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European banks' technical efficiency and performance: do business models matter? The case of European co-operatives banks

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European banks' technical efficiency and performance: do business models matter? The case of European cooperative banks[2]

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European banks' technical efficiency and performance: do business models matter? The case of European cooperatives banks.

This paper analyses the technical efficiency of European co-operative banks compared to European commercial banks from 2006 to 2014. For this we use the B-convexity method, an innovative approach in frontier efficient models estimation, to measure banks' technical efficiency; we also analyse the influence of certain variables on the level of efficiency. Our findings show that: a) a principal component analysis indicates that cooperative banks' balance sheet are oriented towards lending activities while commercial banks are more oriented towards securities and derivatives activities; b) on average, the technical efficiency of the banks in our sample significantly decreased between 2007 and 2009, before recovering markedly between 2010 and 2012 and stabilizing over the period 2013-2014; c) there is no significant difference in technical efficiency between European cooperative banks and commercial banks, although we observe a slight superiority of commercial banks; d) French cooperative banks have higher levels of technical efficiency than their European peers; and (e) technical efficiency is positively impacted by the banks' size, suggesting that large banks tend to have higher technical efficiency than smaller banks. This is in line with a trend towards concentration to improve technical efficiency in the European banking sector.

Keywords: European banking; cooperative banks; technical efficiency; B-convexity; non-parametric frontier approach
JEL classification: C14 ; C67 ; G21 ; G30

L'efficience technique et la performance des banques européennes: les modèles économiques sont-ils importants? Le cas des banques coopératives européennes.

L'article étudie, sur la période 2006 à 2014, l'efficience technique des banques coopératives comparée à celle des banques commerciales européennes. Pour cela, nous utilisons la méthode B-convexity, une approche innovante dans l'estimation des frontières d'efficience, pour le calcul des scores d'efficience. De plus, nous analysons l'influence de certaines variables sur le niveau d'efficience. Cette étude montre que a) une analyse en composantes principales affiche une orientation du bilan des banques coopératives vers les activités de prêt tandis que les banques commerciales ont des activités plus orientées vers les activités de titres et produits dérivés ; b) en moyenne, l'efficience technique des banques de notre échantillon a diminué entre 2007 et 2009, avant de se redresser nettement de 2010 à 2012 et s'est stabilisée sur la période 2013-2014 ; c) il n'y a pas de différence significative en termes d'efficience technique entre les banques coopératives et les banques commerciales européennes, même si nous observons une légère supériorité des banques commerciales ; d) les banques coopératives françaises affichent des niveaux d'efficience technique plus élevés que leurs pairs européens; et e) l'efficience technique est impactée positivement par la taille des banques ce qui suggère que les grandes banques ont tendance à avoir une efficience technique plus élevée que les plus petites. Ce constat va dans le sens d'un processus de concentration pour améliorer l'efficience technique dans le secteur bancaire européen.

Mots-clés: Banques européennes; Banques coopératives; Efficience technique; B-convexity; Frontière d'efficience non-paramétrique
JEL classification: C14 ; C67 ; G21 ; G30

Non-technical summary

Research question

The post-crisis period is marked by major challenges threatening the business models of traditional banks: a persistently low interest rate environment and a rise in Fintech competition. In this context, the Bank Efficiency Study completes the available measurement tools that allow bank regulators to better understand best performance practices that promote financial stability and efficient financing of the economy. Does the decline in average returns of European banks in recent years stem from insufficient margins or inefficiency in the use of available resources? In this reflection, a focus on European cooperative banks seems to be interesting and useful. Indeed, because of their characteristics, cooperative banks play an essential role in the European financial system. Moreover, within the framework of the Single Supervision Mechanism of European banks, studies on the different business models of banks are important issues. In this context, different questions can arise: 1 / Are European cooperative banks different from their counterparts' commercial banks in terms of performance? 2 / As some authors claim, are the business models of cooperative banks obsolete and inefficient? 3 / Does the size of banks have a positive and significant effect on the efficiency of European banks? The latter issue would provide essential information on the current question of regulators on the impact of a possible consolidation of the European banking sector, in particular for the Italian cooperative banks which remain highly fragmented and become concerns of the Italian regulator.

Contribution

Our study is the first to apply the B-convexity method (Briec et al., 2004; 2011) -an innovative approach to the estimation of efficiency frontiers- on European banks. In general, economic analysis is based on a convexity hypothesis (Debreu 1959). However, non-convexity appears in some cases in particular including externalities, increasing returns and non-divisibility (Guesnerie 1975, Starrett 1972). In the case of the banking industry, many circumstances reveal a failure to respect the hypothesis of convexity, in particular the existence of temporary increasing returns due to new banking technologies. In this context, our study completes the existing literature on the application of non-convex methods in the efficiency measurement in banking sector. In addition, we provide a recent view on the performance indicators of European co-operative banks and commercial banks after the 2007-2008 crisis.

Results

Demonstrating that cooperative banks' balance sheet are oriented towards lending activities while commercial banks are more oriented towards securities and derivatives activities, our results suggest that i / there is no significant difference in terms of technical efficiency between cooperative banks and European commercial banks, although we observe a slight superiority of commercial banks; ii / French cooperative banks have higher levels of technical efficiency than their European peers; and iii / technical efficiency is positively impacted by banks' size, suggesting that large banks tend to have higher technical efficiency than smaller ones, but this findings is not more significant for cooperative banks.

Résumé non technique

Problématique

La période post-crise est marquée par des enjeux majeurs menaçant les modèles économiques des banques traditionnelles : un environnement de taux d'intérêts durablement bas et une montée de la concurrence des Fintech. Dans ce contexte, l'étude sur l'efficience des banques complète les outils de mesure disponibles qui permettent aux régulateurs bancaires de mieux comprendre les meilleures pratiques en matière de performance favorisant la stabilité financière et un financement efficace de l'économie. La baisse des rentabilités moyennes des banques européennes de ces dernières années proviennent-elles de marges insuffisantes ou d'une inefficience dans l'emploi des ressources disponibles ? Dans cette réflexion, un focus sur les banques coopératives européennes semble être intéressant et utile. En effet, en raison de leurs caractéristiques, les banques coopératives jouent un rôle essentiel dans le système financier européen. Par ailleurs, dans le cadre du Mécanisme de Supervision Unique des banques européennes, les études sur les différents modèles économiques des banques sont des enjeux importants. Dans ce contexte, différentes question peuvent donc se poser : 1/ les banques coopératives européennes sont-elles différentes de leurs homologues banques commerciales en matière de performance? 2/ Comme le prétendent certains auteurs, les modèles économiques des banques coopératives sont-ils obsolètes et inefficients ? 3/ La taille des banques a-t-elle un effet positif et significatif sur l'efficience des banques européennes ? Cette dernière question apporterait notamment une information essentielle sur l'interrogation actuelle des autorités de régulation sur l'impact d'une éventuelle consolidation du secteur bancaire européen, notamment pour les banques coopératives italiennes qui demeurent très fragmentées et deviennent des préoccupations du régulateur italien.

Contribution

Notre étude est la première à appliquer la méthode B-convexity (Briec et al. 2004; 2011), une approche innovante dans l'estimation des frontières d'efficience, sur les banques européennes. En général, l'analyse économique repose sur une hypothèse de convexité (Debreu 1959). Cependant, la non-convexité apparaît dans certains cas notamment en présence d'externalités, de rendements croissant et non-divisibilité (Guesnerie 1975, Starrett 1972). Dans le cas de l'industrie bancaire, de nombreuses circonstances font apparaître un non-respect de l'hypothèse de convexité notamment l'existence de façon temporaire de rendements croissants grâce aux nouvelles technologies bancaires. Dans ce contexte, notre étude complète la littérature existante sur l'application des méthodes non-convexes dans la mesure d'efficience en banque. De plus, nous apportons une vision récente sur les indicateurs de performance des banques coopératives et des banques commerciales européennes après la crise de 2007-2008.

Résultats

Après avoir démontré que les banques coopératives ont un bilan plutôt tourné vers les activités de Prêts et les banques commerciales sont plutôt orientées vers les activités de Titres et de Produits dérivés, nos résultats suggèrent que : i/ il n'y a pas de différence significative en termes d'efficience technique entre les banques coopératives et les banques commerciales européennes, même si nous observons une légère supériorité des banques commerciales ; ii/ les banques coopératives françaises affichent des niveaux d'efficience technique plus élevés que leurs pairs européens; et iii/ l'efficience technique est impactée positivement par la taille

des banques ce qui suggère que les grandes banques ont tendance à avoir une efficience technique plus élevée que les plus petites, mais ce résultat n'est pas plus significatif pour les banques coopératives.

European banks' technical efficiency and performance: do business models matter? The case of European cooperative banks

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1. Introduction

Recent developments in the European banking sector, notably the persistently low level of interest rates, have reminded us about the risk of business model, which may, if not properly dealt with, jeopardize financial stability and the financing of the economy by banks. Almost all European countries had a dual banking system comprising (commercial) private banks, and (mutual) co-operative banks. Historically, due to their characteristics,[3] co-operative banks have played an essential role in the financial systems of most European countries. However, the wave of financial sector reforms in the last decades has changed their role and institutional features. Over the past years, co-operative banks have been challenged. The main criticisms considered the co-operative banks' business model as, obsolete and inefficient. In some European countries, co-operative banks' business model have changed so much that there is almost no significant difference between them and commercial banks.

