# COMPETITION, SECURITIZATION, AND EFFICIENCY IN U.S. BANKS

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*Abstract:* Using a sample of 74,533 U.S. commercial bank observations from the Call Report of Condition and Income, we investigate the impact of competition and securitization on cost and technical efficiency. We find that market power, as measured by the Lerner index, increases U.S. banks' overall cost and technical efficiency. Additional tests empirically confirm a negative and significant impact of securitization, particularly after the recent financial crisis, on efficiency. We also show that higher incentives to securitize loans in the most restricted and concentrated states reduce banks' overall efficiency. All these results are in favor of the Dodd-Frank Act and may help regulators to avoid the inefficiency consequences of securitization by contributing to a sustainable quality of U.S. loans.

*JEL Classification:* D4; G21.

*Key Words:* Securitization; Bank Competition; Bank Efficiency; Bank Performance; Deregulation.

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## 1. Introduction

The tremendous evolution of the U.S. bank deregulation, starting from the gradual fall of the legal barriers to interstate banking and the federal government's passage of Interstate Banking and Branching Efficiency Act (IBBEA) of 1994 to the introduction the Dodd-Frank Act in 2010, have heightened interest in U.S. banking competition and securitization. The high level of the latter[1] has commonly been identified as the main source of the crisis in the financial system.[2] An evolving body of academic research argues that highly securitized banking markets are characterized by a low loan quality for subprime mortgages (Mian and Sufi, 2009; Keys et al., 2010; Purnanandam, 2011; Dell'Ariccia et al., 2012) as well as for corporate loans (Berndt and Gupta, 2009; Gaul and Stebunovs, 2009).

Securitization involves pooling thousands of mortgages together; selling the pool to a special purpose vehicle that finances their purchase by issuing investment-grade securities with different seniority in the capital markets.[3] This financial technique starts with a bank selling loans to remove them from its balance sheet to generate profits by issuing other loans. These loans are transferred to the special purpose vehicle and placed in one big pool.[4] In broad terms, the proximate cause of the financial crisis that started in 2007 was the collapse of housing bubbles in the U.S., accompanied by a significant increase in securitization activities, stimulated by the huge demand for triple-A securities by foreigners, insurance companies, money market funds, and other investors.[5] Ivashina and Scharfstein (2010) show that lending declined in all categories after the reduction of banks' exposure to mortgage-related debt.

Despite having established the basic importance of securitization, as well as the U.S. banking market structure, the research effort has not turned to the analysis of the mechanisms through which competition affects the financial system performance. What is the impact of banking competition on U.S. banks' cost and technical efficiency during and after the last Great

[1] The U.S. market for securitized loans has grown considerably since the 1970s, reaching 40% of all outstanding loans in 2007, and exceeding the size of the corporate bond market after the financial crisis.

[2] Acharya et al. (2013) argue that banks retain risks in their balance sheets through various securitization methods, which allow a reduction in regulatory arbitrage, a phenomenon that eventually caused the largest crisis since the Great Depression.

[3] Loutskina (2011) show that securitization provides liquidity for banks by converting illiquid loans into marketable securities.

[4] See Gorton et al. (2012) for more details about securitization.

[5] Shleifer and Vishny (2010) argue that bank profits grew significantly due to these activities. More specifically, the net income by assets of the four largest bank holding companies increased, e.g. ,129% for Bank of America, 243% for JP Morgan Chase, 41% for Citigroup, and 57% for Wells Fargo.

Depression that started in 2007? Does securitization have a positive or a negative impact on those efficiencies? What is the influence of securitization on the competition-efficiency nexus? Does this effect change among other characteristics, such as banks' upper and lower efficiency scores, institutional size and branch deregulation restrictiveness?

This paper goes straight in the heart of this academic strand by assessing whether U.S. commercial banks have improved their efficiency through increasing levels of competition and securitization.

First, whether competition is "good" or "bad" for bank efficiency continues to be a mixed and contradictory theory and empirical evidence, we contribute to the ongoing debate about competition-efficiency by empirically providing a clear and significant negative impact of U.S. bank competition on efficiency.

Second, to our best knowledge, no prior studies have investigated the impact of securitization on bank efficiency. Some empirical works have focused on how to reduce the systemic risk caused by securitization[6], but have not provided comprehensive evidence concerning the impact of securitization on bank efficiency. Using U.S. commercial banks data, Casu et al. (2014) find that securitization has an insignificant impact on bank performance. However, we find that securitization has a negative and significant impact on bank performance, as measured by cost and technical efficiency.[7]

Furthermore, the economic theory posits that banks engaged in securitization are able to improve their performance, including the reduction of funding costs and the enhancement of profitability.[8] Shleifer and Vishny (2010) propose a theory of financial intermediaries operating in markets influenced by investor sentiments. The latter contributes to biased expectations or institutional preferences. Furthermore, Shleifer and Vishny (2010) develop a model where banks make, securitize, distribute, and trade loans, or they hold cash. In this model, banks co-invest in newly securitized loans when asset prices are high and buy-and-hold onto distressed securities when asset prices are low. Hence, securitizing assets is quite profitable in good times and increases investments[9], but can be distorted in favor of projects

[6] See, for instance, Benmelech et al. (2012); Keys, Mukherjee, Seru and Vig, (2010); Mian and Sufi (2009).

[7] Matousek et al. (2014) use the efficiency scores as a measure of bank performance when conducting research about the relationship between convergence and bank performance during the financial crisis.

[8] The Office of the Controller of Currency (OCC, 1997) argues that banks have the possibility to diversify interest income and expenses and increase liquidity through securitization channels.

[9] According to Bech and Rice (2009), the period between 2002 and 2006 witnessed a significant increase of 50% in U.S. commercial banks' aggregate net income.

available for securitization during bubbles, which can reduce efficiency, even without any costs of cyclical fluctuations.

Third, it is important to consider the financial crisis period when analyzing the competition-efficiency nexus in the U.S. Moreover, we analyze how securitization affects this nexus, particularly between 2007 and 2009 where mortgage prices fell down sharply. Even in the aftermath of the crisis, achieving high levels of cost efficiency became crucial for banks' survival. Martin-Oliver et al. (2013) emphasize the importance of the efficiency measures after the recent financial crisis. In competitive banking markets, banks providing services at the lowest costs are rewarded by profits. Furthermore, according to the "quiet life" hypothesis, bank management benefits from monopolistic power to capture some rents for inefficiencies in the allocation of resources (Hicks, 1935). These inefficiencies are reflected in the reduction of banks' screening and monitoring incentives. The existence of managerial incentives, as pointed by Rajan (1994), may distort reported profits.

Fourth, our study is the first to empirically test the theoretical models that study the relation between competition and securitization. This is an important improvement, in that we are able to test more directly whether the important level of securitization has a significant influence on the impact through which competition affects bank efficiency, or whether instead, the effect may be different among large banks.

In other words, we investigate the impact of a joint interaction between competition and securitization on U.S. banks' cost and technical efficiency. Breton et al. (2014) consider a simple duopoly model of the loan market where banks compete for borrowers and argue that banks generate more profits as a consequence of a high level of securitization by extracting rents from their borrowers in the primary loan market. These profits are explained by the counterpart of future losses by unsuspecting final investors in the secondary market.[10]

Regarding the methodological contributions, we consider the endogeneity concerns that arise when attempting to estimate the impact of competition on efficiency by using an instrumental variable approach (IV). We also use a difference-in-difference approach to assess the changes in efficiency levels when securitization levels change.

In terms of variables, we take into account both parametric and non-parametric approaches as well as the cost to income ratio to study U.S. commercial banks' efficiency. We also use an

[10] Breton et al. (2014) also demonstrate that the intention of securitization to soften competition is the main reason for reducing monitoring and screening incentives.

indicator of bank market power, the conventional and the inefficiency-adjusted Lerner index, as well as an innovative indicator of banking competition, the Boone indicator.
Using data from the Call Report of Condition and Income with more than 74,000 U.S. bank observations over the period of 2005–2013, we improve a new added perspective to the impact of competition on efficiency as well as to the securitization implications on the originating banks' efficiency.

We start with an instrumental variable regression to address the endogeneity issue between Lerner index of concentration and efficiency. The results confirm the adequacy of the instruments and reject the theories that predict a positive impact of competition on efficiency. We then perform an ordinary least-square regression using various types of securitized loans and find that banks securitize home and commercial loans in an attempt to improve their performance, while the farm and multifamily loans reduce their overall efficiency.
We next move to the difference-in-difference approach to gauge the joint impact of competition and securitization on banks' overall performance. The results suggest that as banks' securitization activities have increased in a concentrated banking structure, their cost and technical efficiency have decreased. This is statistically significant and consistent with previous studies about securitization and cost-efficiency maximization incentives.

We perform several robustness checks to confirm our key findings. We run regressions separately on large banks, we use alternative measures of competition and efficiency, and we analyze the effect of competition and securitization for the less and the most efficient banks through a simultaneous quantile regression. All our results remain statistically significant. Most importantly, we find that banks engaged in more securitization activities and performing in the most restricted states, as shown by Rice and Strahan (2010)'s index of interstate branching restrictions, are less cost and technical efficient than other banks operating in more competitive states.

The policy implications of our paper emphasize the importance of the Dodd-Frank Act, which targets maximizing the financial system stability, through the measures promoting banks' survival. In other words, the negative influence of securitization on efficiency is in favor of the Dodd-Frank Act. These results may help regulators to avoid the inefficiency consequences of the securitization transactions, and hence contribute to a sustainable quality of U.S. loans in the future.

Our paper is structured as follows. Section 2 establishes the related literature in defining and studying the implications of competition and securitization. Section 3 focuses on the methodology and data used to estimate competition and efficiency. In section 4, we present the main competition-efficiency nexus model, while in section 5 we present the methods to estimate competition-securitization-efficiency relationship. Section 6 presents the empirical results, and section 7 concludes.

## 2. Related Literature

Financial innovation (securitization)[11] is stimulated by competition. Akins et al. (2014) argue that competition increases financial stability by enhancing innovation and efficiency. Moreover, concentrated markets increase risk-taking in the case of guarantee for "too-big-to-fail" banks. Safety net policies offer "too-big-to-fail" subsidies to large banks, which enhances their risk-taking incentives and destabilizes the financial system as a whole (Anginer and Warburton, 2011; Kane, 1989). In contrast, competition is considered the main factor of financial crisis by stimulating securitization during the subprime crisis.

Our paper differs from the literature by emphasizing the role of securitization in the competition-efficiency nexus. For this reason, we revisit the literature on the competition-efficiency. After that, we discuss recent work tackling the benefits, the motivations, and the effects of securitization on the originating banks generally.

### *2.1. Competition - Efficiency*

Studying the impact of banking competition on efficiency is a rather established topic in the banking literature. Our main contribution is considering the influence of securitization on this nexus, especially in the after math of the recent financial crisis. First, we briefly discuss the ongoing debate reflecting contradictory hypotheses and empirical results about competition and efficiency in banking.

"Competition-efficiency" is analyzed through two large contradictory theories: "Structure conduct performance" versus "New Empirical Industrial Organization". We briefly define the propositions of these theories.

***Structure Conduct Performance:*** This theory was first proposed by Hicks (1935) and later developed by Nickell et al. (1997). According to these authors, changes in competition are

[11] Gorton et al. (2012) consider the securitization as similar to the financial innovation procedure, especially in terms of the design and structure of the special purpose vehicle.

explained by changes in concentration. A high concentration lowers competition and vice versa. Further, concentration does not encourage banks to make greater efforts to maximize profits and reduce costs. Under this theory, we find many empirical hypotheses, as follows:

*Quiet life*: In a concentrated market, managers benefit from their banks' monopoly power to capture some of the monopoly rents. For them, it is a quiet life free from competition in which they can realize high profits, captured by the form of inefficiency.

*X-inefficiency*: Developed by Leibenstein (1996), this is considered as a complementary theory to the quiet life hypothesis. Confronted with information asymmetries, the internal organizations of firms could be imperfect, which leads to X-inefficiency. The only way to reduce these inefficiencies is by increasing competition, which leads managers to respond to the challenge by increasing their banks' efficiency.

*Efficient structure*: The main idea is the existence of reverse causality between competition and efficiency. Zarutskie (2013) states that banking competition leads to better screening and monitoring, as banks focus on certain types of loans, thus reducing costs as a response to competition.

*Banking specificities*: This theory was developed by Pruteanu-Podpiera et al. (2008) who predict the non-existence of a perfect competition in the banking market. Competition has a detrimental effect on cost efficiency. This theory differs from the other theories by emphasizing the specificity of the bank industry level compared to other industries. Carbo et al. (2009) empirically confirm banking specificities' predictions.

These theories summarize the structure conduct performance (SCP) hypothesis. However, the question of whether concentrated markets lead to less competition was addressed in two main studies that showed contradictory results. Claessens and Laeven (2004) reject the SCP theory by showing that concentration is positively related to competition, while Bikker and Haaf (2002) support the SCP paradigm. [12]

***New Empirical Industrial Organization:*** This literature suggests that market structure and concentration are not sufficient to explain competitive behavior. William Baumol et al. (1982) emphasize the entry/exit barriers and the general contestability of the market. This theory was empirically confirmed by Claessens and Laeven (2004) and Claessens (2009), who show that banks' competitive behavior is positively related not only to market structure, but also to entry barriers, barriers on foreign ownership, and activity restrictions. Under this approach,

[12] Bikker and Haaf (2002) also argue that the increased level of deregulation and innovation have increased the concentration level in banking.

competition is measured by the Lerner index (Lerner, 1934) and the Panzar and Rosse's (1987) H-statistics.

The relationship between competition and efficiency has been empirically analyzed by several papers. Nevertheless, many empirical papers show contradictory results, which calls for a more robust empirical evidence clearly confirming one of the abovementioned theories.

[INSERT TABLE 1 HERE]

What makes our study different from the prior studies is that we confirm a clear and significant impact of competition and efficiency. Furthermore, Koetter et al. (2012) reject the quiet life hypothesis for US commercial banks. We extend their period of study and find similar results. We next move to the literature on securitization.

### *2.2. Securitization Implications*

We are not limited to the impact of competition on efficiency. We investigate if there is any significant impact of the joint interaction between securitization and competition on bank performance. Before doing so, we revisit the literature on securitization, and then we present the theoretical models that predict a relation between competition and securitization.

