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Proposal on ELBE and LGD in-default: tackling capital requirements after the financial crisis

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Abstract

Following the financial crisis, the share of non-performing loans has significantly increased, while the regulatory guidelines on the Internal-Ratings Based (IRB) approach for capital adequacy calculation related to defaulted exposures remains too general. As a result, the high-risk nature of these portfolios is clearly in danger of being managed in a heterogeneous and inappropriate manner by those financial institutions permitted to use the IRB system, with the consequent undue variability of Risk-Weighted Assets (RWA). This paper presents a proposal to construct Advanced IRB models for defaulted exposures, in line with current regulations, that preserve the risk sensitivity of capital requirements. To do so, both parameters Expected Loss Best Estimate (ELBE) and Loss Given Default (LGD) in-default are obtained, backed by an innovative indicator (Mixed Adjustment Indicator) that is introduced to ensure an appropriate estimation of expected and unexpected losses. The methodology presented has low complexity and is easily applied to the databases commonly used at these institutions, as illustrated by two examples.

JEL codes

C51, G21, G28, G32

Keywords

Credit risk, Defaulted exposures, Banking regulation

Non-technical summary

Following the recent financial crisis, a considerable increase in the volume of non-performing assets of the affected financial institutions has shown the need for an appropriate measurement of the associated credit risk. The institutions permitted to use their own estimates for the Own Funds Requirements (OFR) calculation can find some broad guidance in the Capital Requirements Regulation (CRR) that may help on the internal-rating based Advanced (hereinafter, Advanced) models estimation for defaulted exposures, namely Expected Loss Best Estimate (ELBE) and Loss Given Default (LGD) in-default. Nevertheless such guidance appears to have a significant lack of methodological precision. In addition, there are two additional relevant documents issued by the European Banking Authority (EBA)[1] that are still not in force but provide with further details, although they still remain not exhaustive enough. This situation may cause great variability in terms of the Risk-Weighted-Assets (RWA) of defaulted portfolios between institutions with Advanced models already implemented. Moreover, it is worth to mention that the unwarranted RWA variability is currently a concern that is being addressed by the European Central Bank (ECB), for instance through the publicly known Targeted Review of Internal Models (TRIM) exercise.

It is thus evident the need to propose methodologies for ELBE and LGD in-default estimates adapted to the regulatory guidelines that enable model comparability and can be easily adopted by most institutions. With this purpose, a methodological proposal is presented that responds to the problems put forward, in line with current regulations and EBA recommendations, and is suitable for the databases commonly used by the institutions. The proposed models would not only serve for institutions permitted to use Advanced models for the OFR calculation but for all other institutions since it may entail an enhancement on their internal risk management regarding defaulted assets.

The presented parameters for defaulted exposures are calibrated to preserve the crucial risk sensitivity of capital requirements, and moreover, the unexpected losses are estimated in a sufficiently conservative manner to cover potential adverse changes in economic conditions. To achieve said conservatism, an indicator that we call Mixed Adjustment Indicator (MAI) is proposed. This indicator allows to select significant high levels of percentiles of a distribution of variables which are correlated with the losses of recovery processes and based on recent historical data as well as

[1] Final Draft Regulatory Technical Standards on the specification of the assessment methodology for IRB Approach (EBA/RTS/2016/03) and Guidelines on PD LGD estimation and treatment of defaulted assets (EBA/GL/2017/16).

data collected in periods of economic downturn. Afterwards, the mentioned parameters are empirically estimated on the basis of the database of two institutions. Thus it is shown that the proposed methodology performs adequately within the macroeconomic context of certain jurisdictions of diverse nature, namely France and Spain, and enables the viability of the proposal for its successful implementation.