The paper aims to characterize the difference between co-operative banks and commercial banks in European countries.[4] A particular focus is placed on the French case, which is almost unique in so far as the French co-operative banks are deeply rooted in the French economy, with a significant market share after a long consolidation period. In addition, the paper follows contributes to the literature on bank efficiency, which in the past used innovative approaches in frontier model estimation (Berger and Humphrey, 1992; Maudos and Guevara, 2004; Drake et al., 2009), by analysing for the first time European bank efficiency with a B-convexity model (Briec et al.,2004; Briec and Liang, 2011).
Like the Free Disposal Hull (FDH) model (Tulkens, 1993), the main advantage of the method is to relax, to some extent, the convexity assumption which is one of constraints of the traditional Data Envelopment Analysis (DEA) models. Hence the approach appears to be more general. In adopting the B-convexity method, we aim to take into consideration the possibly non-convex production function (Kerstens et al., 2011).

There are several motivations for the present article. Firstly, the focus on European co-operative banks compared to European commercial banks has been relatively scarce in the literature (See for example, Girardone et al., 2009; Altunbas et al., 2003). Secondly, after the financial crisis, which featured the failure of many small and medium sized banks, many

[3] Dense branch networks with a proximity to customers.
[4] The list of countries included in the empirical analysis is: France, Germany, Italy, Portugal, Netherland, United Kingdom, Denmark and Spain

experts expressed critical views regarding co-operative banks, offering ways to adapt their business model. Studying Co-operative banks sector is particularly interesting because of their model design, which stands apart from commercial banks whose main objective is the maximization of shareholders' value. Second, this paper used data after the crisis on the sample 2006-2014 to offer a fresh perspective on the performance and technical efficiency of European banking sectors.
Therefore, the paper aims to answer two questions: first, do European co-operative banks behave differently from European commercial banks since the crisis? Second, if they behave differently, is this difference matter for their efficiency and performance?

The conclusions of the paper as the following:

First, a Constrained Principal Component Analysis (CPCA) shows that co-operative banks have a balance sheet oriented towards lending activities; meanwhile commercial banks have higher securities and derivatives activities. In addition, figures from the last 10 years show that Co-operative banks have relatively lower – but less volatile – profitability indicators, compared to commercial banks.

Second, on average the technical efficiency of all European banks declined significantly between 2007 and 2009, before clearly recovering from 2010 to 2012, and stabilizing over the period 2013-2014. Moreover, our study shows that there is no significant difference in terms of technical efficiency between European Co-operative banks and Commercial banks, even if we observe a slight superiority of European commercial banks on their counterpart cooperative banks. Furthermore, in contrast to other countries, French cooperative banks appear to be much closer to their commercial bank peers on some indicators and show higher efficiency levels.

Third, while technical efficiency is found to have a negative relationship with profitability, the positive relationship between banks' size and technical efficiency suggest that larger banks tend to have higher technical efficiency than the smaller ones; this suggests that large European banks in our sample have benefited from economies of scale over the period. This finding is supporting the concentration process observed in European banking sector.

The paper proceeds as follows. Section 2 provides an overview of the literature on the analysis of the banking sector efficiency, and in particular cooperative banks. Section 3 describes the data used and investigates the broad features of co-operative banks' activity as compared with commercial banks and analyses the performance of the two business models (with a particular focus on French banks). The B convexity approach is discussed and implemented in Section 4, while the determinants of technical efficiency are presented in Section 6. Section 6 concludes.

2. Literature review

Initiated by Farrell (1957), the literature on efficiency measures has continued to progress with the introduction of new techniques to estimate the efficient frontier. New DEA approach

are increasingly applied in banking and finance (Edirisinghe and Zhang, 2007; Brandouy et al., 2010; Barros et al., 2010; Epure M., Kerstens K., Prior D., 2011), and this article goes a step further, using an innovative DEA models applied to European banking.

Moreover, although there is a vast literature on European banks 'efficiency (Dietsch and Lozano-Vivas, 2000; Lozano-Vivas et al., 2002; Bikker, 2002; Casu and Molyneux, 2003; Casu et al., 2004; Weill, 2004; Molyneux and Williams, 2005; Barros et al., 2007; Bos and Schmiedel, 2007), the focus on European co-operative banks is more limited. Some of the recent literature on cooperative banks was published in IMF Working Papers and concerns mainly governance (Fonteyne W., 2007) and financial stability, as in Heiko H., et al. (2007). In the latter paper the role of cooperative banks in financial stability is found to be mainly due to their lower return volatility, so that cooperative banks appear to be more stable than commercial banks. However, they examined only individual bank risk by using a z-score as measure. Altunbas, Evans and Molyneux (2001) investigate the difference of cost and profit inefficiencies between the different types of banks' ownership structures in the German banking market. They provide only limited evidence that privately owned banks (commercial banks) are more efficient than their mutual (cooperative banks) and public-sector counterparts. However, other research works conclude that cooperative banks are more stable and performed better than the large commercial banks especially in Europe (Bülbül et al. (2013); Birchall (2013)).

In this context, this paper complements the previous literature on the difference between cooperative and commercial banks, from a technical efficiency perspective debate about the efficiency of cooperative banks, bringing an innovative method of efficient frontier.

3. Descriptive analysis of activity and profitability

In order to have first grasp at the issue, we start with a descriptive analysis of the business model and profitability of cooperative and commercial banks in Europe.

3.1 Data

The analysis is based on the Bankscope data set, and for the purpose of our research, we cluster banks by their business model according to the description given by Bankscope.
As indicated in Table 1, our sample contains 51 banks including 35 Co-operative banks and 16 Commercial banks, and covers the period 2005-2014. The representativeness of our sample is good if we compare it with the population of banks under ECB direct supervision (appendix 1). If we look at the representativeness within each category, we can observe that, in terms of cumulative total assets, the sample of cooperative banks represents a bit less than two-third of that of the cooperative banks under ECB direct supervision; it is almost 100% of the cumulative total assets of commercial banks under ECB direct supervision. Nevertheless our sample is slightly biased towards commercial banks, as European cooperative banks usually represent almost one third of the total assets of commercial and cooperative banks under the direct supervision of the ECB, while cooperative banks reach 22% in our sample.. Although cooperative banks are more numerous in our sample, they represent less than a third

of Total Assets, thus demonstrating their smaller size compared to commercial banks, a feature which is also shared by the population of banks under ECB direct supervision.

Table 1

Business Models	Number of banks in the sample
Commercial Banks	16
Cooperative Banks	35
Total	51

Table 2 provides the breakdown of the sample by the country where the bank's headquarters are located. We only consider consolidated data and use the highest consolidation level available in the Bankscope database.

Table 2

Country name	Number of banks in the sample
AUSTRIA	8
BELGIUM	1
DENMARK	1
FINLAND	2
FRANCE	5
GERMANY	9
ITALY	7
NETHERLANDS	1
NORWAY	1
Portugal	1
SPAIN	13
UNITED KINGDOM	2
TOTAL	51

3.2 Activity and profitability analysis

The decline of traditional activities (making loans by issuing short-term funding) and a more widespread entry into non-traditional activities (e.g., fee-based services) in European banks has been widely reported in recent years in discussions on banking business models.

To complement this assessment, and in order to identify, how business models can be different in European banking sector, we apply a Constrained Principal Component Analysis (CPCA) to the system of 6 balance sheet and income statement variables.[5] As shown in

[5] Loans, Derivatives, Total Securities, Net Fees and Commissions, Net Insurance Income and Net Gains (Losses) on Trading and Derivatives.

Appendix 2, the CPCA suggests that cooperative banks have a business model focused on lending activities; while commercial banks have balance sheets more oriented on securities and derivatives activities. However, the Crédit Agricole Group differs from its co-operative banks peers being closer to commercial banks. This result can be explained by the universal banking group business model of the Crédit Agricole Group.

Beyond this global analysis provided by CPCA, we now consider how the two sub-populations of commercial and cooperative banks compare, when looking at key financial indicators, one by one, during the 2005-2014 period. In order to identify, how business models of banking activities performed during this period, the analysis focuses on the following indicators:

- Activities and structure of income and expenses
- Resources and liquidity profile
- Risks indicators and performance

a) Structure of income and cost

In the low interest rate environment that characterized the European banking system since the crisis, profitability (in general) is expected to decrease. Activities such as retail and commercial would for example experience a decrease in net interest income.

Commercial banks that are better diversified geographically than co-operative banks (in general) appear to be quite stable, recovering after the fall experienced during the crisis. In order to meet shareholders' expectations, commercial banks seem to have increased their risk appetite and move to an investment banking as well as "carry trade" activity. Indeed, as internationally-oriented institutions, they would also have incentives to take advantage of countries regions where lending rates are higher.

In contrast, according to Fig. 1, co-operative banks, specialized in retail exposures, experienced a fall in Net Interest Margin since 2008,[6] although it has been more constant for the French sector. The latter is due to a decrease in the lending activity for those banks. Depending on the degree of competition, cooperative institutions with business models focusing on lending activities appear to have experienced difficulties to keep margins at the high level reached before the crisis (i. e. 2.5 %). Lagging behind their commercial peers from that perspective, cooperative banks appear therefore to compensate falling interest income with other sources of revenues, e.g. by increasing Non-Interest Income like fees and commissions (moving from the 20% level to close to 30%, while commercial banks stand at 40%). However, if this is true for European co-operative banks in general, we observe according to Fig2., that European commercial banks in our sample and the French co-operative banks, rather experienced a fall in the share of Non-Interest Income on Gross Revenues during the period 2005-2009, which stabilized since 2009 and even has increased since 2013 for French co-operative banks.

[6] Net interest margins are measured in percentage of earning assets.