Our paper is closely related to the following empirical hypotheses:

*Profitability-enhancing theory of securitization:* Prior theoretical models have been focusing on the economic benefits of securitization, such as the risk reduction and the portfolio diversification (Greenbaum and Thakor, 1987; Pavel et al., 1987; Hess et al., 1988), the reduction of financing cost (Rosenthal et al., 1988), and the enhancement of loan monitoring and welfare implications (Chiesa, 2008). Furthermore, Boot and Thakor (1993) link securitization to the increase in their expected revenues by pooling assets and issuing different risk tranches of pooled assets. Bedendo et al. (2012) report beneficial impact of credit risk transfer activities on the economy, since banks are engaged in these activities to sustain credit supply.

*Securitization determinants:* Jones (2000) emphasizes the "economies of scale" incentives to engage in securitization. More precisely, securitization reduces the costs of debt financing and diversifies the funding sources. Allen and Carletti (2006) show that banks use securitization to transfer or diversify credit risks.[13] Furthermore, securitization contributes to a more efficient

[13] In this context, Acharya et al. (2013) emphasize the regulatory arbitrage associated with capital requirements. More precisely, the retention of a proportion of capital for loans is costly. Hence, the main motivation for reducing this cost is by taking loans off the balance sheet.

recycling of bank funds, as shown by Gorton and Pennacchi (1995) and Parlour and Plantin (2008). In fact, retaining a loan until maturity increases the opportunity costs if banks have other more profitable lending opportunities. Securitization allows banks to recuperate their funds earlier and redeploy them in other investment projects, thus reducing opportunity costs and increasing efficiency. Cardone-Riportella et al. (2010) find that Spanish banks' securitization incentives are driven by their need to find new liquidity and alternative funding sources. Moreover, the high levels of efficiency and size, as well as the issuance volumes of securitization, are key determinants of securitization. Bannier and Hansel (2008) show that securitization is motivated by credit risk management and liquidity raising incentives. Consistent with Cardone-Riportella et al. (2010), they also confirm the efficiency incentives for securitization. In terms of profitability, the less profitable banks are more prone to highly securitize their assets. Panetta and Pozzolo (2010), using a large data set for one hundred countries, find that securitization is motivated by the need to face lower costs and binding capital requirements, to reduce the liquidity shocks and to improve their capital ratios. Affinitto and Tagliaferri (2010), while investigating Italian banks' incentives to securitize loans, conclude that those characterized by a low level of capitalization, liquidity, profitability and a high level of nonperforming loans, are the most securitizing banks.

Among the abovementioned incentives, there is also the originator's performance. Hansel and Krahnen (2007) argue that the performance and the securitization levels are positively related to the banks' size, the risk management degree and the efficiency of the risk management expertise. Furthermore, Karaoglu (2005) suggest that credit risk securitization enhances banks' performance through the optimization of the loan portfolio returns and the exploration of more profitable business opportunities as well as core competencies.

More recently, Farruggio et al. (2015) study the loan securitization incentives of European banks. They find that these banks securitize to provide alternative source of funding. Furthermore, larger and less liquid European banks, as well as those that exhibit less loan loss reserve, are more likely to securitize.

*Efficient contracting hypothesis*[14]*:* This theory posits that banks outperform securitization activity to reduce their credit risk exposure by increasing their loan portfolio quality. [15]

[14] Farruggio et al. (2015) present the ambiguous results of this theory, in terms of monitoring and screening incentives, information asymmetry between originating banks and investors, and banks' exposure to their loan portfolio's credit risk.

[15] See for instance Minton et al. (2004) who confirm "Efficient contracting hypothesis" in the regulated and unregulated U.S. banks between 1993 and 2002.

More precisely, this activity has led banks to move from the "Originate-to-Hold" model to the "Originate-to-Distribute" model, where they no longer hold their loans in their balance sheets but rather sell them to a special purpose vehicle (Gorton and Pennacchi, 1995; Duffie, 2008; Purnanandam, 2011).

*Regulatory arbitrage hypothesis*[16]*:* According to this theory, a crucial motivation behind securitization is the realization of capital arbitrage. As Jones (2000) notes, Basel I recommendations were part of securitization's incentives. In other words, banks securitize their assets in order to reduce their regulatory equity capital. This negative relationship was more pronounced by Basel II which has introduced a "substance over form principle" in a way to determine the necessary regulatory capital for each tranche of securitized assets (Blum, 2008 and Johnston, 2009).

***Competition-securitization theories:***

To our best knowledge, no prior studies have empirically considered the role of securitization on the competition-efficiency nexus. However, recent theoretical models investigate the relationship between market structure and securitization activities.

Vives (2001) argue that the increased competition in the U.S. and Europe was mainly caused by financial innovation techniques such as derivatives, securitization, and off-balance-sheet activities. The main motivation for the innovation process is the deregulation of prices, products, and geographic restrictions on permissible banking activities over the past 30 years.[17]

The theoretical model, introduced by Li and Sun (2011), argues that excess demand for credit by investors was enhanced by a fiercer competition in banking markets, which might have distorted the loan market. Nevertheless, the relationship between higher competition level and excess demand for credit was empirically tested by Peterson and Rajan (1995) who argue that in a competitive market, firms will face difficulties in getting loans. Thus, the more the banking market is competitive, the more the demand for credit is high. That's why we should expect a higher level of securitization, as banks securitize to finance more loans.

[16] The empirical evidence of this theory is conflicted: Minton et al. (2004), as well as Martin-Oliver et al. (2007), reject this theory for U.S. and Spanish banks, respectively. However, Uzun and Webb (2007) confirm the theory's predictions by studying the securitization of U.S. credit card receivables.

[17] Miller (1986) argues that efforts to circumvent regulatory and tax burdens are key drivers of financial innovation.

Hakenes and Schnabl (2010) and Huang et al. (2013) contribute to the literature on the relationship between lending capacity and securitization. These authors show that a high level of competition reduces banks' capacity to provide on-balance-sheet funding to risky borrowers, thus increasing securitization to expand their lending capacity. In other words, when operating in competitive markets, banks are characterized by a low profitability, as well as low capital buffers. As a consequence, they are obliged to securitize the risky loans, even if they are highly profitable, so they can increase their underlying loan pools' quality.

In addition, Breton et al. (2014) study the interaction between securitization and competition by considering a model in which banks compete for borrowers and securitization follows a reduction in monitoring, which lowers the competition's intensity. They show a softening effect of securitization on competition, leading banks to benefit from securitization to reduce the negative impact of competition on their profits. Although this softening effect increases banks' profits, it is associated with a reduction in loans' efficiency through reduced monitoring. [18]

More recently, Frankel and Jin (2015) show that the enhancement of interbank competition, through the gradual fall of the legal barriers to interstate banking and the federal government's passage of Interstate Banking and Branching Efficiency Act of 1994 (IBBEA), is mainly due to the pressure of securitization activities, especially by large banks who intended to increase their securitization profits. Furthermore, the model predicts a worsening effect of securitization on screening and monitoring, since this activity allows the entry of uninformed remote lenders. Farruggio et al. (2015), while analyzing the market-specific determinants of loan securitization in European banks, find that competition has a positive impact on securitization, suggesting that under competitive market conditions, banks are more eager to lend risky loans and hence securitize so they increase the income of their loan portfolio diversification.

Overall, the existing literature has focused on different aspects of the securitization, but has not provided comprehensive evidence to the impact of securitization on bank efficiency. While in theory, securitization is related to market-specific determinants, such as banking competition, the empirical evidence to date seems unclear, suggesting a novel study of these factors on bank efficiency. The latter is crucial to banks' survival, especially in the light of the

[18] In other words, securitization can be perceived as a tool to signal a reduction in the intensity of monitoring, which reduces competition as competitor banks know that they can poach their rival's borrowers in a future round of competition. This fact justifies the increased level of competition and securitization before the recent crisis.

recent financial crisis. We therefore believe that it is important to reexamine the impact of competition on efficiency; through an investigation of the securitization influence; otherwise, in the rush to restrict securitization in banking[19], we run the risk of neglecting whether the negative influence of securitization is related to the competition level in U.S. banking industry.

## 3. Estimating Competition and Efficiency

### *3.1. Conventional and Adjusted Lerner index*

Our main variable of competition at the bank level is the Lerner index, which is widely used in the literature.[20] This index measures the market power of the banking industry by subtracting the price of total assets from marginal costs.

In our study, we follow the methodology of Koetter et al. (2012) and use two types of Lerner index: The conventional and the inefficiency-adjusted Lerner index. To do so, we start with a regression of two types (OLS and stochastic frontier analysis; SFA) to estimate marginal costs. Those generated through OLS are used to compute conventional Lerner index, while those generated through SFA analysis are used to compute efficiency-adjusted Lerner index.

Marginal costs are calculated through the intermediation approach (Sealey and Lindely, 1977), which specifies labor and physical capital as inputs to generate deposits that are used to fund loans and other earning assets. We follow previous studies estimating Lerner index in banking (Carbo et al., 2009; Turk-Ariss, 2010) by specifying three inputs (borrowed funds, labor, and capital) and two outputs (securities and loans). We then compute a translog total cost function for bank j at time t as follows:

$$LnTOC_{jt} = \alpha + \sum_{i=1}^{3} \beta_i \log w_{ijt} + \sum_{p=1}^{2} \gamma_p \log y_{jt} + \delta \log(Z_{jt}) + \sum_{i=1}^{3} \varphi_i/2 \log(w_{ijt}^2) + \sum_{i<k} \sum \eta_{ik} \log w_{ijt} \log w_{kjt} + \sum_{p=1}^{2} \theta p/2 (\log y_{pjt})^2 + (\frac{\kappa 12}{2}) \log y_{1jt} \log y_{2jt} + \sum_{i=1}^{3} \sum_{p=1}^{2} \lambda_{pi} \log w_{ijt} \log y_{pjt} + \sum_{k=1}^{2} \nu_k trend^k + \sum_{i=1}^{3} \xi_i \log w_{ijt}\, trend + \sum_{p=1}^{2} \omega_p \log y_{pjt}\, trend + \varepsilon_{jt} \quad (1)$$

Where $TOC_{jt}$ denotes total operating costs, $w_{ijt}$ represents bank j input factor prices at time t (i=1,2,3); $y_{1jt}$ denotes the total securities of bank j at time t; $y_{2jt}$ denotes the total loans of

[19] Dodd-Franck Act Wall Street Reform and Consumer Protection Act (2010) recommends restricting securitization activities, by retaining a portion no less than 5% of credit risk exposure for any securitized asset.

[20] See, for instance, Beck et al. (2013), Turk-Ariss (2010), Berger et al.(2009), Anginer et al. (2014), Koetter et al. (2012), Kick et al. (2015), Delis et al. (2016).

bank j at time t; and *trend* is a time trend used as a tool to take into consideration technical change.

The linear homogeneity restriction requires that the factor prices ($w_1$ and $w_2$) must be divided by the cost of borrowed funds ($w_3$). The input factor prices are clustered at 1 and 99% to reduce the influence of outliers.

Then, the marginal costs can be obtained using the coefficient estimates of the equation (1) as follows:

$$MC_{jt} = TOC_{jt}/y_{1jt}\,[\gamma_1 + \theta_1 \log y_{1jt} + (\tfrac{\kappa_{12}}{2}) \log y_{2jt} + \textstyle\sum_{i=1}^{3} \lambda_{1i} \log w_{ijt} + \omega_1 trend] +$$
$$TOC_{jt}/y_{2jt}[\Upsilon_2 + \theta_2 \log y_{2jt} + \left(\tfrac{\kappa_{12}}{2}\right) \log y_{1jt} + \textstyle\sum_{i=1}^{3} \lambda_{2i} \log w_{ijt} + \omega_2 trend] \qquad (2)$$

The estimated cost frontier coefficients and OLS coefficients are shown in Appendix A.

To approximate revenues, we follow Beck et al. (2013) and define p as the ratio of the total operating income to total assets. The Lerner index is then computed as (p-mc)/p.

The conventional Lerner index is estimated from OLS estimates of MC, as follows:

$$Conventional\ Lerner = \frac{p - MC_{OLS}}{p}$$

In contrast, the efficiency-adjusted Lerner index is estimated from frontier (SFA) estimates of MC, as follows:

$$Adjusted\ Lerner = \frac{p - MC_{SFA}}{p}$$

Detailed Lerner indices are shown in Table 5.

[INSERT TABLE 5 HERE]

The difference between the two Lerner types is that the efficiency-adjusted Lerner takes into account the inter-relatedness of competition and efficiency. Hence, we can rely on this modified index to better examine the implications of the degree of competition on efficiency. Furthermore, the Efficient Structure Hypothesis postulates that market structure is driven by efficiency and reverse causality is likely to prevail between the variables of interest. Conventional Lerner indices implicitly assume full bank efficiency and fail to consider the possibility that banks may not exploit pricing opportunities resulting from market power.

### *3.2. Boone indicator*

In our study, we are not limited to market power indicator; we take into account an innovative indicator of competition: the Boone indicator (2008) that quantifies the impact of marginal costs on performance, measured in terms of market share. More specifically, the main idea of Boone is derived from the Efficient Structure Hypothesis: In a competitive market, the more-efficient firms retrieve the market share from less-efficient firms, which enhances their performance. The higher the competition is in the market, the greater the effect of efficiency on performance. To support this hypothesis, Boone develops a set of theoretical models by approximating the marginal costs by the average variable costs. We follow Kick et al.'s (2015) approach in German regional banking markets by approximating Boone for U.S. commercial banks j operating in each state s at year t as follows:

$$\ln(\pi_{jst}) = \alpha + \beta_{jst} \ln(MC_{jst}) \tag{3}$$

Where π refers to bank profits[21], $\beta_{jst}$ is the Boone indicator of competition, and MC denotes the marginal costs of a bank j in state s at time t.

Some empirical studies have used this indicator to study banking competition. Leuvensteijin et al. (2011) modifies Boone (2008)'s approach by calculating the marginal costs instead of estimating it by the average variable costs, and by considering the market share as dependent variable instead of profits. Tabak et al. (2012), Delis (2012) and Kick and Prieto (2015) also adopt a similar strategy for estimating the marginal costs. In contrast, Schaeck et al. (2014) follow Boone's construction of the indicator, using the average costs of banks measured as a ratio of the total income, and profitability (ROA) as the dependent variable.

According to Boone's idea of a negative relationship between marginal costs and profits in deeper competition level, we can interpret a more negative value of Boone in cases of high competition.

To calculate Boone, we regress the marginal costs computed through equation (2) on the loan income share to generate the coefficient estimates of the marginal costs (MC), which are the Boone indicator values.

[21] Since we are studying the securitization market, we focus on the loan income share (INC) as the profit indicator to derive Boone.