1. Introduction

Because of the financial crisis, banking institutions have borne a considerable increase in the volume of defaulted portfolios, when these had traditionally been scarce. This explains why current regulations and investigations have focused on the credit risk for portfolios of clients up-to-date with their payments. One of the risk categories that entail more capital consumption, fully developed in Basel II, is credit risk. To obtain regulatory capital, institutions can choose from the following methods: the Standardised approach, the Foundation Internal-Ratings Based (IRB) approach and the Advanced IRB approach (hereinafter, Advanced). Adopting an IRB method requires calibrating certain parameters after the corresponding authorisation has been granted by the supervisory authorities. To apply Advanced models, the following must be estimated: Loss Given Default (LGD), Probability of Default (PD) and Exposure at Default (EAD) for exposures that are not in default, and LGD in-default and the Expected Loss Best Estimate (ELBE) for exposures in default situations.

To date, the number of works related to the estimate of risk parameters for defaulted exposures has been low. Kim (2006), starting from single Frye's factor models (2000) and Düllmann and Trapp (2004), conducts several proposals to obtain the LGD in-default and the ELBE as a short-term solution applicable to institutions that had little historical data depth. Dermine and de Carvalho (2006, 2008) estimate the repercussions after the default by considering the default time using two different methods. The first one follows the studies of Altman (1989) and Altman and Suggit (2000), where they analyse the percentage of bad and doubtful loans after n years from their origination to then make an adjustment based on the Kaplan-Meier (Greene, 1993) estimator that corrects the effect of censured data. The second method comprises an empirical estimate of a log-log function. In addition, Weissbach et al. (2010) focus their study on the estimate of economic capital and propose an Advanced model, where both ELBE and LGD in-default are calculated using single-factor models. The appropriateness of survival analysis and mixture distribution models, among others, is assessed by Zhang and C. Thomas (2012) for the recovery rate modelling and subsequent LGD forecasting. Alman and Kalotay (2014) model recoveries of defaulted debt through a mixture of Gaussian distributions. Finally, Fenech et al. (2016) resort once again to the Kaplan-Meier estimator, applied to calculate the survival of institutions close to bankruptcy, in other words, the likelihood of recovering all the debt. The ELBE approach proposed in this paper bears similarities with a survival analysis model.

As an alternative to estimating the LGD in-default independently, it is possible to obtain said parameter as a result of adding to the estimated ELBE an additional amount that responds to any potential unexpected losses that could arise during the debt recovery period. In this regard, Merton (1974) states that the volatility of the recovery ratios disappears with an appropriate diversification of the portfolio. However, Altman et al. (2004) set out a discussion on the presence of said volatility for different times of the economic cycle in different countries. Therefore, they conclude that the assumption of the Merton model contradicts the empirical evidence shown. This reflection gives meaning to the regulatory proposal of the estimate of an unexpected losses supplement.

In the methodology to estimate ELBE and LGD in-default, the time variable acquires special significance. Gürtler and Hibbeln (2013) conclude that most loans usually take little time to come out of the default situation and find a positive correlation between the LGD and the resolution time. Betz et al. (2016) also analyse the resolution time and draw conclusions that are in line with the work of Gürtler and Hibbeln.

Despite the significant increase in defaulted assets at institutions affected by the crisis, there are no specific proposals available in the literature for the estimation of the risk associated with defaulted exposures in line with current regulatory requirements and recommendations. This leads to the existence of wide margins of interpretation and consequently, less homogeneity between the different institutions that already have their Advanced models approved and implemented so that large variability in terms of Risk Weighted Assets (RWA) is observed.

It was in 2013, with the publication of the Capital Requirements Regulation (CRR) by the European Parliament, that general instructions were included to estimate Advanced parameters for defaulted exposures, allocating the drawing up of specific guides to the European Banking Authority (EBA). The final version of the document (EBA, 2016) conducted an analysis of IRB methodology: Regulatory Technical Standards on assessment methodology for IRB approach, hereinafter RTS; however, not enough detail was provided in the area of defaulted exposures. To resolve the lack of precision, the Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA, 2017), hereinafter Guidelines, were published including a more detailed description regarding the estimate of parameters associated with these types of exposures.