Fig1: Net Interest Margin/Total Assets

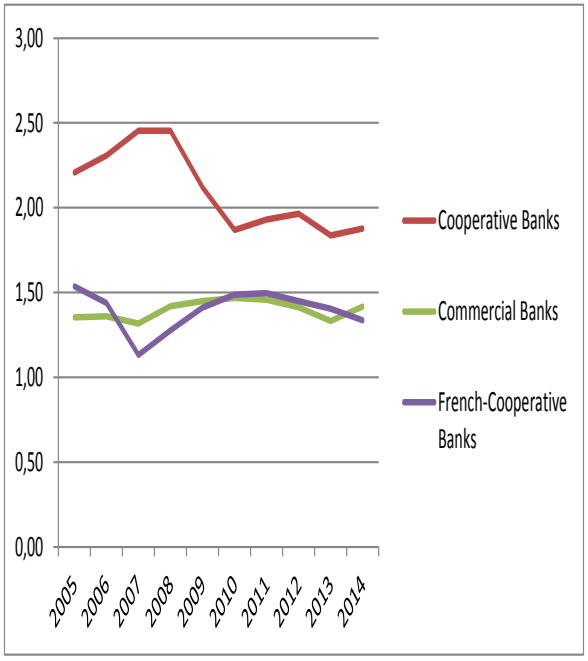
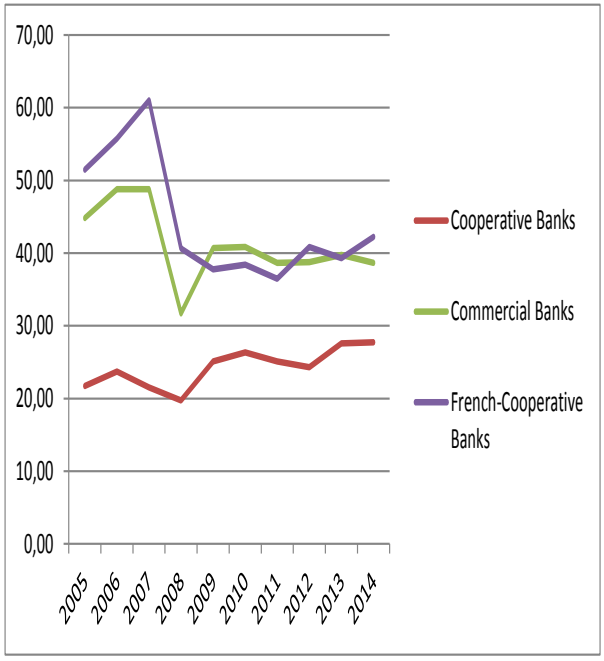


Fig2 : Non-Interest Income / Gross Revenues



Concerning the cost to income ratio (Fig. 3), European co-operative banks are characterized by a relative stability in comparison with European commercial banks. But French co-operative banks, exhibiting a spike around the crisis period, behaved differently from European co-operative banks.

Fig3: Cost-to-Income

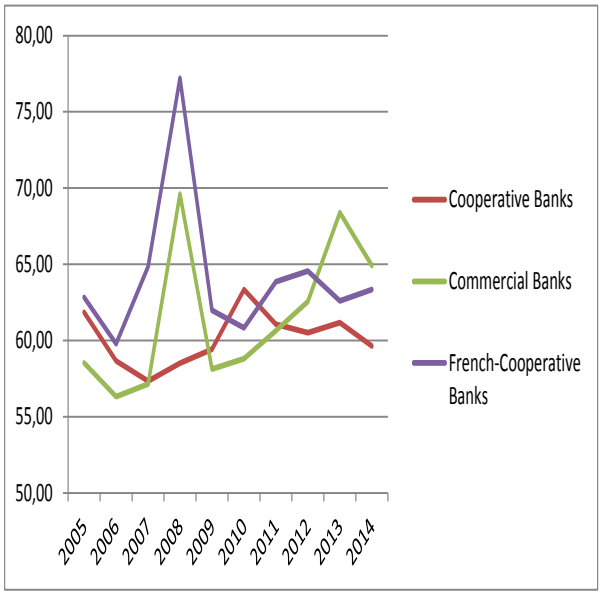
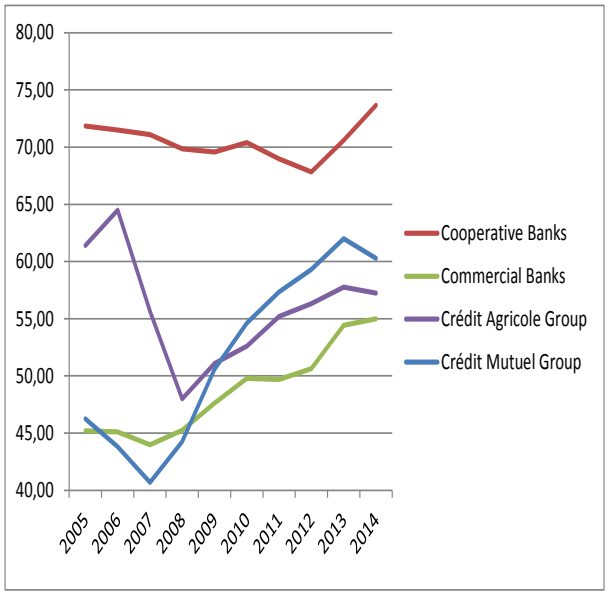


Fig4: Customer Deposits / Total Funding excl Derivatives



b) Resources/ liquidity profile

Regarding funding profile, we can observe in Fig4. that the share of customer deposits on total funding[7] is high and stable around 70% for European cooperative banks between 2005 and 2010 and then increased in 2012 after declining for two years. The situation is different for the two French co-operative banks in our sample.[8] Indeed, the two banks have different profiles, approaching more the European commercial banks funding profile (in general). European commercial banks showed, like the Crédit Mutuel Group, lower share of customer deposits on the total funding[9], but they have made efforts to boost their deposits since 2008. For French co-operative banks (and French banks in general), this situation reflects a high proportion of savings outside bank deposits, such as in life insurance products and investment funds (especially money market funds, long used as an alternative investment vehicle because bank deposits could not legally earn interest). These savings are nevertheless an ongoing source of refinancing for the main French "bancassureurs" groups.

c) Risks indicators and performance

In general, the performance of the European banking sector, as measured by Return On Average Equity (ROAE) or Return On Average Assets (ROAA) –averages are computed over the last three years– fell sharply during the period 2007-2012; but since the end of 2012, we can observe a slight rise. However, the volatility differs by bank business model, indicating differences in business mix, size, and other underlying characteristics. (See Fig 5 to7).

[7] Excluding derivatives.
[8] Crédit Mutuel Group and Crédit Agricole Group.
[9] Excluding derivatives.

Figure 5: ROAA

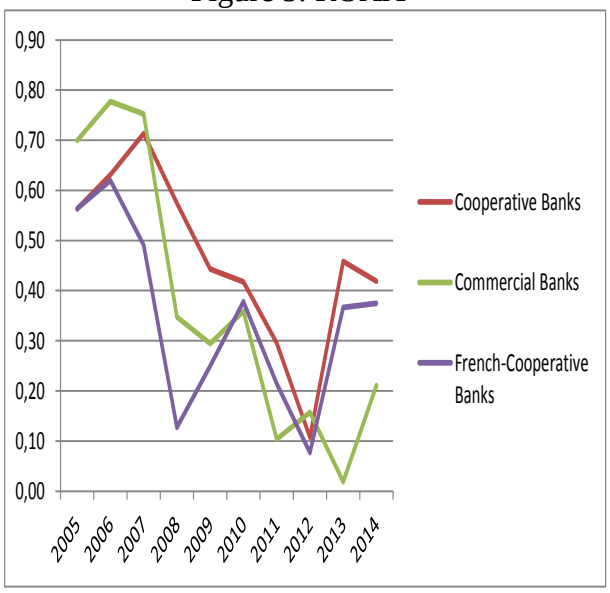
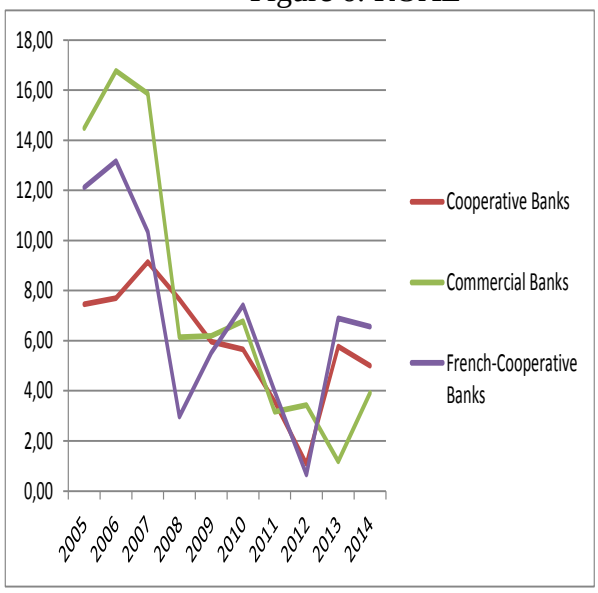
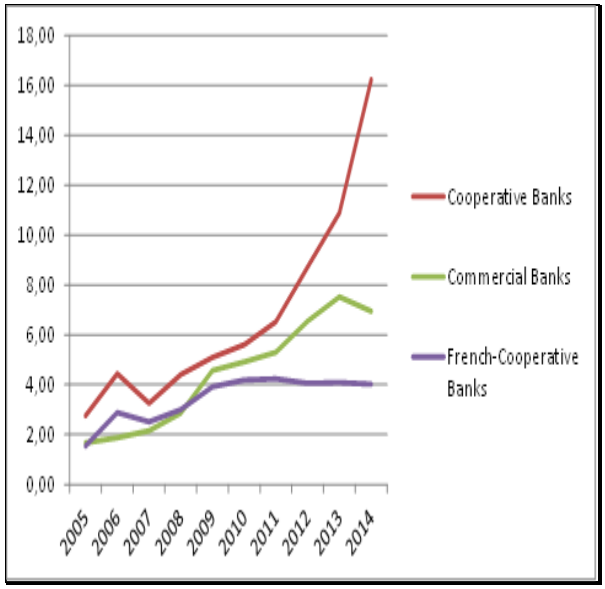


Figure 6: ROAE



If during the period analysed, asset quality, as measured by the ratio of impaired loans/gross loans (Fig 7), is relatively good and stable for French Co-operative banks, we have seen a significant increase of the ratio for European cooperatives, mainly due to rise in Italians Co-operative banks' NPL.