### *3.3. Stochastic Frontier Approach*

The literature on bank efficiency measure suggests two main approaches for measuring bank efficiency: Parametric techniques, such as the Stochastic Frontier Analysis (SFA), and non-parametric techniques, such as the Data Envelopment Analysis (DEA). We start with the stochastic frontier approach in equation (2) to estimate the cost efficiency scores on our sample of U.S. commercial banks.

This approach posits that cost frontier is characterized by the specificity of the inputs priced in their productions and their technological factors. Furthermore, it proposes that symmetrically distributed error terms with zero means are not robust for the analysis of the producer behavior. As a consequence, error terms include a traditional symmetric random noise component and an inefficiency component. In this sense, cost frontier is stochastic because of the random environmental change affecting the producer's behavior. [22]

Stochastic Frontier Analysis is widely used in the literature to estimate efficiency. Since we are testing the impact of competition on efficiency, we briefly present the empirical studies that adopt stochastic frontier approach for the competition-efficiency analysis. For instance, Pruteanu-Podpiera et al. (2008) find a negative impact of competition on Czech banks' cost efficiency Casu and Girardone (2009) argue that market power leads to a positive influence on the efficiency of European banks if it enables those banks to operate at lower costs. Fungacova et al. (2009) apply stochastic frontier approach on 76 Chinese banks over the period 2002 to 2011 and do not find a significant relationship between competition and efficiency. Turk-Ariss (2010) analyze the cost and profit efficiency frontier for the developing countries and find a negative impact of market power on those frontiers. More recently, Duygun et al. (2013) quantify the impact of Schumpeterian competition on British banks and find that the competition, through the launch of new products, reduces cost and profit efficiency.

### *3.4. Non-parametric DEA Approach*

Charnes, Cooper, and Rhodes (1978) introduced data envelopment analysis (DEA) to evaluate performance. Denizer, Dinc, and Tarimcilar (2007) define DEA as: "*a mathematical programming technique that measures the efficiency of a bank relative to a best-practice bank on the efficiency frontier*." This non-parametric approach has several advantages, such as being flexible without making any assumption about the form of production function, and

[22] Kumbhakar and Lovell (2000) introduce and discuss, in their book, the stochastic frontier analysis.

approximating the best-practice decision-making unit and the true production function. It assumes that bank managers perhaps have a higher control on inputs than on outputs (Coelli et al., 2005).

There are two main approaches of DEA: input oriented and output oriented. The input-oriented approach reduces the amount of banking inputs while keeping the outputs constant. In contrast, the output-oriented approach maximizes banking outputs while keeping the inputs constant.

Moreover, there are two versions of DEA: The first one is the constant return to scale (CRS), developed by Chames et al. (1978), which suggests that the same percentage of change in inputs also applies to outputs. The second one is the variable returns to scale (VRS) developed by Banker et al. (1984), which extends CRS by adding a convexity constraint. The assumption of VRS is that banks' outputs may be increasing, constant, or decreasing.

The banking literature has focused on input-oriented approach because banks tend to minimize their costs, but have no direct control on outputs. In our study, we follow Chortareas et al. (2013) by adopting input-oriented DEA with the VRS assumption. We use the following linear assumption:

$\theta^* = \min\theta$

Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \quad i = 1,2,3,\dots,m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r = 1,2,3,\dots,s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,2,3,\dots,n. \tag{4}$$

Where $\theta$ denotes efficiency score for bank i at time t. x and y denote input and output respectively, both $\sum \lambda_j x_{ij}$ and $\sum \lambda_j y_{rj}$ combine the possible values of inputs and outputs of n banks. $\lambda_j$ is the sum of inputs and outputs weights ($\sum \lambda_j = 1$ under the VRS assumption) while j denotes bank observation. Since the main objective is to reduce inputs and maximize

outputs, then $\theta^* = 1$ indicates that the bank is efficient. In contrast, if $\theta^* < 1$, this indicates that the bank is inefficient.

Detailed descriptive statistics of DEA pure technical efficiency scores are provided in Table 2. In other words, we consider that banks invest in fixed assets, salaries, interests, and other noninterest expenses as inputs to obtain total loans, earning assets, interest, and noninterest income as bank outputs.

[INSERT TABLE 2 HERE]

Haslem et al. (1999) were the first to study DEA in U.S. banking. They divide their sample into efficient and inefficient banks and compare efficiency scores of both categories. Casu and Girardone (2009) use the DEA approach by following the financial intermediation approach developed by Sealey and Lindley (1977) and reject the quiet life hypothesis for a sample of European Union commercial banks. Chortareas et al. (2012), using DEA approach for a large sample of European banks, find that the size and the concentration have a positive impact on efficiency. More recently, Barth et al. (2013) find that the activity restrictions have a negative on banks' DEA operating efficiency.

### *3.3. Data to estimate competition and efficiency*

Variables' definitions and descriptive statistics are provided in Tables 1 and 2, respectively. More precisely, the top panel of Table 1 describes the variables used in the SFA to generate the marginal costs. Data are collected for commercial banks from the Call Reports of Condition and Income of the Federal Reserve System. [23]

We start with a quarterly dataset for the period starting from March 31, 2005 until December 31, 2013. We drop missing and negative observations on gross total loans, input factor prices, output variables, and costs. All factor prices are then truncated at the top and bottom percentiles to control for outliers. This cutting and trimming yielded 74,533 bank observations.

By following the intermediation approach, we posit that banks aim to maximize profits and reduce costs. Thus, we specify three input prices: First, the price of fixed assets ($w_1$) is calculated as the ratio of fixed assets expenditures to premises and fixed assets. The second factor price, the cost of labor ($w_2$), is calculated as the ratio of personnel expenses to full-time

[23] The insured commercial banks are required to provide detailed information on a quarterly basis including the complete balance sheet, income statement. They also provide supporting schedules such as off-balance-sheet items, and securitization activities.

employees. The funding cost ($w_3$) is computed as the ratio of total expenses to total interest-bearing liabilities. Additionally, we specify two outputs, securities ($y_1$) and total loans ($y_2$). The dependent variable is the total operating costs.

## 4. Competition-Efficiency Nexus

### *4.1. Empirical methodology*

To test the impact of competition on efficiency, we regress adjusted and conventional Lerner indices on SFA cost efficiency and DEA pure technical efficiency scores. The main hypotheses are the following:

H1 (a): A high Lerner value (less competition) leads to an increase in bank efficiency (*competition-inefficiency*)

H1 (b): A high Lerner value (less competition) leads to a reduction in bank efficiency (*competition-efficiency*)

Since both cost frontier estimates and Lerner indices are derived from the same model, we take into account endogeneity concerns arising from simultaneity using the following instrumental variable specification:

$$L_{jt} = a_0 + b_1 IV_{jt} + b_2 X_{jt} + \eta_{jt} \quad (5)$$

$$EFF_{jt} = c_0 + d_1 L_{jt} + d_2 X_{jt} + \xi_j + \nu_t + \varepsilon_{jt} \quad (6)$$

Where $L_{jt}$ is either the adjusted or unadjusted Lerner index, $EFF_{jt}$ is the cost efficiency of bank j at time t. $IV_{jt}$ denotes instrumental variables used to estimate the Lerner index. $X_{jt}$ is a vector of bank-specific control variables including the equity ratio (ER), the security share (SEC), the income share (INC), the size and the loan loan reserve share (LLR) of bank j at time t. The remaining terms indicate the parameter and the error terms. We perform Wooldridge's (1995) first stage, over identification, and endogeneity tests between dependent and independent variables to select suitable instruments.

### *4.2. Instruments*

Since we address endogeneity concerns between competition and efficiency, we must find adequate instruments of the independent variable (Lerner index) to regress on the dependent variable (Cost efficiency scores).

First, we follow the dynamic panel literature (Blundell and Bond, 1998) and consider lagged values of Lerner as instrumental variables.

Second, the identification of bank competition is based on the argument that the competitiveness of banks is affected by the general economic conditions in the country where banks compete (Chirinko and Fazzari, 2000). For this reason, we use the quarterly unemployment rate.

Third, we follow Schaeck et al. (2014) and use financial freedom as an instrument to gauge how independent the U.S. banking system is from government control and state interference.

We next turn to instrumental variable regressions using the mentioned instruments. For each specification, we consult over identification, first stage, and exogeneity tests.

The resulting specifications require that (a) instrumental variables are not over identified (b) the Lerner indices are exogenous, and (c) robust R-square and F-tests support the choice of instruments.

Table 5 estimates the IV regression parameters for competition-efficiency nexus. More specifically, we use the cost-efficiency frontier estimates as dependent variable and include the specified instruments in the instrumental variable regression.

[INSERT TABLE 5 HERE]

### *4.3. Control variables*

In examining the impact of competition on efficiency, we control for a number of bank-specific characteristics described in Table 1.

Following Maudos et al. (2002) and Beck et al. (2013), we control for the impact of a bank's size (natural logarithm of total assets) on efficiency. We expect a positive impact of size on efficiency. Moreover, we follow Koetter et al. (2012) and control for the possibility that banks exposed to greater competition tend to engage more in non-traditional activities. Hence, we control for the noninterest income (INC) and the share of assets in securities (SEC). Since bank capitalization is considered as a source of bank distress, we include the ratio of equity to total assets (ER) to control for bank capitalization (Koetter et al., 2012; Duygun et al., 2013). In line with theoretical arguments, we expect that better capitalized banks do not have the same impact as securitization, since they are not engaged in more securitization activities as less capitalized banks do.[24] In addition, we include the share of loan-loss reserves (LLR) to take into account the credit risk (Koetter et al., 2012; Bolt and Humphrey, 2015; Farruggio

[24] In the earlier years under Basel I regulation, less capitalized banks are more prone to engage in securitization activities. However, the introduction of Basel II in 2006 has diminished the potential benefits of securitization, especially in terms of regulatory capital arbitrage. Thus, the effect of equity ratio on efficiency is ambiguous.

and Uhde, 2015). We expect that higher loan loss reserves reflect a lower loan portfolio quality and hence a lower efficiency score.

## 5. The Influence of Securitization

### *5.1. Empirical method*

What about securitization? The theoretical predictions argue that securitized banks should be more efficient, as securitization enables them to increase profitability and reduce credit risk. In an effort to better understand the impact of competition on efficiency, we attempt to determine what would have happened to the efficiency levels of securitized banks if competition level changed in response to exogenous deregulation. In other words, we try to identify the impact of securitization on efficiency, then the influence of the securitization on the competition-efficiency nexus.

To assess this impact, we extend previous analyses by performing an OLS regression to gauge the securitization-efficiency nexus, then a difference-in-difference approach to provide a comprehensive analysis of competition-securitization-efficiency in U.S. banks. More specifically, the model takes the following two equations:

$$EFF_{jt} = a_i + b_1 Home_{jt} + b_2 Multifamily_{jt} + b_3 Commercial_{jt} + b_4 Farm_{jt} + b_5 Consumer_{jt} + b_6 X_{jt} + \varepsilon_{jt} \quad (7)$$

Where $EFF_{jt}$ is either the cost efficiency SFA of bank j at time t or the DEA technical efficiency score. $Home_{jt}$ is the ratio of home mortgages to total loans, $Multifamily_{jt}$ is the ratio of multifamily residential mortgages to total loans, $Commercial_{jt}$ is the ratio of commercial mortgages to total loans, $Farm_{jt}$ is the ratio of farm mortgages to total loans, and $Consumer_{jt}$ is the ratio of consumer loans to total loans.[25] $X_{jt}$ is a vector of bank-specific control variables including the equity ratio (ER), the security share (SEC), the income share (INC), the size and the loan loan reserve share (LLR) of bank j at time t. $\varepsilon_{jt}$ denotes the error term.

Equation (7) aims to show the impact of each type of the abovementioned securitized loans on bank cost and technical efficiency.

[25] We follow Casu et al. (2014) who divide each type of securitized loans by total loans to analyze the impact of securitization on US bank performance.

$$EFF_{jt} = a_j + b_1 SECURITIZATION_{jt} + b_2 Lerner_{j,t-1} + b_3\left(SECURITIZATION_{jt} * Lerner_{j,t-1}\right) + b_4\, X_{jt} + \varepsilon_{jt} \quad (8)$$

Where $EFF_{jt}$ is either the cost efficiency of bank j at time t or the DEA efficiency score. Securitization is the ratio of total securitized loans to total outstanding loans.[26] Lerner is either the adjusted or unadjusted Lerner for bank j, lagged by one period. $X_{jt}$ and $\varepsilon_{jt}$ are already defined in equation (7).

We perform the difference-in-difference approach in equation (8) to analyze the impact of the joint competition and securitization on bank cost and technical efficiency and how the efficiency levels change as a response to banks' securitization incentives.

### *5.2. Securitization data*

Loutskina (2011) define securitization variables collected from the Call Report of Condition and Income. Furthermore, we include home mortgages (Home), farm mortgages (Farm), multifamily mortgages (Multifamily), consumer mortgages (Consumer), and commercial mortgages (Commercial).[27] These variables, which reflect the securitized loans in U.S. banks, are divided by total loans to gauge the significant contribution of securitization to the total bank funding. Table 1 provides a detailed description of these variables.

In a first step, we intend to regress these variables on SFA and DEA efficiency scores, to empirically evaluate the impact of securitization on a well-considered measure of bank performance (EFF). We contribute to the existing literature on securitization by showing the change in efficiency due to changes in the securitization level.

After that, we use SECURITIZATION variable, which is the ratio of total securitized loans to total outstanding loans. We include this variable in a difference-in-difference approach with lagged Lerner index values (adjusted and unadjusted) to study the impact of the joint competition-securitization term on bank efficiency and whether this result changes with time.

[26] See, for instance, Loutskina et al. (2011) and Zarutskie (2013) who use the ratio of securitized loans to total loans.

[27] Gorton et al. (2012) emphasized the important role of securitization in financing mortgages, which were sold as a part of residential mortgage-backed security. This has led to pooling thousands of mortgages together, selling the pool to a special purpose vehicle.

Before proceeding to the analysis of the empirical results, we show the evolution of the securitized loans and the concentration of the U.S. banking market as shown by the ratio of the securitized home mortgages, consumer loans, multifamily mortgages and adjusted Lerner index, respectively.

[INSERT FIGURE 1 HERE]

We observe a stable Lerner index ranging between 0.3 and 0.4, indicating a tendency towards concentration characterizing US commercial banks. The home mortgages are following a significant increase, reaching more than 40% of the total outstanding loans, which is a very important contribution to the US economy, thus emphasizing the continuous importance of securitization, even after the recent financial crisis that reached its peak in 2008. Commercial mortgages are starting to decline since 2011, while multifamily mortgages are relatively low, compared to the home and commercial mortgages.