This paper attempts to establish a specific proposal for the construction of the aforementioned models, in line with CRR and EBA recommendations, that enables the comparability of risk parameters estimated with Advanced models and to preserve the risk sensitivity of capital requirements. To do so, the parameter of expected losses, ELBE, is estimated at several reference dates reflecting the variation over time elapsed in default situations. Subsequently, the unexpected losses supplement is estimated as the difference between two curves, computed on the basis of historical observations, whose adjustment is analysed using an indicator created for said purpose called the Mixed Adjustment Indicator (MAI). The intention is for the supplement to be sufficiently conservative to cover potential adverse changes in economic conditions. With this purpose, and using the Root Mean Squared Error (RMSE), usually used to measure the accuracy of forecasting, the model is modified to include said margin of conservatism. Finally, the LGD in-default is obtained as a result of adding the supplement of unexpected losses to the ELBE. The methodology presented has low complexity and is easily applicable to the databases commonly used at these institutions, as shown for two entities that serve as examples.

The paper is structured as follows. In section 2, the methodology of defaulted exposures models is precisely described. In particular, subsection 2.1. focuses on the estimation of ELBE while subsection 2.2. is focused on the LGD in-default. Afterwards, section 3 in the first place provides with a comprehensive description of the data source and preliminary data treatment (3.1.), further details are then given with regards to the selection of the reference sets for the purpose of the models' empirical estimation on the basis of the two portfolios of the respective selected entities (3.2.), then, the outcome of the estimation is carefully explained (3.3.) and, eventually, a subsection is devoted to present a discussion of the results in light of the macroeconomic trend observed in the relevant jurisdictions (3.4.). Last but not least, section 4 concludes highlighting the benefits of the presented proposal, in particular remarking the accurate alignment with the CRR requirements and standards issued by EBA.

2. Methodology

The proposed methodology follows the guidelines marked in current regulations as well as the EBA recommendations that are described below. The CRR includes, in its article 181(1)(h), a requirement for obtaining the ELBE in accordance with the current economic conditions of the time and the status of the considered exposure. It also requires the estimate of an unexpected increase in losses during the recovery[2] period for the calculation of the LGD in-default. The RTS reiterates what is already advanced by the CRR and proposes two potential scenarios: to estimate the LGD in-default as a sum between the ELBE and the unexpected losses supplement, or to estimate each parameter, ELBE and LGD in-default, independently, recommending the inclusion of two relevant variables in the estimate of both parameters[3]—the time elapsed in defaulted and the recoveries realised so far. Then, the Guidelines specify that both mentioned risk drivers may be taken into account either directly, as risk drivers, or indirectly, in setting reference dates for estimation purposes[4]. It is also recommended to consider the possibility of an adverse change in the economic conditions during the collection period when estimating additional unexpected losses, reflecting at least downturn conditions[5]. Also in accordance to the Guidelines a treatment for multiple defaults should be applied in

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2 That is, from the date of default up to the settlement of the exposure.

3 As referred in Article 54 (2) (b) of Final Draft Regulatory Technical Standards on the specification of the assessment methodology for IRB approach. EBA/RTS/2016/03.

4 As stated in paragraph 176 and further specified in paragraphs 171 to 173 of Guidelines on PD estimation, LGD estimation and treatment of defaulted assets. EBA/GL/2017/16.

5 As referred in paragraph 189 of Guidelines on PD estimation, LGD estimation and treatment of defaulted assets. EBA/GL/2017/16.

case several defaults are recognised on a single facility where the time between the moment of the return of an exposure to non-defaulted status and the subsequent classification as default is shorter than a predefined cure period of at least nine months, such exposure should be treated as having been constantly defaulted from the first moment when the default occurred[6].

In the proposed modelisation, we opted for the ELBE estimate and the unexpected losses supplement as a bridge for the estimate of the LGD in-default. The proposal contains the main requirements and recommendations described above. Firstly, the data is treated to consider a one-year cure period. Secondly, the default time is directly included as a risk driver and information of the recovery process, updated at each monthly reference date, is used as a discrete input for estimating both ELBE and LGD in-default models. Besides, there is other reason that supports the convenience of discarding continuous models: the proposed model estimation performed at each reference date appropriately deals with the matter of heteroscedasticity of the series; this is analysed in greater depth in the Appendix A. Finally, a margin of conservatism, based on historical observations, is added on top of the ELBE to obtain the LGD in-default in order to account for potential adverse changes in the economic situation. The proposal thus permits to estimate that margin of conservatism at least on the basis of downturn conditions historically registered during the business cycle. In conclusion, the regulations and the advice given in EBA documents are fully followed.