Figure 7: Impaired Loans (NPLs) / Gross Loans



4. The B-Convexity Methodology

We now investigate banks' efficiency, i.e. the ability of banks to combine production factors to produce financial services. Such an objective is shared by cooperative and commercial banks alike and provides, in our view, a relevant framework to assess their business models. The method defines an efficient frontier of maximum output given available inputs and provides an index of distance between actual output and the efficient frontier.

4.1. Definition of variables

If we compare to other sectors such as manufacturing, the financial sector has certain specificities. Indeed, if the main objective of a commercial banks is to maximize shareholder value (financial profits), cooperative banks aims at maximizing the value for a larger set of stakeholders, i.e. to provide the best trade-off between products, services and prices to its clients. To assess the performance of cooperative banks, one needs to take into account of the differences of organizational structures and ultimate goals with respect to commercial banks. For instance, some stakeholder-owned banks may not maximize profits only, profitability should not be the only performance measure. An interesting and relevant alternative is therefore to investigate other indicators, such as technical efficiency.

The literature typically applies two approaches to evaluate bank efficiency. One is the "intermediation approach", which considered the bank as a financial intermediary (it uses capital and other financial resources to produce loans and investment banking services). In contrast to that view is the "production approach", which is broader view of banks' production of financial services. In Sassenou (1992) French savings banks are modelled according to the production approach, whereby savings account (Livret A, etc) are included among outputs, while commercial banks are modelled with the intermediation approach.

In our paper, we rather rely on the "intermediation approach", which seems to appear to us a more common ground for assessing the two business models at the European level.[10] Under this approach, three outputs and three inputs are identified to investigate the input efficiency of banks. All variables are divided by total assets; the output variables encompass net loans (NL); other earning assets (OEA) and net fees and commissions (NFC). These output variables are commonly adopted in previous literature, such as Berger et al. (2009) and Bonin et al. (2005). With respect to input variables, personnel expenses; physical capital, and funds are the conventional inputs in previous research (Altunbas et al., 2001; Beccalli et al., 2006). Personnel expenses (PE) define Labor; fixed assets (FA) measures physical capital and Funds are total deposits and short-term funding (DSF).[11]

Note that, if the method does not explicitly introduce output prices (we introduce factor prices though), they are not excluded in the analysis, as these output are produced in competitive markets. This means however that the conclusions should be viewed jointly with the indicators described in section 3.

[10] In addition, although this is only specific to France, note that since Sassenou (1992)'s paper, the Livret A has been generalized to all banks. As a consequence, having a different treatement of savings banks is no longer justified.
[11] See table 3 for details.

Table 3: description of inputs and outputs

Variables	Description
Net Loans / Total Assets	Includes Residential Mortgage Loans + Other Mortgage Loans + Other Consumer/ Retail Loans + Corporate & Commercial Loans + Other Loans- Reserve against possible losses on impaired or non performing loans divided by Total Assets
Other Earning Assets	Earning assets not otherwise categorized, including non-current assets held for sale which are not loans
Net Fees and Commissions	Net fees and commissions which are not related to loans
Personnel Expenses	Includes Wages, salaries, social security costs, pension costs and other staff costs, including expensing of staff stock options
Fixed Assets	Property, plant and equipment
Deposits & Short term funding	Total customer deposits + deposits from banks + Other deposits and short-term borrowings

Table 4: Summary statistics of inputs and outputs, 2007-2014

In Thousands EUR		Total Assets	Deposits & Short term funding	Fixed Assets	Personnel Expenses	Loans	Total Securities	Net Fees and Commissions
Total Sample	Minimum	226,400	192,000	400	700	107,400	1,000	-113,000
	Maximum	2,202,423,000	1,207,062,000	19,458,469	15,248,000	750,549,646	1,695,177,000	12,409,000
	Mean	269,029,794	138,559,329	1,681,221	1,917,416	112,965,852	113,902,208	1,514,050
	Stand. Dev.	511,582,856	251,972,759	3,606,069	3,652,900	197,209,189	264,844,240	2,966,858
Cooperative Banks	Minimum	226,400	192,000	400	700	107,400	1,000	-11,100
	Maximum	1,879,536,000	928,045,000	7,999,000	12,312,000	745,678,000	719,191,000	10,796,000
	Mean	73,989,601	40,829,295	368,707	567,954	33,944,500	24,013,127	442,842
	Stand. Dev.	285,471,440	150,896,376	1,271,531	2,095,552	124,110,161	97,998,216	1,695,481
Commercial Banks	Minimum	72,779,800	38,759,800	84,000	504,000	52,463,000	4,454,500	-113,000
	Maximum	2,202,423,000	1,207,062,000	19,458,469	15,248,000	750,549,646	1,695,177,000	12,409,000
	Mean	833,165,037	421,234,175	5,477,543	5,820,607	341,527,613	373,897,840	4,612,418
	Stand. Dev.	595,581,678	271,550,586	5,152,145	4,328,437	191,120,168	392,780,814	3,609,482

4.2. Assessing efficiency: an application of B-convexity analysis.

Proposed by Briec et al (2004, 2009), the B-convexity model is derived from Data Envelopment Analysis methods. It aims at estimating technical efficiency and introduces some innovative aspects. The explanations below are based on the first application of the B-Convexity method on Chinese banking sector by Barros et al. (2011).[12]

First, using a non-parametric modelling method under a B-convexity assumption implies that degree of returns to scale are not assumed a priori. For example they may be locally non-increasing or locally non-decreasing. In particular B-convexity has the advantage to allow the variations of marginal productivity to form an alternating sequence, either increasing or decreasing, according to the frontier points of the production technology one considers.

Second, it allows us to take into account in the production technology variations of marginal productivity that can be either increasing or decreasing. Third, the number of efficient firms characterizing the frontier is smaller than the number found by the non-convex model (FDH model).

A production technology satisfying a B-convexity assumption has an upper semilattice structure. This means that combining two factors will at least provide an output bigger than what each factor can individually provide.[13] Furthermore, it is assumed that inputs and outputs can be radially shrunk.

All in all, the main innovation of the approach is to relax, to some extent, the convexity assumption usually made in Data Envelopment Analysis. In general, economic analysis is based on a convexity hypothesis (Debreu 1959). However, non-convexity appears in some cases in particular including externalities, increasing returns and non-divisibility (Guesnerie 1975, Starrett 1972). In the case of the banking industry, many circumstances reveal a failure to respect the assumption of convexity, in particular the increasing returns due to new banking technologies.

The Appendix 3 describes the method of B-convexity from the details given in Briec et al. (2004, 2009).

4.3. Empirical results

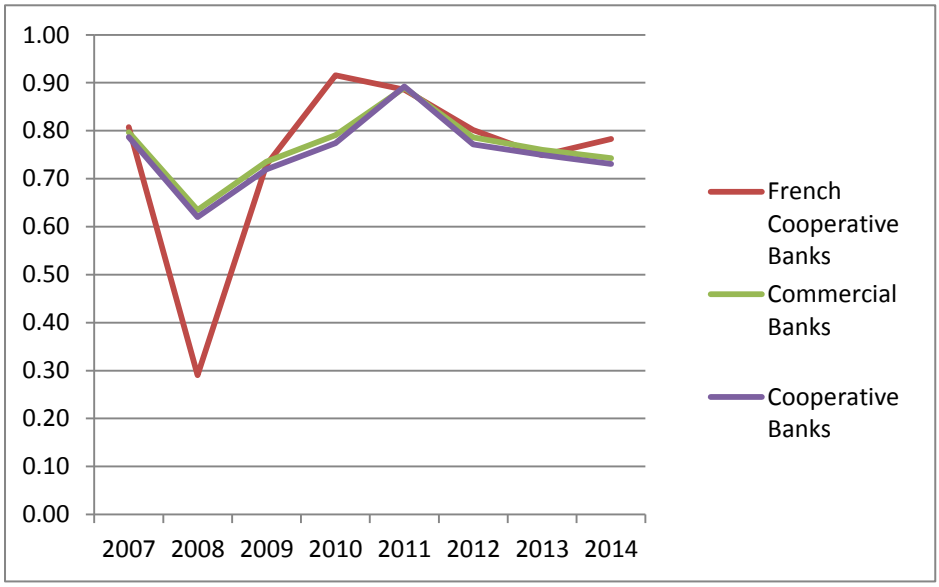
Using the B-convexity analysis, we estimate the technical efficiency (TE) of the 51 European banks of our sample. The results show that the average technical efficiency of the European banks in our panel is 0.79.

As shown in the figure 8, contrary to the common belief, there are no significant differences in technical efficiency between commercial banks and cooperative banks. Moreover, after falling during 2007 to 2008, the average efficiency scores of European banks improved until 2011 then has stabilized since.

[12] Barros, C.P., Chen, Z., Liang, Q.B. and Peypoch, N. (2011). Technical Efficiency in the Chinese Banking Sector. Economic Modelling, 28, 2083-2089

[13] This is possible due to the properties of the upper semilattice structure (the least upper bound of a pair of input vectors can produce the upper bound of the output they can

Figure 8: Average efficiency scores by business models with a zoom on the French cooperative banks



However, during the period 2007-2014, table 5 shows that commercial banks exhibit a higher level of average of Technical Efficiency (TE) of 0.831 than do co-operative banks. As on average commercial banks in our sample are larger than co-operative banks, our results seem to confirm the findings of Berger et al. (1993), who show that large banks have higher average level of technical efficiency ratio than do their smaller peers.