## 6. Empirical Results

We start with the IV regression results for the adequacy of instruments presented in equation (5), then for the test of the competition-efficiency nexus in equation (6). We also present the securitization-efficiency results of the equation (7), then the difference-in-difference approach results of the equation (8).

### *6.1. Competition-efficiency IV regression*

To test the impact of competition on efficiency, we use both adjusted and unadjusted Lerner indices. The mean cost efficiency generated through SFA of 79% is consistent with that of Koetter et al. (2012), who measured the Lerner indices for U.S. banks.

We then turn into instrument adequacy tests. More specifically, we perform Wooldridge's (1995) over-identification test, exogeneity, and first stage. Since the Lerner indices and SFA are derived from the same model, we use SFA cost efficiency scores as dependent variables in columns (1) to (4). Columns (1) and (2) present the results for (a) the adjusted Lerner index as an explanatory variable and (b) the lagged Lerner, financial freedom, and unemployment rate as instruments, while columns (3) and (4) report the results of the unadjusted Lerner indices' instruments. The p-value of the exogeneity test is equal to 0 in all the specifications and the score is high, which means that all the instruments are exogenous to SFA. Furthermore, the first stage results confirm the instruments' robustness. Overall, endogeneity is rejected at the 1% level, and the first-stage explanatory power is high but a little bit weaker when we include

the unemployment rate as an instrument. However, the over-identification tests confirm that the lagged Lerner index and the financial freedom instruments are valid while the unemployment rate is not. We thus only rely on Lagged Lerner index and financial freedom as instruments addressing the endogeneity issue between the cost efficiency scores and the Lerner index.

After testing and choosing the best suitable instruments, we include them in the instrumental variable regression to test the impact of competition on U.S. commercial banks' cost and technical efficiency.

Table 6 reports the estimated coefficients for the IV regression to test the competition-efficiency theories.

[INSERT TABLE 6 HERE]

Does bank market power (LERNER) reduce or increase bank costs (SFA) and technical (DEA) efficiency? We find that the Lerner indices are positive and significant in all columns. Banks with higher Lerner indices reduce their costs more efficiently. By rejecting the quiet life hypothesis, this result is consistent with Koetter et al.'s (2012) finding that market power increases cost efficiency and supports the efficiency structure hypothesis, and with Berger (1995) who finds similar results for 4,800 U.S. banks. Our results are also in line with those of Duygun et al. (2013) who argue that the net impact of British banks' inefficiency levels increase at the same time with the increases in competition intensity, thus suggesting a negative impact of competition on cost efficiency.

As for the difference between the impact of adjusted and unadjusted Lerner indices on efficiency, we find that the parameter estimates of both independent variables are quite similar (0.262 in column 2 and 0.282 in column 4).

We also find a positive and significant impact of size and income on efficiency, as measured by DEA. This is consistent with Chortareas et al. (2013), who adopt the same non-parametric DEA approach, suggesting that large banks achieve higher income and efficiency. Tabak et al. (2013) also find that larger Latin American banks are better at managing their costs. In other words, they reject the quiet life, as smaller banks do not outperform larger banks in concentrated markets. The positive sign of size and the negative sign of loan-loss reserves in our model confirm Tabak et al.'s (2013) findings that large banks holding less loan-loss reserves are more cost efficient. Moreover, the positive sign of the equity to assets ratio confirms that higher capitalization improves the alleviation of agency problems between managers and shareholders (Mester, 1996).

### *6.2. The influence of securitization*

We next test the impact of securitization on bank efficiency. Table 7 reports the estimated coefficients of each category of securitized loans on cost and technical efficiency.

[INSERT TABLE 7 HERE]

Overall, we find a negative and significant impact of securitization on bank efficiency. Although no prior studies appear to have tested this impact, we can explain this result by the fact that banks tend to securitize loans as an incentive to improve their overall performance. This is consistent with Farruggio et al. (2015), who find that the need to improve efficiency drives securitization. Furthermore, Cardone-Riportella (2010), while conducting research for bank securitization determinants, finds a positive and significant impact of the cost-to-income ratio on securitization. In fact, the higher the cost to income, the lower the efficiency scores. Hence, we expect a negative impact of securitization on efficiency. Our results are in line with Cardone-Riportella (2010)'s findings. More precisely, banks securitize home, commercial, and consumer loans to improve their performance, while farm and multifamily loans do not reduce their performance. Regarding the size effect, we find that large banks that securitize more farm and multifamily loans are more cost efficient, while those which securitize more home, commercial, and consumer loans are less cost efficient. We also find, as in Table 6, that larger banks holding a smaller loan-loss reserve are more cost efficient. Interestingly, we find that larger capitalized banks who securitize farm and multifamily loans are more cost efficient that those which securitize home, commercial, and consumer loans.

### *6.3. Difference-in-difference approach*

The abovementioned findings conclude a negative impact of competition and securitization on efficiency and contribute to the literature by showing a clear and significant impact, thus eliminating contradictory results.

Motivated by the need to empirically confirm theoretical predictions about securitization and competition, we test the joint interaction between these two factors. In other words, we investigate how efficiency scores change as a result of a combination between high or less competition and high or less securitization.

Table 8 reports the results for the difference-in-difference approach specification of the equation (8).

[INSERT TABLE 8 HERE]

First of all, we find that securitization keeps on reducing banks' cost efficiency. Furthermore, the Lerner indices remain positive and significant (0.095 and 0.064, respectively). However, when we combine securitization and competition into a single variable (Lagged Lerner*SECURITIZATION), we do not find a significant impact, which suggest that securitization does not change the negative impact of competition on efficiency. In terms of competition-efficiency nexus, we find a negative and significant impact of concentration on the DEA efficiency scores (-0.264 and -0.27 in columns 2 and 4) when including securitization in the model. Once banks securitize loans, they benefit from competition levels to increase their technical efficiency by reducing their employees' salaries, interest and noninterest expenses, and fixed asset expenditures to maximize their total loans, earning assets, interest, and non-interest income. This provides strong evidence that securitization is driven by the need to improve performance and generate more loans to increase banks' market share. In the post-crisis period (2008–2013), the results remain consistent. The more the U.S. banks are concentrated with low levels of securitized loans, the higher their cost and pure technical efficiency.

More generally, our results suggest a negative impact of competition (positive impact of Lerner index) and securitization on bank performance (Efficiency). Our findings are consistent with the predictions of Hakenes and Schnabel (2010), who show in their model that credit constraints may be accompanied by risk transfer to outside investors. If there is only private information, the asymmetric information increases the credit risk transfer. Although the latter improves the access to finance for risky and profitable borrowers, the possibility to finance unprofitable ones is also important. In other words, an increase in credit risk transfer (securitization) accompanied by an increase in competition level completely offsets the welfare expected gains from securitization. Our findings are also in line with those of Dell'Ariccia et al. (2008), who argue that during the pre-crisis period, which saw an increased competition level due to the entry of new financial institutions, most of the newly extended loans were of poor quality. Casu and Girardone (2009), and Maudos et al. (2007) also reject the quiet life hypothesis, which suggests a positive impact of concentration on efficiency.

### 6.4. Robustness checks

To provide further evidence for our results, we perform additional tests including alternative measures of competition and efficiency. We also split the model according to bank's share of total assets, and we perform a quantile regression to show how the effect of competition and

securitization changes among the most and the less efficient U.S. commercial banks. Finally, we show that the negative impact of securitization on efficiency is more pronounced in the most concentrated states, as measured by Rice and Strahan (2010)'s index of interstate branch restrictiveness.

### *6.4.1. Cost to Income Ratio*

To validate our previous results, we consider the cost-to-income ratio[28] as an alternative measure for the efficiency scores. This ratio, computed as the ratio of noninterest expenses to the total operating income, reflects the inefficiency level of banks. One of the most traditional ratios, it measures the degree of change in costs according to the income generated by banks. It also reflects the service and productive effectiveness. A high cost-to-income ratio indicates a low level of efficiency and vice versa.

The results of the difference-in-difference approach are reported in Table 9.

[INSERT TABLE 9 HERE]

We find a negative and significant impact of the lagged Lerner in columns (2) and (4), confirming our previous findings. In the pre-crisis period, we find that securitization reduces the cost-to-income ratio but this impact is insignificant. However, we find that when concentrated, the U.S. securitization market is more inefficient. This is shown by the positive impact of the interaction term between securitization and the lagged Lerner. Overall, we can conclude that securitization plays a significant role in negatively influencing the impact of concentration on bank efficiency. Thus, previous findings concerning the critical role of credit risk transfer in shifting loans to poor-quality borrowers are confirmed by the inclusion of Cost to Income Ratio as an alternative measure of bank efficiency.

### *6.4.2. Institutional Size*

We perform further tests to validate our previous findings by emphasizing the institutional size importance.

More precisely, we perform an analysis of the competition-securitization-efficiency on a sample of large banks retaining assets higher than one billion US dollars.[29]

[INSERT TABLE 10 HERE]

[28] Farruggio et al. (2015) argue that cost to income ratio reflects the efficiency of banks' risk management.

[29] Duygun et al. (2014) use a dummy variable for large banks, characterized by total assets higher than one billion US dollars.

We find that the impact of concentration, as measured by the adjusted Lerner index, is positive and significant in column 1 (0.212) in which we report the competition-securitization-efficiency results for large banks. This finding is consistent with Tabak et al. (2013) who suggest that large banks in concentrated markets (as shown by the positive impact of Lerner index in column 1) outperform smaller banks, and with Elyasiani and Mehdian (1990) and Hunter and Timme (1991) who study the large U.S. commercial banks and confirm that their cost efficiency levels are higher than small banks. Moreover, Hellmann et al. (2000) and Allen and Gale (2000) show that larger banks in concentrated markets have a higher profit margin. Our findings are not far from their findings, as shown by the positive and significant impact of Lerner index on bank efficiency, which reflects banks' performance.

Securitization has a negative and significant impact across large banks, which is consistent with our previous results. In other words, securitization reduces banks' cost efficiency when operating in competitive markets, as competition impairs large banks' performance. Furthermore, Hughes and Mester (2013) argue that significant scale economies, as well as technological factors, motivate banks to increase their size. In other words, these factors drive large banks to be more efficient, by increasing their productivity and reducing their information costs and other costs that do not increase proportionately with size.

### *6.4.3. Boone indicator*

Another set of robustness checks includes the Boone indicator of competition.

[INSERT TABLE 10 HERE]

More precisely, the difference-in-difference model takes the following form:

$$EFF_{jt} = a_j + b_1 SECURITIZATION_{jt} + b_2 Boone_{js,t-1} + b_3\left(SECURITIZATION_{jt} * Boone_{js,t-1}\right) + b_4(Xjt) + \varepsilon_{jt} \quad (9)$$

Where $EFF_{jt}$ is the cost efficiency score of bank j at time t. Securitization is the ratio of total securitized loans to total loans. $Boone_{jt}$ is the Boone indicator of competition for bank j in state s, lagged by one period (t-1). $X_{jt}$ is a set of control variables including the security share (SEC), the size, the loan loss reserve share (LLR) and the equity ratio (ER).

The model tests the following hypotheses:

H1 (a): A high negative value of Boone (high competition) leads to a reduction in bank efficiency (*competition-inefficiency*).

H1 (b): A high positive value of Boone (less competition) leads to a reduction in bank efficiency (*competition-efficiency*).

Since Boone is obtained through a regression of marginal costs on bank profits, we expect that more competitive banking markets have a more negative value of Boone, while the more concentrated markets have a more positive value of Boone.

Kick and Prieto (2015) analyze the impact of competition on bank risk, using Lerner index and Boone indicator. They find that, when using Lerner index, competition reduces bank risk taking. However, when using Boone indicator, competition increases bank risk taking of German regional banking markets.

Consistent with their findings, we must note that both indicators of competition reflect very different perspectives of bank competition. On the one hand, the adjusted Lerner index measures banks' capacity to obtain profits purely by extracting monopoly rents. On the other hand, the Boone indicator measures how severely less efficient banks are punished for their inefficiency levels. More generally, the Lerner index is a direct indicator of concentration that shows the advantages of concentrated banking markets, while the Boone indicator shows the advantages for being more efficient in a competitive banking market.

Our results that reject the H1(a) are consistent with those of Schaeck and Cihak (2010) who study the impact of competition, as measured by the Boone indicator, on U.S. banks' cost efficiency. In column (3) of table 10, the negative and significant impact of Boone indicator on the stochastic cost frontier efficiency scores indicates that a higher competition (negative sign of Boone) increases overall cost efficiency. The impact remains significant in column (4), when controlling for size, loan loss reserve share, equity ratio and security shares. Concerning the securitization impact, when banks tend to securitize their loans, their efficiency levels reduce significantly. This effect is shown by the negative sign of securitization on SFA technical efficiency and positive sign on cost to income ratio (-0.195). These results are consistent with our previous findings, showing that securitization has a detrimental effect on banks' efficiency.

We also find a significant positive impact of the combination between Boone indicator and securitization (0.001) on SFA efficiency scores. This suggests that when banks tend to securitize in a concentrated banking market, their efficiency levels increase. However, securitizing loans in a competitive market reduce their overall efficiency. Furthermore, while focusing on the efficiency advantages in a competitive market through the Boone indicator,

securitization has a negative effect on banks' efficiency in a more concentrated banking market where banks are efficiently punished for securitizing their loans.

### *6.4.4. Herfindahl-Hirschman Index*

We take into consideration another widely used measure of concentration, the Herfindahl-Hirschman index of concentration. It is the sum of the market share of loans square, indicating the degree of loans concentration in the banking industry. A higher value of HHI indicates a lower competition and vice versa. It ranges from zero to one, from a huge number of very small banks, as long as it is near the value of zero, to monopolistic structure as long as it is near the value of one.

The results of this analysis empirically confirm the theoretical predictions rejecting the quiet life hypothesis, since concentration increases efficiency. Moreover, securitization holds its negative and significant impact on efficiency. The negative and significant impact of the joint interaction between concentration and securitization (-0.153 and -0.094 in columns (5) and (6), respectively) suggests that the more the loans are concentrated and securitized by a single bank, the less the cost efficiency of this bank. Furthermore, the inclusion of the control variables in the model increases the cost efficiency, in the sense that the size, the income share, the equity ratio and the security share are in favor of banks that are more engaged in securitization activities. Better capitalized and large banks, holding more liquidity, can benefit from these characteristics (capitalization, size, and liquidity) to reduce the negative influence of their securitization activities.

