314*	*0.155*	*0.132*	*0.277*
ROA Total	0.4981*	-0.8170**	-0.6070	0.3951	-0.7391	0.8644	0.9600***	-0.3086*	1.5986*	0.4289***	-0.3352***	-0.1681
	5.729	*3.018*	*11.798*	*7.595*	*7.863*	*8.174*	*0.131*	*3.323*	*3.334*	*0.888*	*0.287*	*5.121*
L.SD(ROA)	-0.2447*	0.8721**	-0.4417	-0.0040	1.5127***	0.6924	0.4327*	0.3400	1.7732***	0.0614	0.2640	-0.1824
	0.139	*0.362*	*0.460*	*0.152*	*0.432*	*0.538*	*0.229*	*0.223*	*0.540*	*0.118*	*0.179*	*0.246*
L2.SD(ROA)	0.2523	-0.0677	0.6960	-0.1831	-0.4644	-0.3319	0.1853	0.5049***	1.0903**	0.3770**	0.2111	1.1901***
	0.157	*0.323*	*0.660*	*0.199*	*0.401*	*0.538*	*0.178*	*0.127*	*0.490*	*0.149*	*0.170*	*0.335*
SD(ROA) Total	0.0076	0.8044***	0.2543	-0.1871	1.0483***	0.3605	0.6180**	0.8449***	2.8635***	0.4384**	0.4751***	1.0077***
	9.901	*0.244*	*12.080*	*6.280*	*0.167*	*8.050*	*2.538*	*0.131*	*0.131*	*1.950*	*0.128*	*0.515*
L.EQUITY	0.1289**	0.1061	1.1599***	0.0697	0.1735*	0.5622**	-0.1788**	-0.1454*	0.0165	0.0531	-0.0026	0.6222**
	0.063	*0.121*	*0.290*	*0.044*	*0.091*	*0.262*	*0.071*	*0.075*	*0.238*	*0.102*	*0.148*	*0.304*
L2.EQUITY	-0.0998*	-0.0691	-0.1024	-0.0080	-0.1898*	0.0092	0.0830**	0.0319	0.3845***	-0.0907	0.0057	0.1694
	0.057	*0.119*	*0.153*	*0.047*	*0.115*	*0.219*	*0.038*	*0.040*	*0.133*	*0.080*	*0.108*	*0.179*
EQUITY Total	0.0291	0.0370	1.0575***	0.0617	-0.0163	0.5714**	-0.0958**	-0.1135	0.4010***	-0.0376	0.0031	0.7916***
	7.392	*11.363*	*0.244*	*7.231*	*6.016*	*1.799*	*2.488***	*4.691*	*0.949*	*5.413*	*2.800*	*0.129*
CONSTANT	-0.1304	0.1172	-0.1003	-0.3669	0.5436	3.2434**	0.2725	0.7630***	2.2129***	0.1430	0.1962	1.1895
	0.271	*0.559*	*1.249*	*0.339*	*0.607*	*1.315*	*0.212*	*0.256*	*0.835*	*0.199*	*0.216*	*0.750*
N	593	593	593	280	280	280	171	171	171	165	165	165
N(g)	226	226	226	111	111	111	65	65	65	69	69	69
AR1-p	0.0027	0.253	0.0008	0.0091	0.0647	0.0071	0.2948	0.7354	0.6034	0.1292	0.7716	0.0018
AR2-p	.	.	.	.	.	.	.	.	.	.	.	.
J	27	27	27	27	27	27	27	27	27	27	27	27
Hansen df	20	20	20	20	20	20	20	20	20	20	20	20
Hansen-p	0.4094	0.4212	0.0022	0.0447	0.4977	0.053	0.4619	0.8276	0.5723	0.3659	0.4199	0.0594

The variables ROA Total, SD(ROA) Total, EQUITY Total are the estimated coefficients for the test that the sum of lagged terms is equal to zero. A significance level lower than 10% enables to reject the null hypothesis of no causality from the x to the y. A coefficient greater than zero show a positive causation from the x to the y; a coefficient smaller than zero show a negative causation from the x to the y. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.