If we look more specifically the results of co-operative banks, we observe that, except for the period 2007-2008, French cooperative banks are on average more efficient compared to their peers. The sharp decline in the TE ratio of French cooperative banks over this period is consistent with the observed peak in the Cost-to-Income ratio (see Fig.3) due in particular to the significant decrease in revenues.

5. Determinants of Technical Efficiency : methodology and results

After measuring the bank efficiency using B-Convexity, the efficiency scores derived from this method is used now as a dependent variable to examine factors affecting the bank efficiency.

5.1. Methodology

We try to answer the question: why are some banks more efficient than others? In this step, we consider an array of bank specific features, including bank profitability, bank size and Bank capitalization. The regression estimated to analyse the determinants of bank efficiency is:

$$\boldsymbol{EFF = \beta_0 + \beta_1\, ROAA + \beta_2\, lnTA + \beta_3\, CTI + \beta_4\, ETA + \beta_5\, lnTA * Coop} \quad (1)$$

Where (see table 7):

- EFF is Bank efficiency score,
- ROAA is Return On Average Assets; the usual anticipation is that the higher the ROAA, the more efficient bank is.
- lnTA is the natural logarithm of Total Assets, and is used as a measure for bank size.
- CTI is the Cost to Income Ratio. The higher this ratio, then the less efficient bank is.
- ETA is the Equity to Total Assets ratio, and is used as proxy for bank capitalization. It is difficult to expect the sign of this ratio as the capital is generally considered as a buffer to cover losses in case of default; however, having too much capital can be a higher cost for banks.
- LnTA*Coop is the interaction variable between Total Asset and Cooperative bank status. This variable controls whether being cooperative bank and to have a significant total assets is a significant indicator for technical efficiency level.

5.2. Empirical results

The regression results of the efficiency determinants study based on the explanatory variables discussed above are given in Tables 8. The model is estimated by OLS including bank fixed effects.

It is found that the ROAA is a weakly significant regressor with a negative coefficient. This may seem hard to explain, however, the ROAA tended to decline significantly during the economic crisis period while the efficiency scores of European banks in our sample is on average stable over the period.

Bank size is found to be positively and significantly related to banks' technical efficiency score. This finding is consistent with the hypothesis that the Bank size has a positive impact on Bank efficiency (see Berger et al., 1993) and suggests that large banks have benefited from economies of scale over the period.

Not surprisingly, the Cost-to-Income ratio is negatively related to bank's technical efficiency.

The Equity-to Total Asset variable (ETA) is found to be positively and significant regressor, it suggests a positive impact of capitalization on technical efficiency.

LnTA*Coop is the not significant and therefore indicates the size variable has no particular impact on efficiency for cooperative banks. We conclude from that the impact of size on efficiency is similar across commercial and cooperative banks.

6. Conclusions

In conclusion, we observed that on average European co-operative banks presented more stable cost ratios than European commercial banks; and a higher customers' deposit funding profile. However, their risk profile has deteriorated faster compared to European commercial banks. Moreover, they have lower but less volatile performance.

However, it should be emphasized that French co-operative banks have behaved in a different way. Indeed, the French co-operative banks showed some similarities compared to French commercial banks, including their funding profile, their income structure and their cost-to-income ratio volatility.

Regarding the efficiency calculations results, we found that during the period 2007-2014, technical efficiency levels appear relatively similar between commercial banks and cooperative banks. However, on average European commercial banks were relatively more efficient than European co-operative banks. Moreover, we our results suggest that on average French cooperative banks have higher levels of technical efficiency than their European peers. However, we must be careful not to draw from the observation of these relative levels of technical efficiency the conclusion that the performance of French cooperative banks is satisfactory in absolute terms. Technical efficiency is a relative concept.

Regarding efficiency determinants, we conclude in favour of the positive impact of banks size and banks capitalization on the technical efficiency. This finding seems intuitive; this could be explained by the history of consolidations that have experienced large groups of European co-operative banks. Indeed, consolidation is expected to reduce costs by economies of scale and thus increase the banks' efficiency. The consolidation of co-operative groups is relatively new and continues to move, so the benefits of the consolidation cannot therefore be fully observed yet.

Further research should aim to test the relationship that may exist between business model and performance.

References

Allen L., Rai A. (1996), Optimal Efficiency in Banking: An International Comparison, Journal of Banking and Finance, 20, 655-672.

Altunbas, Y., L. Evans and P. Molyneux (2001): "Bank Ownership and Efficiency", Journal of Money, Credit and Banking, Vol. 33, 926-954.

Altunbas Y., Gardener E.P.M., Molyneux P., Moore B. (2001), Efficiency in European banking, European Economic Review, 45, 1931-1955.

Barros, C.P., Chen, Z., Liang, Q.B. and Peypoch, N. (2011). Technical Efficiency in the Chinese Banking Sector. Economic Modelling, 28, 2083-2089

Barros, C., Ferreira, C. and Williams, J. (2007) "Analyzing the determinants of performance of best and worse European banks: A mixed logit approach", Journal of Banking and Finance, 31, pp. 2189-2203.

Barros, C.P. Peypoch, N. and Williams, J., 2010. A note on productivity change in European cooperative banks: the Luenberger indicator approach. International Review of Applied Economics, 24, pp. 137-47.

Bauer, P.W., A.N. Berger, and Humphrey, D.B. (1993). Efficiency and Productivity Growth in U.S. Banking, in H.O. Fried, C.A.K. Lovell, and S.S. Schmidt, eds., The Measurement of Productive Efficiency: Techniques and Applications, (Oxford: Oxford University Press), 386-413.

Berger A.N., and Humphrey, D.B. (1993). The dominance of inefficiency over scale and product mix economies in banking. Journal of Monetary Economics 28, 117-148.

Brandouy, O., Briec, W., Kerstens, K. and Van de Woestyne, I. (2010). Portfolio performance gauging in discrete time using a Luenberger productivity indicator, Journal of Banking & Finance, 34, 1899-1910.

Briec W. and C.D. Horvath (2004). B-convexity. Optimization, 53, 103-127.

Briec W. and C.D. Horvath (2009). A B-convex Production Model for Evaluating Performance of Firms. Journal of Mathematical Analysis and Applications, 355, 131- 144.

Briec W. and Chavas J-P (2012), «On Economic Efficiency under Non-Convexity», Economic Theory, 2012, 50, pp. 671-701.

Bikker J. A., 2002, "Efficiency and Cost Differences across Countries in a Unified European Banking Market", De Nederlandsche Bank, DNB Staff Reports, No. 87.

Birchall, J., 2013. Resilience in a downturn: The power of financial cooperatives. International Labour Office.

Bos, J. W. B. and H. Schmiedel (2007). 'Is there a single frontier in a single European banking market?' Journal of Banking and Finance 31(7): 2081-2102.

Bülbül, D., Schmidt, R.H. and Schüwer, U., 2013. Savings banks and cooperative banks in Europe. White Paper Series no. 5.

Casu, B. and P. Molyneux (2003). 'A comparative study of efficiency in European banking.' Applied Economics 35(17): 1865-1876.

Casu, B., Girardone, C., Molyneux, P., 2004. Productivity in European banking – A comparison of parametric and non-parametric approaches. Journal of Banking & Finance 28, 10, 2521-2540.

Cuevas, C., and K. Fischer, 2006, "Cooperative Financial Institutions: Issues in Governance, Regulation, and Supervision," Working Paper No. 82 (Washington: World Bank).

Dietsch, M. and A. Lozano-Vivas (2000). 'How the environment determines banking efficiency: A comparison between French and Spanish industries.' Journal of Banking and Finance 24(6): 985-1004.

Dietsch M. and L. Weill, 1998, Banking Efficiency and European Integration: Productivity, Cost and Profit Approaches, paper presented at the 21st Colloquium of the SUERF (Frankfurt, 15 –17 October 1998).

Epure M., Kerstens K., Prior D., (2011). Bank Productivity and Performance Groups: A Decomposition Approach Based upon the Luenberger Productivity Indicator, *European Journal of Operational Research*, 211 (3) 630-641.

Fonteyne W. (2007), "Co-operative Banks in Europe - Policy Issues", IMF Working Papers No. 07/159, July.

Groeneveld J.M. and B. de Vries (2009), "European Co-operative banks: first lessons from the subprime crisis", Working Paper, Rabobank.

Gurtner E., M. Jaeger, and J. Ory, 2002, "Le Statut de Coopérative est-il Source d'Efficacité dans le Secteur Bancaire?" *Revue d'Economie Financière*, 67, pp. 133–64.

Heiko H., et al., (2007) "Cooperative Banks and Financial Stability", IMF Working Papers No.07/02.

Lozano-Vivas, A., J. T. Pastor and J. M. Pastor (2002). 'An efficiency comparison of European banking systems operating under different environmental conditions.' Journal of Productivity Analysis 18: 59-77.

Molyneux, P., Williams, J., 2005. The productivity of European co-operative banks. Managerial Finance 31, 11, 26-35.

Salanié Bernard (2000). "Nonconvexities". Microeconomics of market failures (English translation of the (1998) French Microéconomie: Les défaillances du marché (Economica, Paris) ed.). Cambridge, MA: MIT Press. pp. 107–125.

Sassenou, M. (1992) "Economies des coûts dans les banques et les caisses d'épargne, impact de la taille et de la variété des produits" *Revue Economique*, mars.

Starrett, David A. (1972). "Fundamental nonconvexities in the theory of externalities". Journal of Economic Theory. 4 (2). pp. 180–199.

Turati, G, 2004, “Are Cooperative Banks and Stock Banks Different Contracts? Empirical Evidence Using a Cost Function Approach” (Universitá degli Studi di Torino).

Weill, L. (2004). Measuring Cost Efficiency in European Banking: A Comparison of Frontier Techniques. Journal of Productivity Analysis 21, 133–152.