The database thus contains information on defaulted contracts in relation to the following aspects: date of default, date of settlement of the debt, exposure at the time of default, updates of the outstanding exposure amount at each reference date after default and the reporting date, which is the creation date of the database. The estimate of the parameters requires the differentiation of two reference sets primarily defined qualitatively, in accordance with the following conditions:

- *Set for estimating expected and unexpected losses* (E)*:* This set collects data close to the reporting date and contains a sample that is sufficiently representative of fully observed defaults[7]. This assumes that defaulted exposures on a date very near the

[6] As stated in paragraph 101 of Guidelines on PD estimation, LGD estimation and treatment of defaulted assets. EBA/GL/2017/16.
[7] From the default up to the time of total settlement of the debt.

reporting date are not included in this set. It is the set used to estimate the ELBE and derive the LGD in-default.

- *Set for estimating unexpected losses* (I)*:* This set is made up of the data associated with exposures that have entered a default situation very near the reporting date, so that the collection processes are observed only for a few months of default and therefore, the most recent recovery trend is captured. It may also collect data recorded during past economic downturn periods so that possible downward changes in the business cycle are considered in the model. The LGD in-default is partly estimated based on this set.

2.1. ELBE model

The ELBE parameter is estimated at each reference date as described below.

$[0, \mathrm{T}] \subset \mathbb{R}$ is an interval of defaulted time. $0 < t_0 < t_1 < \cdots < t_k < \cdots < t_n < T$ is a partition such that t_0 is the time of default for a given exposure. Another partition is $0 < \tilde{t}_0 < \tilde{t}_1 < \cdots < \tilde{t}_k < \cdots < \tilde{t}_m < T$ such that $t_0 < \tilde{t}_0$ and $\tilde{t}_m < t_n$.

The recoveries of the debt recorded throughout the default period are $r_{\tilde{t}_0}, r_{\tilde{t}_1}, \dots, r_{\tilde{t}_k}, \dots, r_{\tilde{t}_m}$ / $r_{\tilde{t}_i}$ $\forall \tilde{t}_i \in (0, \mathrm{T})$ and EAD the exposure at the time of default.

Then, the following is defined:

$$\widetilde{\mathrm{ELBE}}_{t_k} = 1 - \frac{\sum_{\tilde{t}_i > t_k} r_{\tilde{t}_i}}{\mathrm{EAD} - \sum_{\tilde{t}_i < t_k} r_{\tilde{t}_i}} \tag{1}$$

Being,

$$\widetilde{\mathrm{ELBE}}_{t_0} = 1 - \frac{\sum_{\tilde{t}_i > t_0} r_{\tilde{t}_i}}{\mathrm{EAD} - \sum_{\tilde{t}_i < t_0} r_{\tilde{t}_i}} = 1 - \frac{\sum r_{\tilde{t}_i}}{\mathrm{EAD}} \tag{2}$$

$$\widetilde{\mathrm{ELBE}}_{t_{n+1}} = 1 - \frac{\sum_{\tilde{t}_i > t_{n+1}} r_{\tilde{t}_i}}{\mathrm{EAD} - \sum_{\tilde{t}_i < t_{n+1}} r_{\tilde{t}_i}} = 1 - \frac{0}{\mathrm{EAD} - \sum r_{\tilde{t}_i}} = 1 \tag{3}$$

The variable $\widetilde{\mathrm{ELBE}}_{t_i}$ follows a normal distribution, and in the case t_0, its formula is applicable for the calculation of the realised LGD of non-defaulted exposures. For reference dates subsequent to t_0 the distribution will be of use for the empirical estimate of the ELBE parameter. This gives the formula consistency by being applicable for exposures that are not defaulted and for those in default situations.