### *6.4.4. Quantile Regression*

We also test whether heterogeneous responses to competition and securitization exist. Particularly less efficient banks may reply differently than the most efficient banks to the competition and securitization levels in US. Such varying effects call for an analysis of more than one single slope parameter to describe the impact of banking competition and securitization on efficiency.

Table 11 reports the coefficients of the quantile regression for the $10^{th}$, the $25^{th}$, the $50^{th}$, the $75^{th}$, and the $90^{th}$ quantile of the distribution of cost efficiency.

[INSERT TABLE 11 HERE]

The impact of Lerner index on bank efficiency remains negative and significant across the quantiles. This impact tends to be reduced each time we cross a higher plot (from 0.21 in

column 1 to 0.065 in column 5), which suggests that the impact of bank market power is higher for the less efficient US banks. To gauge the weight of this change, we perform F-test for the equality of the coefficients. This test is rejected, suggesting that relying on a single plot of central tendency is not sufficient to evaluate the impact of competition.

Similarly, securitization significantly reduces the lower and the upper tails of US banks' efficiency scores, with a strong effect on the less efficient banks compared to the most efficient banks. However, despite the insignificant effect of the joint interaction between securitization and competition, we must note that, following the impact of securitization and competition, it is also less pronounced for the most efficient banks. Figure 2 shows that the securitization effect on cost efficiency tends to be positive for higher cost efficiency scores

[INSERT FIGURE 2 HERE]

Our results highlight that policy makers need to consider that any competition restriction policy or any securitization activity restriction may differently affect banks' efficiency, which is crucial for their survival. Second, the decreasing magnitude the coefficient of concentration and securitization underscores that banks at the lower tail of the distribution of cost efficiency benefit less from concentration and securitization at the same time.

This is important. A bank that faces higher costs and could not increase its productivity and hence its scale economies, could not survive in concentrated banking markets, where the interstate branching activities are restricted, but can perform better under the Dodd-Frank Act of 2010 that restricts securitization activities by forcing banks more engaged in securitization to retain no less than 5% of their risky loans in their balance sheets.

#### *6.4.5. Interstate Branching Restrictions*

Our previous results argue that securitization reduces bank efficiency in concentrated banking market. To confirm these results, we split the sample into two categories: the first category includes the states having the highest degree branch activity restrictiveness and all the other states.

This test is motivated by the need to provide further evidence that the negative impact of securitization on efficiency is more pronounced in the most concentrated banking states than the other states.

Moreover, considering the U.S. Congress Interstate Banking and Branching Efficiency Act (IBBEA) of 1994 is an important contribution to our analysis. As Rice and Strahan (2010)

argue, "Allowing interstate branching was the watershed event of IBBEA". They argue that if the states are relaxing bank branching restrictions, the interbank competition will increase and vice versa. So we expect that the less competitive states are those having the most branching restrictions by the Congress.

To compare the most and the less competitive states, we refer to Rice and Strahan (2010)'s index that attributes a score ranging between zero and four to each state according to four principal factors: (1) the minimum age of the target institution, (2) de novo interstate branching, (3) the acquisition of individual branches, and (4) a statewide deposit cap. [30]

To perform our analysis, we hypothesize a more negative impact of securitization on efficiency in the less deregulated states having the lowest level of competition rather than the highest deregulated states. The more the index is close to zero, the more the state is deregulated and hence the banking market is more competitive and vice versa. [31]

We regress the securitization variable on cost efficiency and technical efficiency, as well as the cost to income ratio, for two samples: The first sample includes the states that obtain an index value of four, indicating the most restrictive stance toward interstate entry and hence the most concentrated states[32], while the second one includes the other states, which are characterized by a higher interstate branch competition than the first sample. More precisely, we include a dummy variable that equals one for the first sample and zero otherwise. We expect a negative and significant impact of the interaction between the dummy variable and the securitization variable. The model takes the following form:

$$EFF_{jt} = a_j + b_1 SECURITIZATION_{jt} + b_2 SECURITIZATION_{jt} * BRANCHING\ REST_{jt} + b_3 BRANCHING\ REST_{jt} + b_4(X_{jt}) + \varepsilon_{jt} \quad (10)$$

Where $EFF_{jt}$ is the cost efficiency SFA of bank j at time t, or the DEA technical efficiency score or the Cost to Income ratio of bank j at time t. $X_{jt}$ is a vector of bank-specific control variables including the equity ratio (ER), the security share (SEC), the income share (INC), the size and the loan loan reserve share (LLR) of bank j at time t. $\varepsilon_{jt}$ denotes the error term. $SECURITIZATION_{jt}$ is the ratio of total securitized loans to total outstanding loans.

[30] See, for instance, Rice and Strahan (2010) for more details about their index's analysis.

[31] Cornaggia et al. (2015) use this index to analyze the impact of competition on innovation. A value of zero indicates the most open interstate entry, while a value of four indicates the most restrictive stance toward interstate entry and hence the highest level of concentration.

[32] According to Rice and Strahan (2010), the most restrictive states are: Arkansas, Iowa, Kansas, Kentucky, Montana, Missouri, Mississippi, and Nebraska. The other states have index values ranging from zero to three.

$BRANCHING\ REST_{jt}$ is a dummy variable equal to one if the bank is located in one of the following eight states that have the highest interstate branching restriction index: Arkansas, Iowa, Kansas, Kentucky, Montana, Missouri, Mississippi, and Nebraska. If the bank is not located in these states, we assign a value of zero to the branching restrictiveness' dummy.

[INSERT TABLE 12 HERE]

The results of equation (10) are reported in table 12. We are interested in analyzing the coefficient $(b_2)$ of the joint interaction $SECURITIZATION_{jt} * BRANCHING\ REST_{jt}$. A negative and significant impact of this coefficient indicates that the impact of securitization is more negative and hence stronger in the states having an index equal to 4, thus the most restricted and concentrated states, rather than the most interbank branching competitive states having an index ranging between zero and 3.

The impact of securitization on bank efficiency is negative and significant on the cost and technical scores, and positive and significant on the cost to income ratio. The joint interaction between securitization and Branching Restrictiveness is negative and significant in columns (1) to (4), suggesting that the negative impact of securitization is fiercer and detrimental for concentrated banking states' efficiency levels. Furthermore, it is positive and significant on the cost to income ratio measuring the inefficiency level, suggesting that securitization increases to a large extent the banks' inefficiency located in one of the eight concentrated states. These results, in line with our previous findings, put forward the importance of the U.S. bank deregulation in promoting bank survival.

## 7. Conclusion

The tremendous evolution of the U.S. bank deregulation, starting from the passage of the IBBEA in 1994 to the Dodd Frank Act in 2010 and preceded by the continuous rise of securitization markets, have heightened interest in the factors driving banking competition and securitization. The latter has often been analyzed as contributing to the financial crisis.

We contribute to the literature by revisiting the competition-efficiency analysis to which we add the post-crisis period, and by testing the impact of securitization for the first time in the literature on bank cost and technical efficiency.

Using data from the Call Report of Condition and Income, we revisit the competition-efficiency nexus by alleviating the influence of a newly debated type of financial innovation, loan securitization, often seen as contributing factor behind the 2007 financial crisis. Our

measurement of bank competition includes concentration measures, mainly the conventional and adjusted Lerner indices. The main motivation for using the latter consists of its ability to show the interrelatedness between competition and efficiency. However, we also perform endogeneity tests using instrumental variable regression to avoid any correlation between competition and efficiency. Furthermore, we contribute to the existing securitization literature by showing how loan portfolio securitization reduces bank cost and technical efficiency before, during, and after the financial crisis. This impact is statistically significant and consistent with previous studies linking securitization to cost-efficiency maximization incentives. We interestingly find that some types of securitized loans are cost efficient, while others are not.

We conduct several robustness tests, which confirm the key findings across large banks; using alternative measures of competition, Boone indicator and HHI; and efficiency as alternatively measured by the cost to income ratio; and also for the most and the less efficient US banks as shown by the quantile regression. In addition, we find that banks engaged in more securitization activities and performing in the most restricted states, as shown by Rice and Strahan (2010)'s index of interstate branching restrictions, are less cost and technical efficient than other banks operating in more competitive states.

Further studies should be performed to evaluate the reasons behind the negative impact of securitization on efficiency, especially in the states that are faced by a stricter branching restriction. We provide a preliminary analysis that can help regulators to avoid the negative consequences of securitization, as targeted by the Dodd Frank Act, and contribute to the social welfare. Such an analysis could not be well performed without linking efficiency to systemic risk, a feasible linkage if we take into consideration, for example, the theories explaining how a high degree of efficiency could enhance the systemic stability of U.S. banks. Until achieving these objectives, securitization activities' restrictions by the Federal Reserve Bank may reduce the inefficiency constraints of the U.S. banking system and contribute to a sustainable loan quality in the future.

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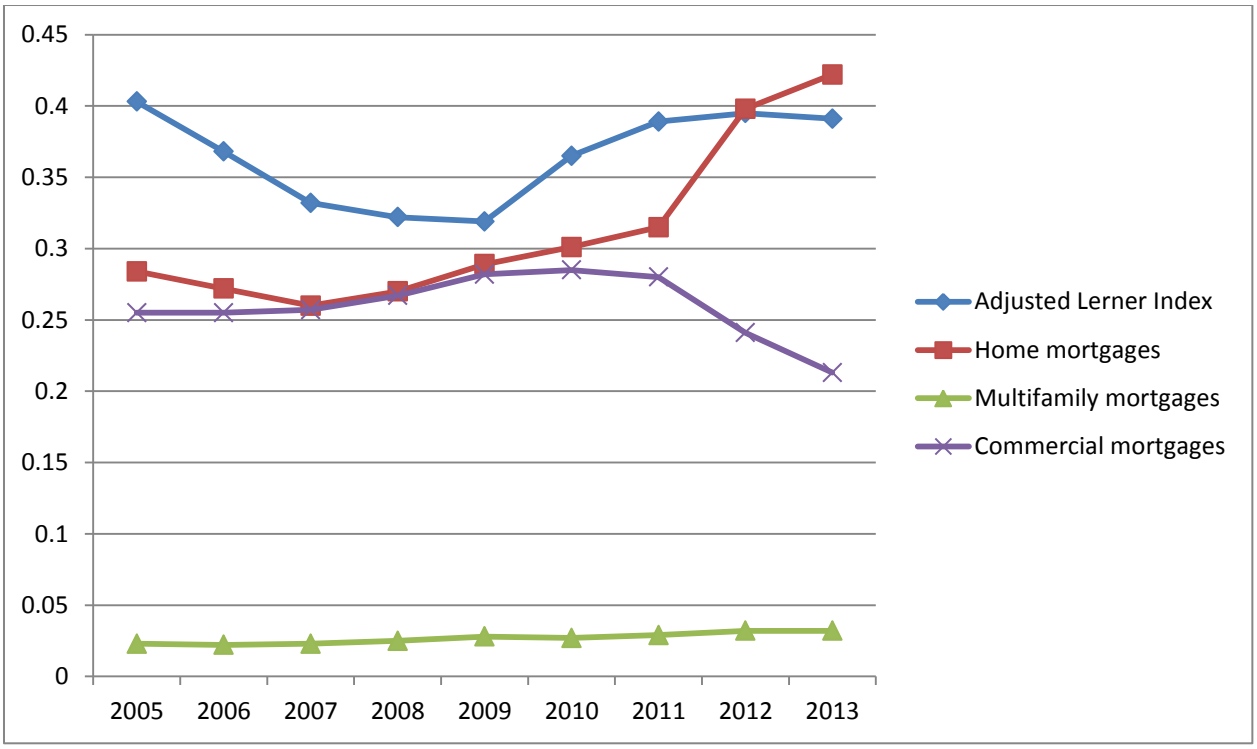
**FIGURE 1. The evolution of bank market power and securitized loans**

**US commercial banks over the period 2005-2013**




*Notes: Figure 1 shows the evolution of securitization and concentration level over time (2005-2013).*

Lerner index is the inefficiency-adjusted Lerner indicator of concentration in banking.
'Home mortgages' denotes the ratio of home mortgages secured by family residential mortgages to total outstanding loans.
'Multifamily mortgages' denotes the ratio of multifamily residential mortgages to total outstanding loans.
'Commercial mortgages' indicates the ratio of mortgages secured by nonfarm nonresidential properties to total outstanding loans.
All these data are collected from the Call Report of Condition and Income.