Appendix 1: **Governance of euro-area banking groups under ECB supervision (end-2015).**

Governance	Number of banks	Total assets (€ billions)	CET1 ratio in %	Leverage ratio in %
Commercial	41	€ 12,258	12.4	4.9
- Dispersed ownership	*30*	*€ 11,892*	*12.4*	*4.8*
- Privately held	*11*	*€ 366*	*13.7*	*7.3*
Cooperative	27	€ 6,269	13.6	5.2
Government	32	€ 3,591	17.9	4.9
- Public sector banks	*22*	*€ 2,279*	*19.2*	*4.9*
- Nationalised	*10*	*€ 1,312*	*15.7*	*4.8*
Total	100	€ 22,118	13.6	5

Source: Bruegel based on SNL data and ECB (2016a). Notes: The CET1 ratio and leverage ratio are calculated as an average weighted by total assets.

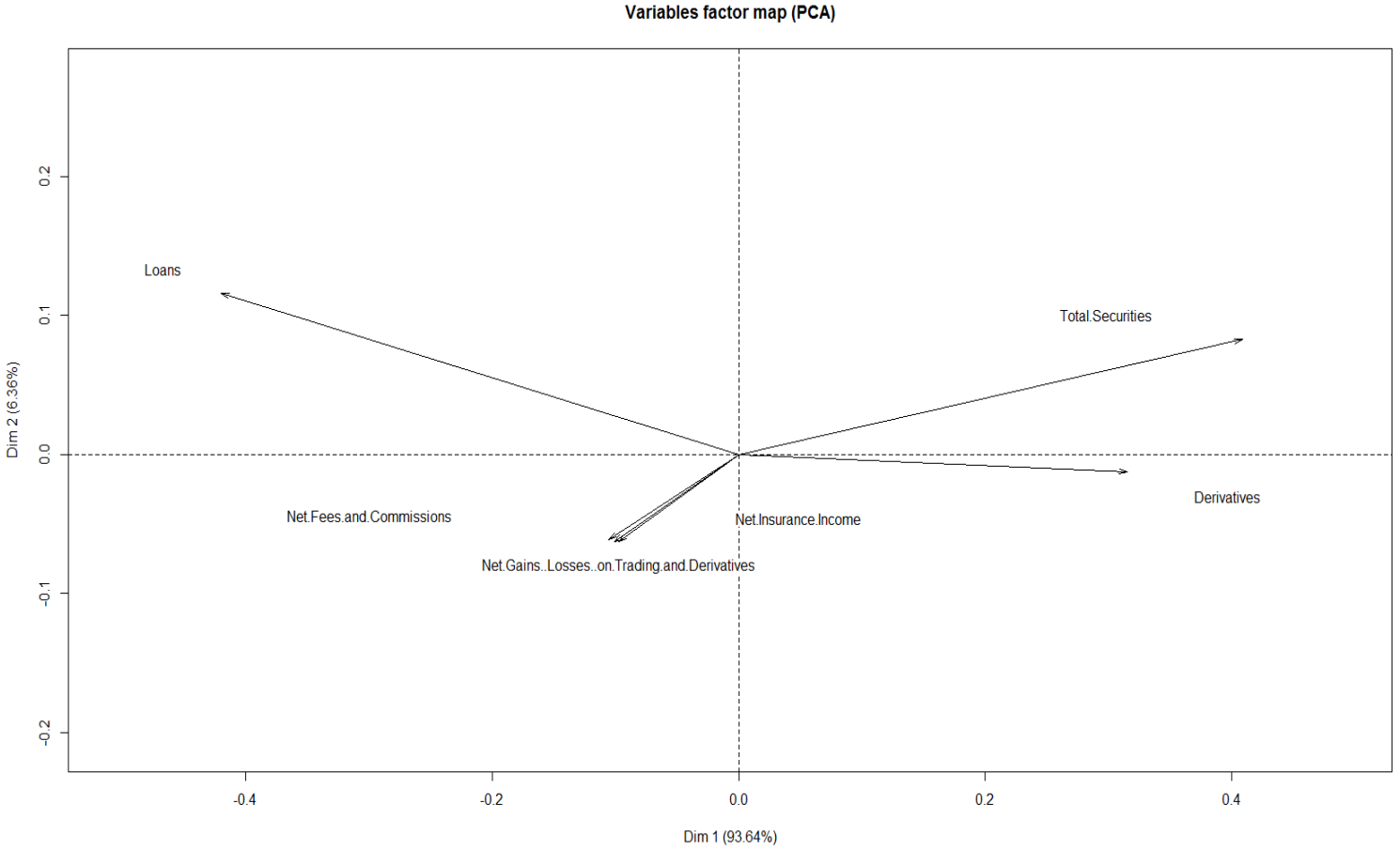
Table 5: Sample statistics: Total Assets in thousand euros

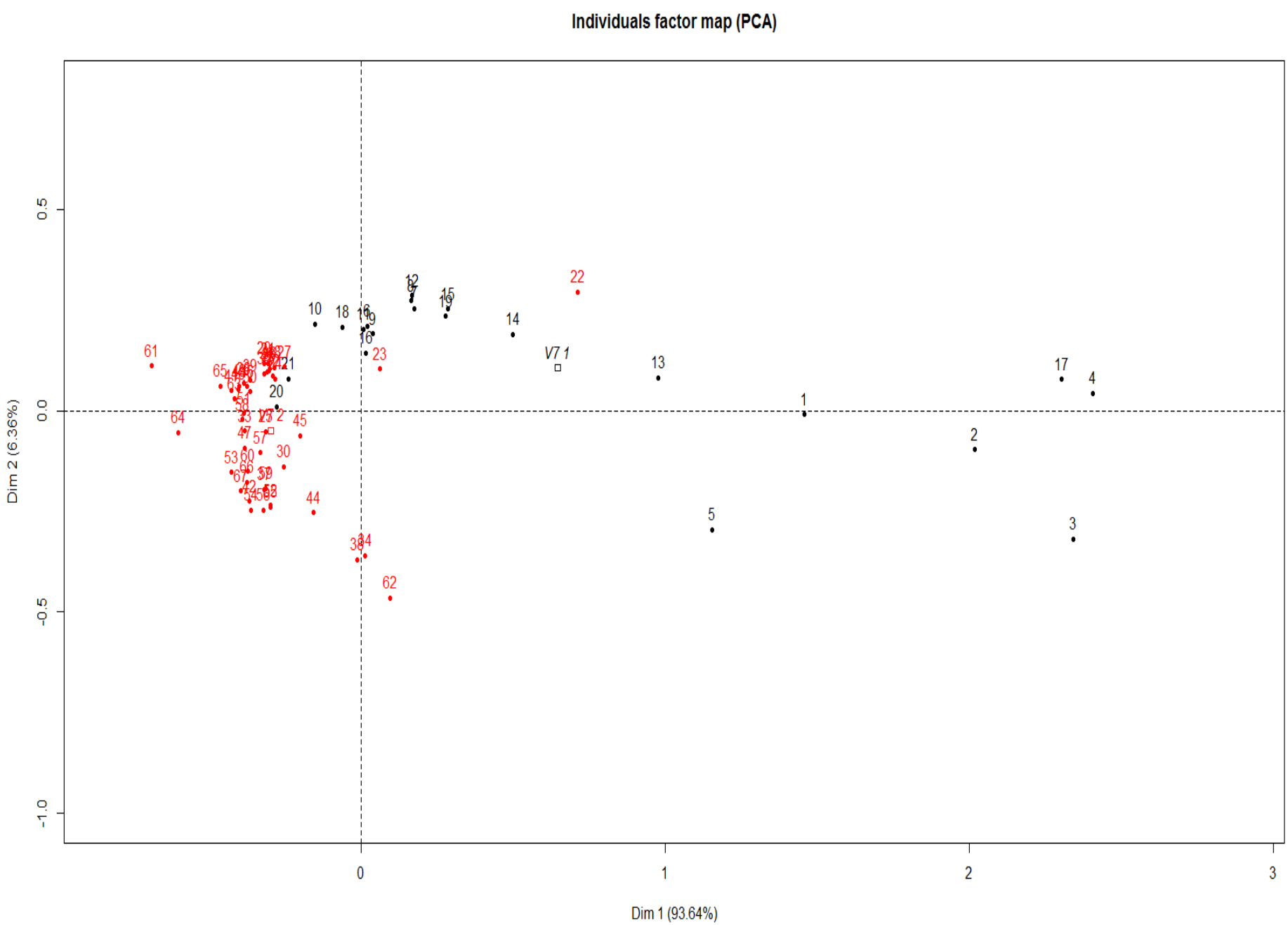
Business Models	**Total Assets**	**%**
Commercial Banks	14,328, 181.1	78%
Cooperative Banks	3, 963,811.7	22%
Total	18, 291,992.8	100%

The table display the relative share of each type of banks (commercial vs cooperative) in our sample, as measured by cumulative total assets

Appendix 2: **Constrained Principal Component Analysis result**

Explanatory notes: the projection on the space of variables (first chart) opposes, on the x-Axis (93.64% of total variance), loans (left-hand side) to securities and derivative activities (right hand side); with the exception of Credit Agricole Group, the cooperative banks (in red, in the projection of individuals, 2nd chart) are concentrated on the let-hand side of the x-axis.