For an appropriate empirical estimate of ELBE, the data relating to the collection process that is in the set *E* are used. Under these conditions, the following notation is used:

$\mathrm{ELBE}_{\mathrm{t_i}}^{E}\ \forall\, t_i \in (0, \mathrm{T}), i\ \in \{1, \dots, \mathrm{n}\}$

That reference set permits an estimate based on a sufficiently representative sample that includes the expected tendency of losses present in a period that is as close as possible to the reporting date. Due to the construction of the set *E*, it may be considered said parameter as the best estimate of the expected loss.

2.2. LGD in-default model

The model begins from the ELBE distribution defined to derive the supplement of unexpected losses associated with the movements of recovery of the collection process that will enable us to obtain the LGD in-default. This supplement is obtained as the deviation of a given percentile of the ELBE distribution with regard to its median.

The set *I*, upon collecting data from incomplete collection processes observed only during a short period of time after default, is not sufficiently representative to conduct the estimate of unexpected losses solely based on said set. However, the set includes the tendency of the economic conditions existing on dates near the reporting date, and that tendency will be captured by using the proposed method.

The last time moment after the default is $t_s \in (0, T)$ for certain $s > 0$, in which debt recoveries are recorded within the set *I*.

$\mathrm{ELBE}_{t_i}^{C,p}$ is defined as the percentile p of the ELBE distribution in the moment t_i based on the data contained in any set *C*.

Note that the defined variable represents, for percentiles greater than 50, the distribution of losses of certain exposures that, throughout time, have had recovery processes equal to or more deficient than those associated with the median of the distribution. Thus, the variations of distribution, according to the selected percentile, are similar to the potential variations associated with different economic scenarios. For percentiles near 100, the losses of distribution would be comparable to those associated with years of economic recession.

Considering the previously defined reference sets E and I, we calculate the following difference:

$$\Delta_p^{E,I}(t_i) = ELBE_{t_i}^{E,p} - ELBE_{t_i}^{I,50} \ \forall\, t_i \in (0, t_s], i \in \{1, \dots, \mathrm{n}\}, p \in [50{,}100] \quad (4)$$

Below we propose a method that seeks to approach the median of the ELBE distribution, empirically calculated with data from set I (hereinafter, median distribution), through a percentile greater than 50 of the ELBE distribution determined with data from set E (hereinafter, percentile distribution). The purpose of this approach is that, in all t_i, the percentile distribution is greater than or equal to the median distribution.

To obtain the percentile p that optimises the described relation, the root mean square error (RMSE) is used:

$$RMSE_p = \sqrt{\frac{1}{s}\sum_{i=1}^{s} \Delta_p^{E,I}(t_i)^2} \qquad \forall\, p \in [50{,}100] \quad (5)$$

In cases with negative differences, a penalising element is added whose result is greater than the higher number of negative differences when these are of greater magnitude:

$$RMSE_p^{neg} = \begin{cases} \sqrt{\dfrac{1}{\delta_p} \displaystyle\sum_{\{\mathrm{i} \in \{1,\dots,\mathrm{s}\}/\Delta_p^{E,I}(t_i) > 0\}} \Delta_p^{E,I}(t_i)^2} & if\ \delta_p > 0 \\ 0 & if\ \delta_p = 0 \end{cases} \quad (6)$$

Being $\delta_p = \#\,\{\mathrm{i} \in \{1, \dots, \mathrm{s}\}/\Delta_p^{E,I}(t_i) > 0\}$ and for all $p \in [50{,}100]$

Both measurements are used to construct an indicator we call the MAI. The purpose is to approach the median distribution in the most conservative way possible; in other words, by obtaining the value of the percentile for which the percentile distribution is higher than the median distribution by being the one that records the desired economic tendency, such as the one present at times near the reporting date. It is essential for the percentile distribution to be greater than the median, since it enables a conservative character to be included in the unexpected loss. In fact, the RMSE is widely used but is not useful for this purpose. Therefore, the indicator contained in the second addend penalises those cases in which for a certain moment of time, the percentile distribution is lower than the median. It is defined as:

$$MAI_p = RMSE_p + RMSE_p^{neg} \quad \forall\, p \in [50{,}100] \qquad (7)$$

For the estimate to be sufficiently conservative, i.e., to have a wide margin that enables a potential adverse change in economic conditions to be included, the set of the eligible percentile values can be restricted, as the one proposed below. Therefore, the optimal percentile p^* will be that for which the aforementioned indicator is minimised:

$$p^* = min\left\{MAI_p /\, p \in \{50, 60, 70, 80, 82, 86, 88, 90, 92, 94, 96, 98, 100\}\right\} \qquad (8)$$