**FIGURE 2. THE QUANTILE REGRESSION PLOT- SECURITIZATION EFFECT ON COST EFFICIENCY**

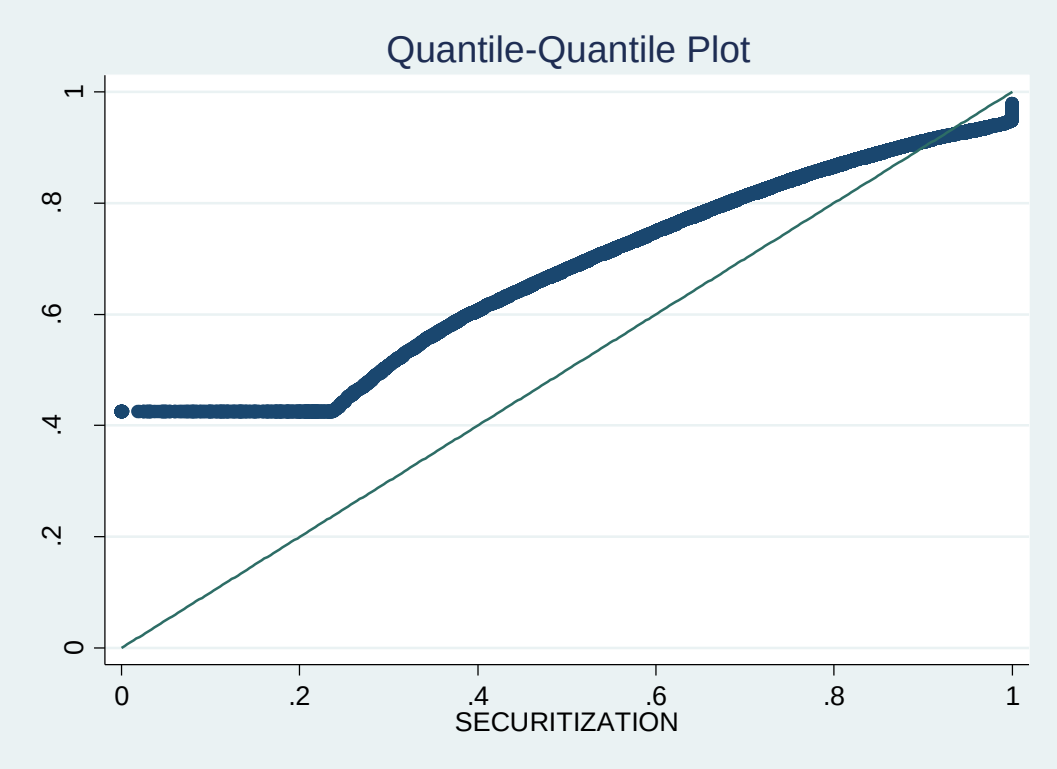


**TABLE 1. LITERATURE REVIEW (COMPETITION-EFFICIENCY)**

| Authors | Period of study | Countries | Methodology | Main empirical results |
|---|---|---|---|---|
| Williams (2012) | 1985-2010 | Latin American banks | Stochastic Frontier Model<br>Lerner indices | Rejection of quiet life hypothesis |
| Fernandez de Guevara et al. (2005) | 1993-2002 | European banking sector | Lerner index | Market power has a positive effect on efficiency |
| Pruteanu-Podpiera et al. (2008) | 1994-2005 | Czech banking system | Lerner index<br>Granger-causality<br>SFA | Competition has a negative effect on cost efficiency<br>Efficiency does not granger-cause competition |
| Koetter et al (2012) | 1976 – 2007 | U.S. commercial banks | Lerner index<br>Cost and profit inefficiencies | Market power increases cost efficiency<br>Support for ESH rather than quiet life |
| Schaeck and Cihak (2008) | 1995 – 2005 | US and European banks | Granger causality<br>Boone | Competition increases profit efficiency |
| Weill (2004) | 1994 – 1999 | Western European Banks | Panzar and Rosse H-statistic | Inverse relation between competition and efficiency |
| Duygun et al. (2013) | 2001-2012 | UK commercial banks | Stochastic frontier approach (Cost and profit efficiency)<br>Trademark intensity | Intensity of Competition through innovation increases cost and profit inefficiency |
| Bolt et al. (2010) | 1987-2006 | Sweden, Norway, Netherlands, Belgium, Finland, France, Denmark, Germany, Italy, United Kingdom, Spain | Competition efficiency frontier | Differences in banking competition play a small role in explaining cross-country variations in banking revenues |
| Angelini and Cetorelli (2000) | 1993 | Italy | Lerner index | Higher competition is associated with higher X-efficiency |
| Schure and Wagenvoort | 1993-1997 | Italy | Recursive thick frontier approach<br>RTFA | Improvement of X-efficiency after 1993 |
| Evanoff and Ors (2002) | 1984 – 1999 | U.S.A. | Competition measured as an increase in the entry | An improvement in competition is associated with higher X-efficiency |
| Berger and Hannan (1998) | 1988 | 12263 US commercial banks | EFF: ratio of predicted costs of efficient bank to that of a bank | Banks not exposed to competition tend to be less efficient than banks subject to more competition. |

| Authors | Period of study | Countries | Methodology | Main empirical results |
|---|---|---|---|---|
| Maudos and De Guevara (2007) | 1993 – 2002 | European banks | Lerner index<br>Cost efficiency (Logit) | Positive relation between market power and efficiency |
| Delis and Tsionas (2009) | 2000 – 2007 | European and US banks | Novel maximum localization technique to derive market power | Negative relation between market power and efficiency<br>Support for Quiet life |
| Turk Ariss (2010) | 1999-2005 | Developing countries | SFA<br>3 adjusted Lerner indices<br>Z-score | Market power decreases cost and increases profit efficiency. |
| Casu and Girardone (2009) | 2000-2005 | France, Germany, Italy, Spain, United Kingdom<br>2701 banks | DEA, SFA, HHI, CR3, Lerner | Increased market power may have a positive effect on efficiency if it enables banks to operate at lower costs. |
| Berger (1995) | 1980-1989 | 4800 US banks | X-efficiency<br>Scale efficiency: ratio of predicted unit cost<br>HHI | Positive relation between cost efficiency and concentration |
| Fu and Heffernan (2009) | 1985-2002 | China<br>14 banks | SFA<br>MS HHI CR4 | No relation between concentration and cost efficiency |
| Solis and Maudos (2008) | 1993 – 2005 | Mexican banks | Lerner index for deposits and loans | Negative link between competition and efficiency in deposit market<br>Positive link in loan market |
| Fungacova et al. (2009) | 2002-2011 | 76 Chinese banks | Lerner<br>SFA | No significant relation between competition and efficiency |
| Stiroh and Strahan (2003) | 1976 – 1994 | US banks | ROE | Competition reallocates profits from weak to “well run banks” |
| DeYoung (1998) | 1991 – 1992 | CAMEL 2-rated banks | TFA methodology | Competition enhances efficiency |

**TABLE 2. VARIABLE DESCRIPTION AND SOURCES**

| Name | Description | Source |
|---|---|---|
| ***Stochastic Frontier Analysis*** | | |
| Cost of fixed assets( $w_1$) | Fixed assets (riad4217) divided by premises and fixed assets (rcfd 2145) | Call Report of Condition and Income, Federal Reserve Bank of Chicago |
| Cost of borrowed funds ($w_2$) | Personnel expenses (riad4135) divided by number of employees (riad4150) | |
| Cost of labor ($w_3$) | Interest expenses on deposits (riad417) divided by sum of total deposits (rcfd2200) | |
| Total securities ($y_1$) | Sum of securities held to maturity (rcfd1754) and securities held for sale (rcfd1773) | |
| Total loans ($y_2$) | Total loans and leases (rcfd1400) | |
| Equity (Z) | Gross total equity (rcfd3210) | |
| Operating costs (TOC) | Sum of interest expenses on deposits (riad4170), on fed funds (riad4180), loan-loss provisions (riad4230), expenditures on fixed assets (riad4217) and salaries (riad4135) | |
| Profits before tax (PBT) | Operating income (riad4000) less TOC | |
| ***IV regression*** | | |
| **Instruments** | | |
| Lagged Lerner | Lerner indices derived from OLS (Conventional) and SFA estimates of marginal cost (Adjusted) lagged by one period | Own calculations |
| Financial freedom | Index measuring the interference of government in financial system | The Heritage Foundation |
| Unemployment rate | Total unemployed as percentage of the civilian labor force | Bureau of Labor Statistics |
| **Control variables** | | |
| Security share (SEC) | Share of securities ($y_1$) of total assets | |
| Loan income share (INC) | Interest and fee income from loans (riad4230) divided by operating income (riad4000) | |
| Size | Logarithm of total assets (rcfd2170) | |
| Loan-loss reserve share (LLR) | Loan-loss reserves (rcfd 3123) divided by total loans | |
| Capital to asset ratio (ER) | Equity ratio defined as gross total equity (rcfd 3210) divided by gross total assets (rcfd 2170) | |
| ***Securitization variables*** | | |
| Home mortgages | Mortgages secured by family (<4) residential mortgages (rcon1430) | |
| Multifamily residential mortgages | Mortgages secured by family (>5) residential mortgages (rcon1460) | |
| Commercial mortgages | Mortgages secured by nonfarm nonresidential properties (rcon1480) | |
| Farm mortgages | Real Estate Loans secured by farmland (rcon1420) | |
| Consumer loans | Loans to individuals for household and family (rcfd1975) | |

**TABLE 3. DESCRIPTIVE STATISTICS**

| Variables | Mean | Standard Deviation | Percentiles 5th | Percentiles 95th | Number of observations |
|---|---|---|---|---|---|
| ***Stochastic Frontier Analysis*** | | | | | |
| $W_1$ | 22.37 | 22.16 | 5.51 | 64.77 | 74,533 |
| $W_2$ | 45.17 | 16.49 | 21.24 | 76.34 | 74,533 |
| $W_3$ | 1.74 | 0.70 | 0.92 | 3.15 | 74,533 |
| $Y_1$ | 240.42 | 3756.66 | 4.56 | 351.87 | 74,533 |
| $Y_2$ | 958.8 | 0.001 | 50.37 | 1336.29 | 74,533 |
| Z | 156.06 | 2306.71 | 7.46 | 180.96 | 74,533 |
| ***IV regression*** | | | | | |
| Instruments | | | | | |
| Unemployment rate | 6.44 | 2.08 | 4.4 | 9.9 | 74,533 |
| Financial freedom | 81.47 | 6.74 | 70 | 90 | 74,533 |
| Control variables | | | | | |
| SEC | 0.69 | 0.13 | 0.45 | 0.87 | 74,533 |
| INC | 0.73 | 0.12 | 0.50 | 0.90 | 74,533 |
| LLR | 0.01 | 0.006 | 0.004 | 0.02 | 74,533 |
| ER | 0.10 | 0.032 | 0.06 | 0.15 | 74,533 |
| ***Data Envelopment Analysis*** | | | | | |
| **Outputs** | | | | | |
| Total Loans ($y_2$) | 958.80 | 0.001 | 50.37 | 1336.29 | 74,533 |
| Earning assets | 1288.84 | 0.001 | 74.81 | 1712.97 | 74,533 |
| Noninterest income | 20.96 | 399.06 | 0.12 | 14.56 | 74,533 |
| Interest income | 61.70 | 966.94 | 2.86 | 80.02 | 74,533 |
| **Inputs** | | | | | |
| Personnel expenses | 15.37 | 252.46 | 0.70 | 19.95 | 74,533 |
| Fixed assets | 16.50 | 169.60 | 0.59 | 31.60 | 74,533 |
| Interest expense | 26.27 | 478.36 | 0.96 | 31.57 | 74,533 |
| Noninterest expense | 18.76 | 291.96 | 0.56 | 19.74 | 74,533 |
| ***Competition measures*** | | | | | |
| Conventional Lerner | 0.39 | 0.11 | 0.22 | 0.54 | 74,533 |
| Adjusted Lerner | 0.35 | 0.12 | 0.17 | 0.50 | 74,533 |
| Boone indicator | -0.01 | 1.57 | -0.26 | 0.14 | 72,374 |
| HHI loans | 0.62 | 0.16 | 0.35 | 0.912 | 74,533 |

| | | | | | |
|---|---|---|---|---|---|
| ***Efficiency variables*** | | | | | |
| Cost Efficiency (SFA) | 0.791 | 0.097 | 0.61 | 0.92 | 74,533 |
| Technical Efficiency (DEA) | 0.3 | 0.142 | 0.137 | 0.569 | 74,533 |
| Cost to Income Ratio | 0.456 | 0.456 | 0.273 | 0.679 | 74,533 |
| ***Securitization variables*** | | | | | |
| Home mortgages ratio | 0.281 | 0.176 | 0.051 | 0.635 | 74,533 |
| Commercial mortgages ratio | 0.264 | 0.139 | 0.058 | 0.51 | 74,533 |
| Consumer loans ratio | 0.065 | 0.092 | 0.002 | 0.197 | 74,533 |
| Farm mortgages ratio | 0.047 | 0.073 | 0.001 | 0.208 | 74,533 |
| Multifamily mortgages ratio | 0.024 | 0.039 | 0.001 | 0.083 | 74,533 |
| Securitization | 0.683 | 0.156 | 0.406 | 0.918 | 74,533 |

**TABLE 4. ADJUSTED AND UNADJUSTED LERNER INDICES: US BANKS IN THE PERIOD 2005-2013**

| | **Competition** | | **Efficiency scores** | |
|---|---|---|---|---|
| Year | Conventional Lerner | Adjusted Lerner | SFA | DEA |
| 2005 | 0.447 | 0.403 | 0.783 | 0.378 |
| 2006 | 0.411 | 0.368 | 0.796 | 0.302 |
| 2007 | 0.374 | 0.332 | 0.812 | 0.277 |
| 2008 | 0.367 | 0.322 | 0.809 | 0.287 |
| 2009 | 0.366 | 0.32 | 0.777 | 0.262 |
| 2010 | 0.41 | 0.364 | 0.763 | 0.306 |
| 2011 | 0.434 | 0.389 | 0.764 | 0.318 |
| 2012 | 0.439 | 0.394 | 0.779 | 0.303 |
| 2013 | 0.434 | 0.39 | 0.79 | 0.299 |
| TOTAL | 0.396 | 0.352 | 0.792 | 0.3 |

*Notes*: Table 4 reports yearly average of adjusted and unadjusted Lerner indices, as well as SFA cost efficiency and DEA technical efficiency scores.

**TABLE 5. SPECIFICATION TESTS FOR IV REGRESSION MODELS ON THE ADEQUACY OF INSTRUMENTS**

| Adjusted Lerner index | Yes | | No | |
|---|---|---|---|---|
| Dependent | **(1)** | **(2)** | **(3)** | **(4)** |
| | **SFA** | **SFA** | **SFA** | **SFA** |
| **Instruments** | | | | |
| Lagged Lerner | YES | YES | YES | YES |
| Financial freedom | YES | YES | YES | YES |
| Unemployment rate | NO | YES | NO | YES |
| **Wooldridge (1995)** | | | | |
| **Over identification test** | | | | |
| Chi square | 2.315 | 1079.35 | 2.765 | 1099.85 |
| p-value | 0.128 | 0.000 | 0.0963 | 0.000 |
| **Exogeneity tests** | | | | |
| Score | 59.693 | 59.75 | 64.0754 | 65.205 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |
| Robust F-statistic | 14.221 | 14.225 | 14.562 | 14.637 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |
| **First-stage results** | | | | |
| R squared | 0.7485 | 0.7485 | 0.7505 | 0.750 |
| Robust F-statistic | 2322.74 | 1612.74 | 2382.57 | 1625.75 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |

*Notes*: We present instruments adequacy test presented in the equation (5).

SFA denotes cost efficiency scores as dependent variable.

Instruments used are Lagged Lerner indices by one period, financial freedom and unemployment rate.