Individuals factor map (PCA)
Dim 2 (6.36%)
Dim 1 (93.64%)
0.5
0.0
-0.5
-1.0
0
1
2
3
V7 1

Identification number for PCA chart	Bank name	Category
1	BNP Paribas SA	Commercial Banks
2	Barclays Bank Plc	Commercial Banks
3	Deutsche Bank AG	Commercial Banks
4	Royal Bank of Scotland Plc (The)	Commercial Banks
5	Société Générale SA	Commercial Banks
6	Banco Santander SA	Commercial Banks
7	BPCE Group	Cooperative Banks
8	UniCredit SpA	Commercial Banks
9	ING Bank NV	Commercial Banks
10	Credit Mutuel (Combined - IFRS)	Cooperative Banks
11	Intesa Sanpaolo	Commercial Banks
12	Banco Bilbao Vizcaya Argentaria SA	Commercial Banks
13	Commerzbank AG	Commercial Banks
14	Danske Bank A/S	Commercial Banks
15	ABN AMRO Bank NV	Commercial Banks
16	ABN AMRO Group N.V.	Commercial Banks
17	Nordea Bank Finland Plc	Commercial Banks
18	Caixabank, S.A.	Commercial Banks
19	DnB ASA	Commercial Banks
20	Banco de Sabadell SA	Commercial Banks
21	Caixa Geral de Depositos	Commercial Banks
22	Crédit Agricole-Crédit Agricole Group	Cooperative Banks
23	OP-Pohjola Group-OP Osuuskunta	Cooperative Banks
24	Verband der Sparda-Banken e.V.	Cooperative Banks
25	Deutsche Apotheker- und Aerztebank eG	Cooperative Banks
26	Banca di Credito Cooperativo di Roma	Cooperative Banks
27	Bank für Sozialwirtschaft Aktiengesellschaft	Cooperative Banks
28	Frankfurter Volksbank eG	Cooperative Banks
29	BBBank eG	Cooperative Banks

Identification number for PCA chart	Bank name	Category
30	Raiffeisen Bausparkasse GmbH-Raiffeisen Wohn Bausparen	Cooperative Banks
31	Evangelische Kreditgenossenschaft eG	Cooperative Banks
32	Raiffeisen-Landesbank Tirol AG	Cooperative Banks
33	Banca Popolare dell'Alto Adige Societa Cooperativa Per Azioni-Suedtiroler Volksbank	Cooperative Banks
34	Raiffeisenlandesbank Vorarlberg Waren-und Revisions Verband GmbH	Cooperative Banks
35	Caja Rural del Sur, S. Coop de Credito.	Cooperative Banks
36	Caja Rural de Granada	Cooperative Banks
37	Mainzer Volksbank eG	Cooperative Banks
38	Sparda-Bank Berlin eG	Cooperative Banks
39	Banca Valsabbina Societa cooperativa per azioni-La Valsabbina	Cooperative Banks
40	Banca Popolare di Puglia e Basilicata	Cooperative Banks
41	Banca Popolare Pugliese-Gruppo Bancario Banca Popolare Pugliese	Cooperative Banks
42	Volksbank Wien-Baden AG	Cooperative Banks
43	Raiffeisenlandesbank Burgenland	Cooperative Banks
44	Agricaisse - Caisse Coopérative de Dépôts et de Crédit Agricole	Cooperative Banks
45	Raiffeisenlandesbank Kaernten - Rechenzentrum und Revisionsverband rGmbH	Cooperative Banks
46	Caja Rural de Jaen, Barcelona y Madrid, Sociedad Cooperativa de Credito	Cooperative Banks
47	CajaSiete, Caja Rural	Cooperative Banks
48	Caja Rural de Almendralejo Sociedad Cooperativa de Credito	Cooperative Banks
49	Caja Rural de Zamora	Cooperative Banks
50	Raiffeisenlandesbank Kaernten - Rechenzentrum und Revisionsverband rGmbH	Cooperative Banks
51	Raiffeisen Regionalbank Moedling eGen	Cooperative Banks
52	Caja Rural de Teruel Sociedad Cooperativa de Crédito	Cooperative Banks
53	Volksbank Tirol Innsbruck-Schwaz AG	Cooperative Banks
54	Volksbank Niederosterreich-Mitte rGmbH	Cooperative Banks
55	Volksbank Landeck eG	Cooperative Banks
56	Volksbank Kufstein-Kitzbuehel eG	Cooperative Banks
57	Raiffeisenbank Im Rheintal eGen	Cooperative Banks
58	Caja Rural de Salamanca Sociedad Cooperativa de Crédito	Cooperative Banks
59	Raiffeisenbank Kitzbühel rGmbH	Cooperative Banks
60	Volksbank Alpenvorland rGmbH	Cooperative Banks
61	Raiffeisenbank Reutte rGmbH	Cooperative Banks
62	Caja Rural de Guissona Sociedad Cooperative de Crédito	Cooperative Banks
63	Raiffeisenbank Noe-Sued Alpin	Cooperative Banks
64	Walser Privatbank Aktiengesellschaft	Cooperative Banks
65	Volksbank, Gewerbe-und Handelsbank Kaernten eGen	Cooperative Banks
66	Volksbank Voecklabruck-Gmunden e.Gen.	Cooperative Banks
67	Caixa Rural Altea Cooperativa de Credit Valenciana	Cooperative Banks

Appendix 3: B-convexity methodology

This appendix presents the B-convexity concept. Complete details are given in Briec et al. (2004, 2009)

Notations

First, let us define the notations used. Let R_+^d be the non-negative Euclidean d-orthant.

Now let m, n ∈ N be two positive natural numbers such that d = m + n. A production technology transforms inputs x = (x_1,..., x_m) into outputs y =(y_1, …. y_n).

The set T ⊂ R^{m+n} of all input-output vectors that are feasible is called the production set. Namely, it is defined as follows:

T = {(x, y) ∈R^{m+n} : x can produce y}

One can characterize the technology T by an input correspondence:

L: y −→ L(y) and an output correspondence P: x −→ P (x), where:

L(y) = {x∈R_+^m : z = (x,y)∈T} is the set of all input vectors that yield at least y and

P(x) = {y∈R_+^n : z=(x,y)∈T } is the set of all the output vectors obtainable from x.

Now, let K = R^m+ ×(−R_+^n) the free disposal cone. There are some assumptions that the production technology must obey (Shephard, 1970).

T1: T is a closed set.

T2: T is a bounded set, i.e. for an y, z∈T,(z−K)∩T is bounded.

T3: T is strongly disposable, i.e. T = (T + K) ∩ R_+^d

T1-T3 defines a technology with freely disposable inputs and outputs.

B-convex concept

B-convexity is obtained from usual convexity, making the formal substitution + → max. Semilattice[14] plays a crucial role in this context.

For $z^1, z^2, \dots, z^l \in R_+^d$, we denote:

$$\bigvee_{k=1}^{d} z^k = \left\{\max\left\{z_1^1, \dots, z_1^l\right\}, \dots\dots, \max\left\{z_d^1, \dots\dots, z_d^l\right\}\right\}$$

The B-convex sets satisfy the connectedness assumption. It is important because it allows the possibility of transforming a production technique continuously.

[14] . A subset L ⊂ Rd is said to be a upper-semilattice if ∀z, t ∈ L then z ⋁ t ∈ L, where: z ⋁t = (max {z1,t1},..., max {zd,td}).

Let $A = \{z_1, ..., z_m\} \subset R_+^d$ then the set:

$$B(A) = \left\{ \bigvee_{k=1}^{d} \rho_k z^k, \rho \geq 0, \max\{\rho_k\} = 1 \right\}$$

is called the B-convex set hull of A.

5.2 B-convex estimation of the production technology

Let us present the B-convex nonparametric estimation of a production set.

Let $A = \left(z^1, \dots, z^l\right) \subset R_{++}^d$ a set of l observed production vectors.

If we consider $K=R^m_+ \times(-R_+^n)$ then,

$$T_{max} = (B(A) + K) \cap R_+^d$$

is called B-convex estimation of the production technology.

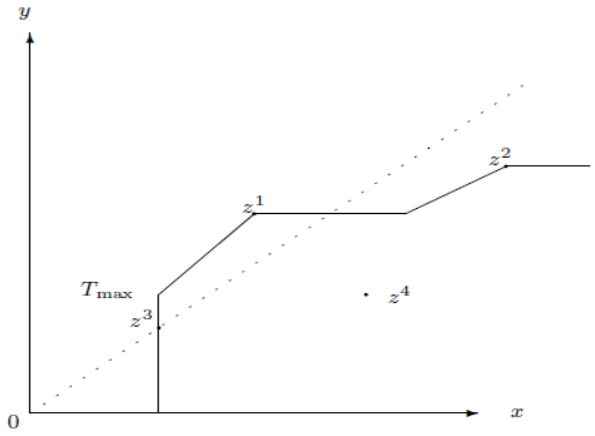
Equivalently, one can write:

$$T_{max} = \left\{z = (x, y) \in R_+^d : x \geq \bigvee_{k=1}^{l} \rho_k x^k, y \leq \bigvee_{k=1}^{l} \rho_k y^k, \max \rho_k = 1, \rho \geq 0\right\}$$

Where $\max_{k=1...l}\{\rho_k\} = 1$ characterizes the variable returns to scale assumption (VRS). By dropping the above constraint we can define the B-convex estimation of the production technology under constant returns to scale assumption (CRS). The following result states the basic properties of the above estimation. The above estimation has a comprehensive economic meaning. In short, the semilattice conditions imply that if a producer uses a greater input quantity then he/she is able to produce a greater output quantity. If the maximum of two input bundles is feasible, then the maximum that they produce is also feasible. This condition is of course stronger than the free disposal assumption.

This kind of technology is illustrated with the figure 1.

Figure 9. B-convex estimation



The lines joining the points are broken. The returns to scale are locally decreasing between the points z3 and z1 and locally increasing between the points z1 and z2. The technology is non convex in the

production set but it can be convex in some subsets.

Comparing such an assumption to convexity, B-convexity has some advantages and some drawbacks. B-convexity encompasses as a special case the situation in which the technology assumes that the inputs are freely disposable in the input orientation. Regarding the output orientation, B-convexity implies, under a free disposal assumption, which means that the production set has an output cubic structure and exhibits an output complementarity.