Therefore, the additional unexpected loss is given by:

$$\Delta_{p^*}^{E}(t_i) = ELBE_{t_i}^{E,p^*} - ELBE_{t_i}^{E,50} \;\forall\, t_i \in (0, \mathrm{T}], i \;\in \{1, \dots, \mathrm{n}\} \qquad (9)$$

Then, the LGD in-default is defined as indicated:

$$LGD_{\mathrm{t_i}} = \mathrm{ELBE}_{\mathrm{t_i}}^{E} + \Delta_{p^*}^{E}(t_i) \quad \forall\, t_i \in (0, \mathrm{T}], i \;\in \{1, \dots, \mathrm{n}\} \qquad (10)$$

3. Data and results

3.1. Data description and treatment

The data used corresponds to two large European financial institutions from two different countries: France and Spain. The database of the French institution belongs to a leasing portfolio dated 30 June 2010, obtaining all the defaults recorded in the 2003-2008 period. The database of the Spanish institution contains different product types than leasing, such mortgages, consumer loans and credit cards for individuals. Its reporting date is 31 December 2012, and it contains all the defaults recorded up to that time.

The two proposed databases represent two portfolios of diverse nature: the Spanish one, containing a large number of defaults linked to clients severely affected by the crisis, and the French portfolio, with a smaller-sized sample of defaults associated to leasing clients who were better placed to face the crisis[8]. The gap between the risk profiles of the two portfolios is also evidenced while considering the macroeconomic indicators of each country during the relevant periods[9], on which Spain clearly lags behind.

Complying with regulatory recommendations, we conducted an overlap treatment of the data in the case of multiple defaults, considering a year as cure period. The recovery amounts obtained at each reference date, established on a monthly basis, are derived from the periodic updates of the due debt.

3.2. Selection of reference sets

The reference sets are established qualitatively based on the observation of the mean of ELBE throughout the collection period per default year. In other words, the ELBE is calculated from the data related to processes of recovery of exposures that have defaulted in a certain year. Figures 1, 2 and 3 represent the evolution of ELBE for both institutions.

[8] The leasing business is made via contractual agreements calling for the lessee (client), to pay the lessor (bank) for use of an asset such as buildings, vehicles, etc. The recent economic crisis did not battered leasing companies significantly because many enterprises considered to stop buying assets to start leasing them in order to reduce costs during those years so that the leasing business benefited from this circumstance.

[9] Reflected in Appendix B.