**TABLE 6. INSTRUMENTAL VARIABLE REGRESSION MODEL RESULTS OF LERNER INDEX ON STOCHASTIC FRONTIER AND DATA ENVELOPMENT ANALYSIS EFFICIENCY SCORES**

**US BANKS IN THE PERIOD 2005-2013**

| *Dependent* | *(1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* | *(7)* | *(8)* |
|---|---|---|---|---|---|---|---|---|
| | ***SFA*** | ***SFA*** | ***SFA*** | ***SFA*** | ***DEA*** | ***DEA*** | ***DEA*** | ***DEA*** |
| **Adjusted Lerner** | 0.161*** | | 0.168*** | | 0.288*** | | 0.262*** | |
| | (0.004) | | (0.0049) | | (0.01) | | (0.009) | |
| **Conventional Lerner** | | 0.162*** | | 0.176*** | | 0.308*** | | 0.282*** |
| | | (0.004) | | (0.005) | | (0.01) | | (0.009) |
| **Security share** | | | -0.124*** | -0.121*** | | | -0.017*** | -0.013*** |
| | | | (0.007) | (0.007) | | | (0.01) | (0.01) |
| **Loan income share** | | | 0.412*** | 0.411*** | | | -0.043*** | -0.044*** |
| | | | (0.008) | (0.008) | | | (0.012) | (0.012) |
| **Loan-loss reserves** | | | -2.646*** | -2.654*** | | | 0.403*** | 0.411*** |
| | | | (0.141) | (0.141) | | | (0.13) | (0.13) |
| **Equity ratio** | | | 0.23*** | 0.231*** | | | 0.833*** | 0.831*** |
| | | | (0.016) | (0.016) | | | (0.025) | (0.025) |
| **Size** | | | 0.006*** | 0.006*** | | | 0.008*** | 0.009*** |
| | | | (0.000) | (0.000) | | | (0.001) | (0.001) |
| **Constant** | 0.745*** | 0.737*** | 0.448*** | 0.43*** | 0.18*** | 0.16*** | 0.036*** | 0.004*** |
| | (0.001) | (0.001) | (0.006) | (0.007) | (0.003) | (0.004) | (0.017) | (0.017) |
| **Number of observations** | 48,189 | 48,189 | 48,189 | 48,189 | 48,189 | 48,189 | 48,189 | 48,189 |
| **R-squared** | 5.26 | 4.97 | 23.22 | 23.35 | 6.08 | 6.17 | 10.8 | 10.91 |

*Notes*: Table 6 presents the coefficient estimates of the instrumental variable regression in the equation (6) analyzing the competition-efficiency nexus, whereby we use one Lag period of Lerner indices and financial freedom index as instruments for Adjusted and Unadjusted Lerner indices.

Columns (1) to (4) include SFA cost efficiency score as dependent variable, while Columns (5) and (8) presents regression scores on DEA technical efficiency scores.

Control variables are: security share, loan income share, loan-loss reserve, equity ratio and size respectively. Bank fixed effects are used but not reported.

A more detailed description of these variables is available in table 1.

Robust standard errors are in parentheses. R-squared are reported in percent.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

## TABLE 7. REGRESSION MODEL RESULTS ON THE LOAN PORTFOLIO SECURITIZATION-EFFICIENCY US BANKS IN THE PERIOD 2005-2013

| *Dependent* | *(1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* | *(7)* | *(8)* | *(9)* | *(10)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***SFA*** | ***SFA*** | ***SFA*** | ***SFA*** | ***SFA*** | ***DEA*** | ***DEA*** | ***DEA*** | ***DEA*** | ***DEA*** |
| **Home mortgages** | -0.021*** | | | | | -0.05*** | | | | |
| | (0.001) | | | | | (0.002) | | | | |
| **Multifamily mortgages** | | 0.134*** | | | | | -0.083*** | | | |
| | | (0.008) | | | | | (0.013) | | | |
| **Commercial mortgages** | | | -0.036*** | | | | | -0.169*** | | |
| | | | (0.002) | | | | | (0.003) | | |
| **Farm mortgages** | | | | 0.146*** | | | | | 0.302*** | |
| | | | | (0.004) | | | | | (0.007) | |
| **Consumer mortgages** | | | | | -0.143**** | | | | | 0.186*** |
| | | | | | (0.003) | | | | | (0.005) |
| **Loan-Loss Reserve** | -3.55*** | -3.455*** | -3.35*** | -3.398*** | -3.122*** | -1.02*** | -0.76*** | -0.383*** | -0.681*** | -1.183*** |
| | (0.054) | (0.053) | (0.053) | (0.053) | (0.053) | (0.084) | (0.083) | (0.082) | (0.082) | (0.083) |
| **Equity ratio** | 0.297*** | 0.301*** | 0295*** | 0.308*** | 0.358*** | 0.959*** | 0.968*** | 0.943*** | 0.983*** | 0.894*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) |
| **Size** | 0.004*** | 0.004*** | 0.005*** | 0.007*** | 0.004*** | 0.001*** | 0.002*** | 0.003*** | 0.006*** | 0.002*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Security share** | -0.107*** | -0.105*** | -0.107*** | -0.096*** | -0.104*** | 0.02*** | 0.024*** | 0.014*** | 0.042*** | 0.022*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) |
| **Loan income share** | 0.382*** | 0.379*** | 0.392*** | -0.381*** | 0.359*** | -0.106*** | -0.099*** | -0.064*** | -0.108*** | -0.07*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) |
| **Constant** | 0.533*** | 0.531*** | 0.521*** | 0.481*** | 0.544*** | 0.274*** | 0.243*** | 0.244*** | 0.163*** | 0.22*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| **Number of observations** | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 | 74,533 |
| **R-squared** | 17.11 | 17.24 | 17.21 | 18.08 | 18.65 | 6.53 | 6.21 | 8.72 | 8.39 | 7.49 |

*Notes:* We report regression results of equation (7) for each type of securitized loans on cost efficiency scores in columns (1) to (5) and pure technical efficiency in columns (6) to (10). Control variables are: Loan-loss reserve, equity ratio, size, security share and loan income share. A more detailed description about these variables can be found in table 1.

R-squared are reported in percent.

Robust standard errors are in parentheses.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

**TABLE 8. DIFFERENCE-IN-DIFFERENCE REGRESSION MODEL RESULTS FOR SECURITIZATION INFLUENCE ON COMPETITION-EFFICIENCY IN THE PERIOD 2005-2013**

| *Sample* | **2005Q1-2007Q2** | | | | **2007Q3-2013Q4** | | | |
|---|---|---|---|---|---|---|---|---|
| *Adjusted Lerner* | *Yes* | *Yes* | *No* | *No* | *Yes* | *Yes* | *No* | *No* |
| *Dependent* | ***(1)*** | ***(2)*** | ***(3)*** | ***(4)*** | ***(5)*** | ***(6)*** | ***(7)*** | ***(8)*** |
| | ***SFA*** | ***DEA*** | ***SFA*** | ***DEA*** | ***SFA*** | ***DEA*** | ***SFA*** | ***DEA*** |
| **Lagged Lerner** | 0.095*** | -0.264*** | 0.064*** | -0.27*** | 0.171*** | 0.027*** | 0.183*** | 0.026*** |
| | (0.037) | (0.034) | (0.0142) | (0.036) | (0.007) | (0.018) | (0.008) | (0.019) |
| **SECURITIZATION** | -0.048*** | -0.303*** | -0.334*** | -0.37*** | -0.251*** | -0.091*** | -0.243*** | -0.11*** |
| | (0.009) | (0.023) | (0.01) | (0.026) | (0.007) | (0.011) | (0.008) | (0.013) |
| **Lagged Lerner** | 0.062 | 0.861 | -0.148 | 0.927 | -0.061 | 0.175 | 0.183 | 0.026 |
| ***SECURITIZATION** | (0.013) | (0.056) | (0.022) | (0.059) | (0.018) | (0.027) | (0.013) | (0.019) |
| **Constant** | 0.831*** | 0.397*** | 0.827*** | 0.412*** | 0.919*** | 0.289*** | 0.907*** | 0.289*** |
| | (0.006) | (0.014) | (0.006) | (0.016) | (0.005) | (0.007) | (0.005) | (0.008) |
| **R-squared** | 1.34 | 2.14 | 1.24 | 1.96 | 3.43 | 5.51 | 3.27 | 5.74 |
| **Number of observations** | 30,743 | 30,743 | 30,743 | 30,743 | 30,743 | 30,743 | 30,743 | 30,743 |

*Notes:* We report results based on the difference-in difference regressions presented in equation (8).

Columns (1) to (4) study the pre-crisis period (First quarter of 2005 till second quarter of 2007).

Columns (5) to (8) report coefficient estimates of the post-crisis period (Third quarter of 2007 till last quarter of 2013).

Columns (1), (3), (5) and (7) show the regression results of Lagged Lerner and securitization on cost efficiency while the other columns present regression on pure technical efficiency.

Independent variables are: Lagged values of Lerner, securitization variable, and interaction term between Lagged Lerner and securitization.

R-squared are reported in percent.

Robust standard errors are in parentheses.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

## TABLE 9. ROBUSTNESS CHECKS

## DIFFERENCE-IN-DIFFERENCE REGRESSION ON COST TO INCOME RATIO

## US BANKS IN THE PERIOD 2005-2013

| *Sample* | **2005Q1-2007Q2** | | | | **2007Q3-2013Q4** | | | |
|---|---|---|---|---|---|---|---|---|
| *Adjusted Lerner* | *Yes* | *Yes* | *No* | *No* | *Yes* | *Yes* | *No* | *No* |
| *Dependent* | ***(1)*** | ***(2)*** | ***(3)*** | ***(4)*** | ***(5)*** | ***(6)*** | ***(7)*** | ***(8)*** |
| | ***CIR*** | ***CIR*** | ***CIR*** | ***CIR*** | ***CIR*** | ***CIR*** | ***CIR*** | ***CIR*** |
| **Lagged Lerner** | -0.386*** | -0.313*** | -0. 4*** | -0.325*** | -0.695*** | -0.569*** | -0.742*** | -0.608*** |
| | (0.037) | (0.019) | (0.022) | (0.02) | (0.022) | (0.021) | (0.024) | (0.022) |
| **SECURITIZATION** | -0.025 | -0.019 | -0.068*** | -0.048*** | 0.249*** | 0.202 | 0.242*** | 0.198*** |
| | (0.014) | (0.013) | (0.016) | (0.015) | (0.003) | (0.012) | (0.015) | (0.014) |
| **Lagged Lerner *SECURITIZATION** | 0.419*** | 0.282*** | 0.479*** | 0.321*** | 0.102*** | -0.038*** | 0.146*** | -0.012 |
| | (0.033) | (0.031) | (0.036) | (0.033) | (0.034) | (0.031) | (0.036) | (0.034) |
| **Size** | | -0.046*** | | -0.046*** | | -0.016*** | | -0.017*** |
| | | (0.001) | | (0.001) | | (0.001) | | (0.001) |
| **LLR** | | -0.301*** | | -0.303*** | | 6.42*** | | 6.523*** |
| | | (0.202) | | (0.203) | | (0.105) | | (0.106) |
| **Equity Ratio** | | 0.301*** | | 0.307*** | | 0.071*** | | 0.069** |
| | | (0.028) | | (0.028) | | (0.027) | | (0.027) |
| **Security share** | | 0.06*** | | 0.059*** | | -0.31*** | | -0.323*** |
| | | (0.01) | | (0.01) | | (0.01) | | (0.01) |
| **Income share** | | -0.347*** | | -0.347*** | | 0.035*** | | 0.039*** |
| | | (0.011) | | (0.011) | | (0.01) | | (0.01) |
| **Constant** | 0.482*** | 1.248*** | 0.504*** | 1.271*** | 0.511*** | 0.848*** | 0.289*** | 0.912*** |
| | (0.009) | (0.019) | (0.01) | (0.2) | (0.009) | (0.018) | (0.007) | (0.019) |
| **R-squared** | 9.32 | 20.68 | 6.92 | 19.42 | 32.92 | 39.76 | 30.56 | 38.21 |
| **Number of observations** | 17,446 | 17,446 | 17,446 | 17,446 | 30,743 | 30,743 | 30,743 | 30,743 |

*Notes:* We report results based on difference-in difference regressions. Columns (1) to (4) study the pre-crisis period starting from the first quarter of 2005 to the second quarter of 2007. Columns (5) to (8) report coefficient estimates of the post-crisis period starting from the third quarter of 2007 to the last quarter of 2013.

Columns (1), (3), (5) and (7) show the regression results of Lerner indices and securitization on Cost to Income Ratio without control variables while the other columns report the results of regressions controlled by size, loan loss reserve share, equity ratio, security share and income share. Cost to Income Ratio is the ratio of total noninterest expenses (riad4093) to the total operating income (riad4000) and is collected from the Call Report of Condition and Income, Federal Reserve Bank of Chicago. Independent variables are: Lagged values of conventional and adjusted Lerner indices, securitization, and interaction term between Lagged Lerner and securitization.

Robust standard errors are in parentheses. R-squared are reported in percent.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

**TABLE 10. ROBUSTNESS CHECKS**

**DIFFERENCE-IN-DIFFERENCE REGRESSION FOR LARGE BANKS, BOONE INDICATOR, and HHI LOANS**

| *Dependent* | *(1)* *LARGE* | *(2)* *LARGE* | *(3)* *ALL* | *(4)* *ALL* | *(5)* *ALL* | *(6)* *ALL* |
|---|---|---|---|---|---|---|
| **Lerner $_{t-1}$** | 0.212*** | 0.058 | | | | |
| | (0.083) | (0.066) | | | | |
| **Boone$_{t-1}$** | | | -0.000** | -0.000** | | |
| | | | (0.000) | (0.000) | | |
| **HHI Loans$_{t-1}$** | | | | | 0.091*** | 0.051*** |
| | | | | | (0.014) | (0.012) |
| **SECURITIZATION** | -0.24*** | -0.313*** | -0.306*** | -0.195*** | -0.202*** | -0.13*** |
| | (0.057) | (0.005) | (0.003) | (0.009) | (0.015) | (0.013) |
| **Competition $_{t-1}$** | -0.017 | 0.162 | 0.001** | 0.001** | -0.153*** | -0.094*** |
| ***SECURITIZATION** | (0.14) | (0.112) | (0.000) | (0.000) | (0.021) | (0.018) |
| **LLR** | | -2.857*** | | -3.157*** | | -3.23*** |
| | | (0.425) | | (0.212) | | (0.213) |
| **Equity Ratio** | | 0.205 | | 0.075* | | 0.089** |
| | | (0.105) | | (0.01) | | (0.035) |
| **Security share** | | 0.202*** | | 0.267*** | | 0.234*** |
| | | (0.039) | | (0.038) | | (0.012) |
| **Income share** | | 0.298*** | | | | 0.093*** |
| | | (0.044) | | | | (0.017) |
| **Size** | | | | 0.02*** | | 0.017*** |
| | | | | (0.000) | | (0.002) |
| **Constant** | 0.878*** | 0.601*** | 1.001*** | 0.5*** | 0.94*** | 0.459*** |
| | (0.034) | (0.044) | (0.007) | (0.039) | (0.01) | (0.038) |
| **R-squared** | 3.31 | 23.69 | 1.30 | 5.22 | 1.12 | 7.27 |
| **Number of observations** | 4,466 | 4,466 | 72,373 | 72,373 | 74,532 | 74,532 |

*Notes:* We report regression results of competition-securitization-efficiency for US commercial banks. R-squared are reported in percent.
In columns (1) and (2), we use the adjusted Lerner index, lagged by one period.
In columns (3) and (4), we use Boone indicator, lagged by one period for the entire sample (Regression model is presented in equation (9)).
In columns (5) and (6), we use Herfindahl- Hirschman index, lagged by one period.
Columns (7) and (8) report regression results of HHI loan concentration measure on cost efficiency for the entire sample.
The dependent variable is the cost efficiency score generated through stochastic frontier analysis. Large banks have total assets higher than one billion US dollars (consistent with Duygun et al., 2014). Robust standard errors are in parentheses. Bank fixed effects are included but not reported.