The above model offers additional choice on the nature of the structure analysis technology. Compared to the DEA model, which postulates a priori a returns to scale assumption of the technology which may be variable, the B-convex model does not define the nature of returns to scale (increasing, decreasing, non-increasing etc.).

Measurement of technical efficiency of B-convex nonparametric technologies

This section present a method for calculating the Farrell measure over a B-convex set nonparametric technologies under a variable returns to scale assumption.

Let A = $z^1, z^2, \ldots, z^l \in \mathrm{R}^{\mathrm{d}}_{++}$. Let us consider $\mathrm{T}_{\max} = (\mathrm{B}(\mathrm{A}) + \mathrm{K}) \cap \mathrm{R}^{\mathrm{d}}_{+}$. Moreover, we denote:

$$\alpha_k^{\bar{k}} = \min_{i=1\ldots m} \left\{ \frac{x_i^{\bar{k}}}{x_i^k} \right\}$$

The input distance function is:

$$D^i_{T_{\max}}(x^{\bar{k}}, y^{\bar{k}}) = \max \left\{ \max_{j=1\ldots n} \min_{\substack{k \\ y_j^k \le y_j^k}} \left\{ \frac{y_j^{\bar{k}}}{y_k^k \alpha_k^{\bar{k}}} \right\}, \min_k \left\{ \frac{1}{\alpha_k^{\bar{k}}} \right\} \right\}$$

The output distance function is:

$$D^o_{T_{\max}}(x^{\bar{k}}, y^{\bar{k}}) = \min_{j=1\ldots n} \max_k \left\{ \frac{y_j^k \min\{\alpha_k^{\bar{k}}, 1\}}{y_j^{\bar{k}}} \right\}$$

Table 6: Average efficiency scores by business models with a zoom on the French cooperative banks (BPCE has been introduced from 2008):

Business Models	2007	2008	2009	2010	2011	2012	2013	2014	Std Dev.
Cooperative Banks	0.79	0.62	0.72	0.77	0.89	0.77	0.75	0.73	0.08
Commercial Banks	0.80	0.63	0.74	0.79	0.89	0.79	0.76	0.74	0.07
French Cooperative Banks	0.81	0.29	0.73	0.92	0.89	0.80	0.75	0.78	0.19

Table 7:

Business Models	Average of Input efficiency ratio
Commercial Banks	0.831
Cooperative Banks	0.741
Average	0.79

Table 8:

Country name	Average of Input efficiency ratio
AUSTRIA	0.786
BELGIUM	1
DENMARK	0.81
FINLAND	0.87
FRANCE	0.781
GERMANY	0.647
ITALY	0.839
NETHERLANDS	0.501
NORWAY	0.68
Portugal	0.517
SPAIN	0.785
UNITED KINGDOM	0.94
TOTAL	0.769

Table 9 Determinants of Efficiency

Variables	Definition	Min	Median	Mean	Maxi	Std.Dev.
EFF	Technical cost efficiency score.	0.39	1	0.89	1	0.14
ROAA	Return on Average Assets. This is perhaps the most important single ratio in comparing the efficiency and operational performance of banks as it looks at the returns generated from the assets financed by the bank.	-3.24	0.31	0.32	2.28	0.49
lnTA	Natural logarithm of Total Assets is used to capture the impact of size.	6.31	8.85	9.94	14.94	2.87
CTI	This ratio measures the overheads or costs of running the bank, the major element of which is normally salaries, as percentage of income generated before provisions. It is a measure of efficiency although if the lending margins in a particular country are very high then the ratio will improve as a result. It can be distorted by high net income from associates or volatile trading income.	27.15	62.48	63.80	320	18.57
ETA	Equity to Total Assets ratio. As equity is a cushion against asset malfunction, this ratio measures the amount of protection afforded to the bank by the equity they invested in. The higher this figure the more protection there is.	1.45	6.35	6.57	12.38	2.36

lnTA_Coop	Interaction variable between Total Asset and Cooperative bank status. This variable controls whether being cooperative bank and to have a significant total assets is significant.	-	-	-	-	-

Tableau 10 Determinants of Efficiency

This table reports estimates of the fixed effect regressions at the bank level of Efficiency score on a set of independent variables over the period 2007-2014. Variable definitions appear in table 8. Hubert/White heteroscedasticity robust standard-errors are reported into brackets. ***, ** and * denote statistical significance respectively at 1%, 5% and 10%

ROAA	-0.0200
	(0.0144)
CTI	-0.00227***
	(0.000541)
ETA	0.00714**
	(0.00338)
lnTA	0.0140***
	(0.00250)
lnTA_Coop	7.85e-05
	(0.00143)
Constant	0.835***
	(0.0602)
Year Fixed Effects	Yes
Observations	466
R-square	0.156

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Débats Économiques et Financiers

1. M. Dietsch, H. Fraisse, « De combien le capital réglementaire diffère-t-il du capital économique : le cas des prêts aux entreprises par les grands groupes en France », Février 2013.
2. O. de Bandt, N. Dumontaux, V. Martin et D. Médée, « Mise en œuvre de stress tests sur les crédits aux entreprises», Mars 2013.
3. D. Nouy, « Les risques du *Shadow banking* en Europe : le point de vue du superviseur bancaire », Avril 2013.
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   Aout 2013.
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12. O. de Bandt, B. Camara, P. Pessarossi, M. Rose, « *Does the capital structure affect banks' profitability? Pre- and post-financial crisis evidence from significant banks in France* », Mars 2014.
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17. F. Borel-Mathurin, P.-E. Darpeix, Q. Guibert, S. Loisel, « Principaux déterminants de la stratégie de revalorisation dans le secteur de l'assurance-vie en France », Juillet 2015.
18. H. Fraisse, J. Hombert et M. Lé, « Les impacts d'une mégafusion sur la distribution du crédit », Octobre 2015

19. B. Camara, F-D. Castellani, H. Fraisse, L. Frey, J-C. Héam, C. Labonne and V. Martin « MERCURE : un modèle de stress test macro prudentiel développé à l'ACPR», Octobre 2015
20. C. Labonne et C. Welter-Nicol « crédit bon marché, immobilier cher ?», Décembre 2015
21. F. Vinas, « Les effets réels du modèle de banque universelle sur l'investissement des entreprises : Résultats d'une analyse sur la période 2004-2009 », Avril 2016
22. I. Argimon, M. Dietsch, et A. Estrada, « Filtres Prudentiels, composition des portefeuilles et ratios de capital dans les banques européennes», Août 2016.
23. M. Dietsch, K. Düllmann, H. Fraisse, P. Koziol and C. Ott «En faveur du facteur de soutien aux PME – Résultats empiriques au niveau international sur les exigences en capital des prêts aux PME», Octobre 2016
24. O. de Bandt, B. Camara, A. Maitre et P. Pessarossi, « Capital Optimal, exigences réglementaires et performances bancaires en période de crise : l'exemple de la France », Octobre 2016.
25. Eugenio Avisoa « L'efficience technique et la performance des banques européennes: les modèles économiques sont-ils importants? Le cas des banques coopératives européennes», Décembre 2016.

Economic and Financial Discussion Notes

1. M. Dietsch and H. Fraisse, “How different is the regulatory capital from the economic capital: the case of business loans portfolios held by major banking groups in France”, February 2013.
2. O. de Bandt, N. Dumontaux, V. Martin and D. Médée, “Stress-testing banks’ corporate credit portfolio”, March 2013.
3. D. Nouy, “The risks of the Shadow banking system in Europe: the perspective of the banking supervisor”, April 2013.
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6. O. de Bandt, J-C. Héam, C. Labonne and S. Tavolaro, “Measuring Systemic Risk in a Post-Crisis World”, Juin 2013.
7. B. Camara, L. Lepetit, and A. Tarazi, “Ex ante capital position, changes in the different components of regulatory capital and bank risk”, Juin 2013.
8. M. Brun, H. Fraisse, D. Thesmar, “The Real Effects of Bank Capital Requirements”,
   August 2013.
9. M. Lé, “Deposit Insurance Adoption and Bank Risk-Taking: the Role of Leverage”,
   December 2013.
10. S. Tavolaro and F. Visnovsky, “What is the information content of the SRISK measure as a supervisory tool?”, January 2014.
11. Olivier de Bandt, Boubacar Camara, Pierre Pessarossi, Martin Rose, “Regulatory changes and the cost of equity:evidence from French banks”, March 2014.
12. Olivier de Bandt, Boubacar Camara, Pierre Pessarossi, Martin Rose, “Does the capital structure affect banks’ profitability? Pre- and post-financial crisis evidence from significant banks in France”, March 2014.
13. Michel Dietsch and Cécile Welter-Nicol, “Do LTV and DSTI caps make banks more resilient?”, August 2014.
14. M. Chaffai and M. Dietsch, “Modelling and measuring business risk and the resiliency of retail banks”, December 2014.
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16. P. Pessarossi, F. Vinas, “Banks’ supply of long term credit after a liquidity shock: Evidence from 2007-2009”, February 2015.
17. F. Borel-Mathurin, P.-E. Darpeix, Q. Guibert, S. Loisel, “Main determinants of profit sharing policy in the French life insurance industry”, July 2015.
18. H. Fraisse, J. Hombert et M. Lé “ The competitive effects of a bank megamerger on access to credit”, October 2015

19. B. Camara, F-D. Castellani, H. Fraisse, L. Frey, J-C. Héam, C. Labonne and V. Martin “MERCURE : a macroprudential stress testing model developped at the ACPR”, October 2015
20. C. Labonne and C. Welter-Nicol “Cheap Credit, Unaffordable Houses”, December 2015
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24. O. de Bandt, B. Camara, A. Maitre and P. Pessarossi « Optimal capital, regulatory requirements and bank performance in times of crisis: Evidence from France » October 2016.
25. Eugenio Avisoa « European banks’ technical efficiency and performance: do business models matter? The case of European co-operatives banks », December 2016.

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