Fig. 1. ELBE per year of default of the French entity

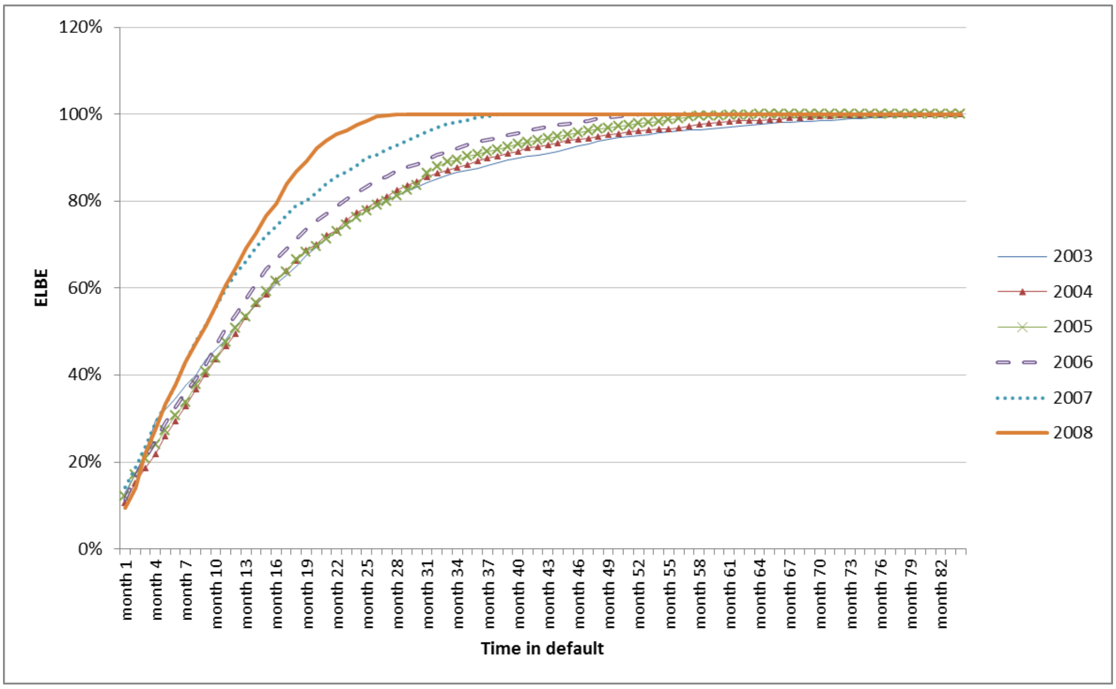


Fig. 2. ELBE per year of default of the Spanish entity

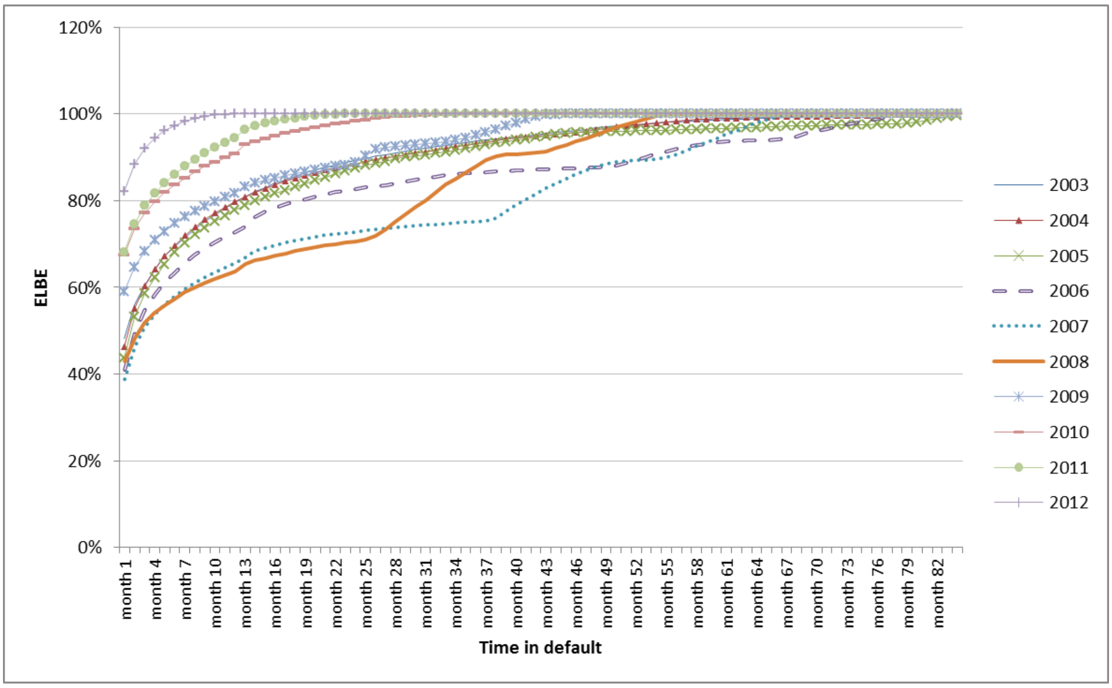


Fig. 3. ELBE per year of default presented sequentially after default in 2006 of the Spanish entity