## TABLE 11. QUANTILE REGRESSION

| *Dependent* | *(1)* *10th Quantile* | *(2)* *25th Quantile* | *(3)* *50th Quantile* | *(4)* *75th Quantile* | *(5)* *90th Quantile* |
|---|---|---|---|---|---|
| **Lagged LERNER** | 0.21*** | 0.17*** | 0.153*** | 0.124*** | 0.065*** |
| | (0.042) | (0.021) | (0.029) | (0.021) | (0.02) |
| **SECURITIZATION** | -0.049*** | -0.066*** | -0.05*** | -0.028** | -0.028*** |
| | (0.021) | (0.012) | (0.017) | (0.011) | (0.01) |
| **Lagged LERNER** | 0.006 | 0. 02 | -0.001 | -0.004 | -0.003 |
| ***SECURITIZATION** | (0.062) | (0.03) | (0.044) | (0.029) | (0.026) |
| **LLR** | -5.483*** | -4.54*** | -2.97*** | -1.767*** | -1.097*** |
| | (0.199) | (0.149) | (0.159) | (0.112) | (0.142) |
| **Equity Ratio** | 0.157*** | 0.224*** | 0.32*** | 0.388*** | 0.342*** |
| | (0.019) | (0.021) | (0.019) | (0.013) | (0.011) |
| **Security share** | -0.121*** | -0.141*** | -0.138*** | -0.116*** | -0.078*** |
| | (0.01) | (0.008) | (0.009) | (0.009) | (0.008) |
| **Income share** | 0.529*** | 0.51*** | 0.434*** | 0.322*** | 0.208*** |
| | (0.013) | (0.013) | (0.009) | (0.009) | (0.009) |
| **Size** | 0.008*** | 0.007*** | 0.006*** | 0.004*** | 0.003*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Constant** | 0.266*** | 0.385*** | 0.485*** | 0.606*** | 0.722*** |
| | (0.021) | (0.013) | (0.014) | (0.012) | (0.01) |
| **R-squared** | 17.2 | 13.69 | 11.3 | 8.65 | 6.57 |
| **Number of observations** | 46,751 | 46,751 | 46,751 | 46,751 | 46,751 |

*Notes:* We report simultaneous quantile regressions at the 10th, the 25th, the 50th, the 75th, and the 90th quantile of the distribution of the cost efficiency score.

*Control variables: Loan Loss Reserve, Equity ratio, Security Share, Income Share and Bank size.*

R-squared are reported in percent.

Robust standard errors are in parentheses.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

## TABLE 12. ROBUSTNESS CHECKS

## COMPARING SECURITIZATION-EFFICIENCY RESULTS BY INTERSTATE BRANCHING RESTRICTIONS

| *Dependent* | *(1)* *SFA* | *(2)* *SFA* | *(3)* *DEA* | *(4)* *DEA* | *(5)* *CIR* | *(6)* *CIR* |
|---|---|---|---|---|---|---|
| **SECURITIZATION** | -0.053*** | -0.044*** | -0.044*** | -0.056** | 0.069*** | 0.061*** |
| | (0.002) | (0.002) | (0.004) | (0.004) | (0.004) | (0.004) |
| **BRANCHING REST.** | 0.077*** | 0.074*** | 0.057*** | 0.063*** | -0.084*** | -0.085*** |
| | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) | (0.005) |
| **BRANCHING REST.*SECURITIZATION** | **-0.105*** ** | **-0.095*** ** | **-0.064*** ** | **-0.074*** ** | **0.084*** ** | **0.073*** ** |
| | **(0.005)** | **(0.005)** | **(0.009)** | **(0.009)** | **(0.007)** | **(0.007)** |
| **LLR** | | -3.454*** | | -0.803*** | | 5.76*** |
| | | (0.131) | | (0.123) | | (0.29) |
| **Equity Ratio** | | 0.304*** | | 0.975*** | | 0.109*** |
| | | (0.015) | | (0.022) | | (0.041) |
| **Security share** | | -0.117*** | | 0.013 | | -0.05*** |
| | | (0.006) | | (0.008) | | (0.009) |
| **Income share** | | 0.388*** | | -0.099*** | | -0.128*** |
| | | (0.007) | | (0.009) | | (0.01) |
| **Size** | | 0.005*** | | 0.002* | | -0.024*** |
| | | (0.000) | | (0.001) | | (0.000) |
| **Constant** | 0.827*** | 0.553*** | 0.327*** | 0.282*** | 0.414*** | 0.787*** |
| | (0.002) | (0.006) | (0.003) | (0.014) | (0.003) | (0.01) |
| **R-squared** | 1.84 | 18.57 | 0.62 | 7.03 | 1.57 | 10.08 |
| **Number of observations** | 74,077 | 74,077 | 74,077 | 74,077 | 74,077 | 74,077 |

*Notes:* We report regression results including a dummy variable (BRANCHING RESTRICTIVENESS) to test the difference between the most restrictive branching states and the other states.

*Control variables: Loan Loss Reserve, Equity ratio, Security Share, Income Share and Bank size.*

Robust standard errors are in parentheses. R-squared are reported in percent.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

## Appendix A. ORDINARY LEAST SQUARE AND STOCHASTIC COST FRONTIER RESULTS FOR THE ESTIMATION OF MARGINAL COSTS

| Dependent | OLS | | SFA | |
|---|---|---|---|---|
| | Parameter | *p*-value | Parameter | *p*-value |
| Constant | 2.352*** | 0.000 | 1.406*** | 0.000 |
| $Lnw_1$ | -0.0332*** | 0.000 | -0.397*** | 0.000 |
| $Lnw_2$ | -0.031*** | 0.003 | -0.062 | 0.116 |
| $Lny_1$ | 0.241*** | 0.000 | 0.248*** | 0.000 |
| $Lny_2$ | 0.571*** | 0.000 | 0.593*** | 0.000 |
| lnZ | 0.054*** | 0.000 | 0.0166*** | 0.000 |
| ½ $(lnw_1)^2$ | -0.091*** | 0.000 | -0.106*** | 0.000 |
| ½ $(lnw_1 \text{ x } lnw_2)$ | 0.073*** | 0.000 | 0.087*** | 0.000 |
| ½ $(lnw_2)^2$ | 0.153*** | 0.000 | 0.097*** | 0.000 |
| ½ $(lny_1)^2$ | 0.062*** | 0.000 | 0.056*** | 0.000 |
| ½ $(lny_1 \text{ x } lny_2)$ | -0.07*** | 0.000 | -0.063*** | 0.000 |
| ½ $(lny_2)^2$ | 0.106*** | 0.000 | 0.095*** | 0.000 |
| $Lny_1 \text{ x } lnw_1$ | 0.012*** | 0.000 | 0.013*** | 0.000 |
| $Lny_1 \text{ x } lnw_2$ | 0.012*** | 0.000 | 0.01*** | 0.000 |
| $Lny_2 \text{ X } lnw_1$ | -0.003 | 0.144 | -0.006*** | 0.000 |
| $Lny_2 \text{ x } lnw_2$ | -0.52*** | 0.000 | -0.043*** | 0.000 |
| Trend | 0.041*** | 0.000 | 0.019*** | 0.000 |
| $Trend^2$ | 0.002*** | 0.000 | 0.001*** | 0.000 |
| $Lnw_1$ x trend | -0.0006* | 0.0836 | -0.0001*** | 0.000 |
| $Lnw_2$ x trend | 0.001*** | 0.0002 | 0.0008*** | 0.000 |
| $Lny_1$ x trend | -0.006*** | 0.000 | -0.006*** | 0.000 |
| $Lny_2$ x trend | -0.012*** | 0.000 | -0.005*** | 0.000 |
| Lambda | | | 1.943*** | 0.000 |
| Sigma | | | 0.351*** | 0.000 |
| Number of observations | | 74,533 | | 74,533 |

*NOTES*: Appendix A reports coefficient estimates of independent variables for the ordinary least square (OLS) and the cost frontier analysis (SFA) approach in equation (2).

Parameters definitions: $Lambda = \sigma_u/\sigma_v$ $Sigma^2 = \sigma_u + \sigma_v^2$

We use robust standard errors.

Symmetry and homogeneity restrictions are taken into consideration.

The dependent variable is the natural logarithm of total operating costs.

Variables definition is available in table (2).

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

## Appendix B. Boone indicator for each state

| Year | 2005 | 2006 | 2007 | 2008 | 20009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|
| **Arkansas** | 0.012 | 0.047 | -0.001 | -0.000 | -0.09 | -0.295 | -0.161 | -0.167 | 0.0418 |
| **California** | -0.156 | 0.004 | -0.055 | -0.006 | -0.083 | -0.171 | -0.073 | 0.134 | 0.059 |
| **Colorado** | 0.328 | 0.336 | 0.142 | 0.226 | 0.162 | -0.384 | -0.306 | -1.129 | -0.156 |
| **Connecticut** | 0.113 | 0.086 | 0.032 | 0.026 | 0.003 | -0.038 | 0.439 | 0.027 | 0.743 |
| **Florida** | -0.098 | -0.229 | -0.095 | -0.075 | -0.001 | 0.021 | -0.04 | -0.346 | -0.057 |
| **GA** | -0.18 | -0.123 | -0.054 | -0.038 | -0.026 | -0.107 | -0.164 | -0.055 | 0.219 |
| **Iowa** | 0.039 | 0.013 | -0.002 | 0.011 | 0.043 | 0.063 | 0.07 | -0.109 | -0.122 |
| **Illinois** | -0.049 | -0.024 | -0.033 | -0.018 | -0.062 | -0.069 | -0.233 | -0.482 | 0.278 |
| **Indiana** | -0.023 | 0.048 | 0.091 | 0.045 | 0.003 | -0.133 | -0.028 | -0.006 | -0.086 |
| **Kansas** | -0.283 | -0.157 | -0.059 | -0.052 | -0.108 | -0.174 | -0.425 | -0.128 | 0.707 |
| **Kentucky** | 0.025 | 0.06 | 0.007 | 0.002 | 0.059 | 0.045 | 0.14 | -0.001 | 0.366 |
| **Los Angeles** | 0.161 | 0.089 | 0.055 | 0.076 | 0.129 | 0.079 | 0.073 | 0.079 | 0.124 |
| **Massachussets** | 0.045 | 0.028 | 0.083 | 0.066 | 0.008 | -0.062 | -0.251 | 0.227 | -0.013 |
| **Maryland** | -0.331 | -0.086 | -0.016 | -0.046 | -0.068 | -0.123 | -0.152 | -0.138 | -0.098 |
| **Maine** | -0.016 | -0.014 | -0.023 | -0.005 | -0.015 | -0.122 | -0.375 | 0.07 | -0.018 |
| **Michigan** | -0.038 | -0.011 | -0.038 | -0.032 | 0.006 | -0.04 | -0.109 | -1.275 | -0.071 |
| **Minnesota** | 0.011 | 0.021 | -0.017 | -0.01 | 0.003 | 0.013 | 0.026 | 0.125 | 0.11 |
| **Missouri** | -0.038 | -0.011 | -0.022 | -0.018 | 0.031 | 0.033 | 0.077 | -0.038 | -0.081 |
| **Mississippi** | -0.002 | 0.064 | 0.049 | 0.026 | 0.027 | 0.047 | 0.262 | 0.034 | 0.38 |
| **North Carolina** | -0.056 | -0.021 | -0.033 | -0.038 | -0.087 | -0.086 | -0.121 | 0.007 | -0.283 |
| **North Dakota** | -0.125 | -0.022 | -0.028 | 0.026 | 0.035 | -0.088 | 0.067 | -0.078 | -0.135 |
| **Nebraska** | -0.408 | -0.349 | -0.394 | -0.35 | -0.348 | -0.13 | -0.244 | -0.327 | -0.318 |
| **New Jersey** | 0.115 | 0.141 | 0.035 | 0.1 | -0.023 | -0.022 | -0.264 | -0.316 | 0.047 |
| **New York** | 0.132 | 0.412 | 0.22 | 0.074 | 0.012 | 0.038 | 0.139 | -0.443 | 0.618 |
| **Ohio** | -0.365 | -0.185 | -0.223 | -0.209 | -0.293 | 0.131 | 0.408 | 0.349 | 0.39 |
| **Pennsylvania** | -0.033 | -0.024 | -0.011 | 0.038 | 0.018 | -0.013 | 0.036 | -0.173 | 0.389 |
| **South Carolina** | -0.052 | 0.02 | -0.005 | -0.021 | -0.062 | -0.071 | 0.011 | -0.015 | 0.189 |
| **South Dakota** | -0.595 | -0.646 | -0.558 | -0.443 | -0.39 | -0.542 | -0.934 | -0.75 | -0.307 |
| **Tennessee** | -0.046 | -0.007 | -0.049 | -0.004 | 0.015 | -0.051 | -0.059 | -0.183 | 0.24 |
| **Texas** | 0.07 | -0.013 | -0.04 | -0.02 | 0.022 | 0.175 | 0.358 | 0.748 | 0.874 |
| **Virginia** | -0.212 | -0.042 | -0.087 | -0.084 | -0.088 | -0.136 | -0.007 | 0.033 | -0.013 |
| **Washington** | -0.145 | -0.113 | -0.016 | -0.049 | -0.096 | -0.119 | 0.047 | 0.251 | 0.035 |
| **Wisconsin** | -0.002 | -0.013 | -0.022 | -0.02 | -0.013 | -0.076 | -0.104 | -0.132 | -0.136 |
| **West Virginia** | -0.047 | 0.006 | 0.034 | 0.131 | 0.028 | -0.007 | -0.112 | -0.097 | -0.179 |