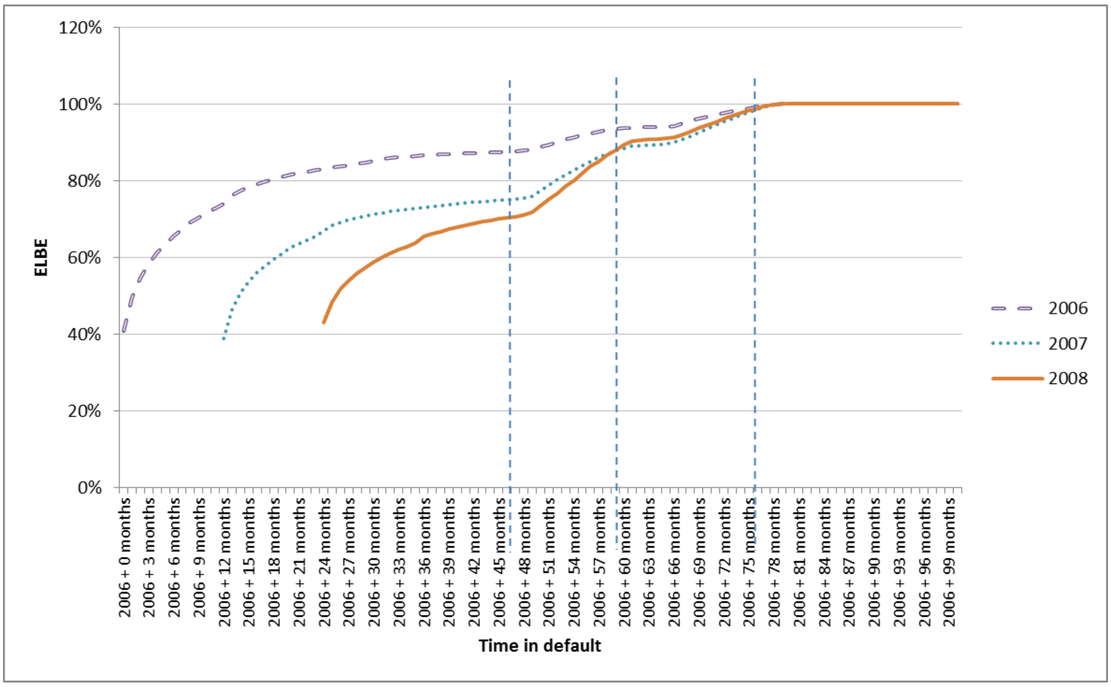


Fig. 1 shows how the ELBE of 2007 and specially 2008 show a more accelerated convergence at 100%, indicating that debt recoveries have stopped being observed. This tendency is in line with the recent economic crisis that in 2008 was significantly negative largely in European economies, compared to the ELBE of 2005 that converged 60 months after the default. Therefore, the reference sets for the French entity are established in such a way that the data associated with defaulted exposures from 2003 up to and including 2007 form set *E*, while the defaults in 2008 belong to set *I*.

When we examine the evolution of the ELBE of the Spanish institution (Fig. 2), we see how the gradient of the curves increases significantly for defaults from month 27 in 2008 and from month 38 in 2007. Further, the defaults subsequent to 2009, 2010 and the first half of 2011 record very high levels at the start of the collection year, indicating that debt recovery capacity fell with the passage of time after the recent economic crisis. In Fig. 3 the ELBE curves are included sequentially in 2006-2008 prior to the crisis and the debt recovery capacity is seen more clearly.

When establishing the reference sets in this case, it is necessary to take into account that curves from more recent years correspond to the data of defaults whose collection process has been observed only during a short period of time. For example, for those that entered a default situation in 2012, at most, the first 12 months could be observed. To not include censured data in the reference sets, the data associated with exposures that have been classified as defaulted after 30 June 2011 are filtered, recording any default observed for a minimum of 18 months. Therefore, it is established that the data of defaults from 2003 up to and including 2009 form set *E*, while those of defaults in 2010 and the first half of 2011 belong to set *I*.

3.3. Estimation results

By following the proposed methodology, the estimate of unexpected losses is constructed from the so-called percentile distributions and median distribution, which are represented in Fig. 4 for the French institution and in Fig. 5 for the Spanish institution.

Fig. 4. Percentile distributions based on the French entity

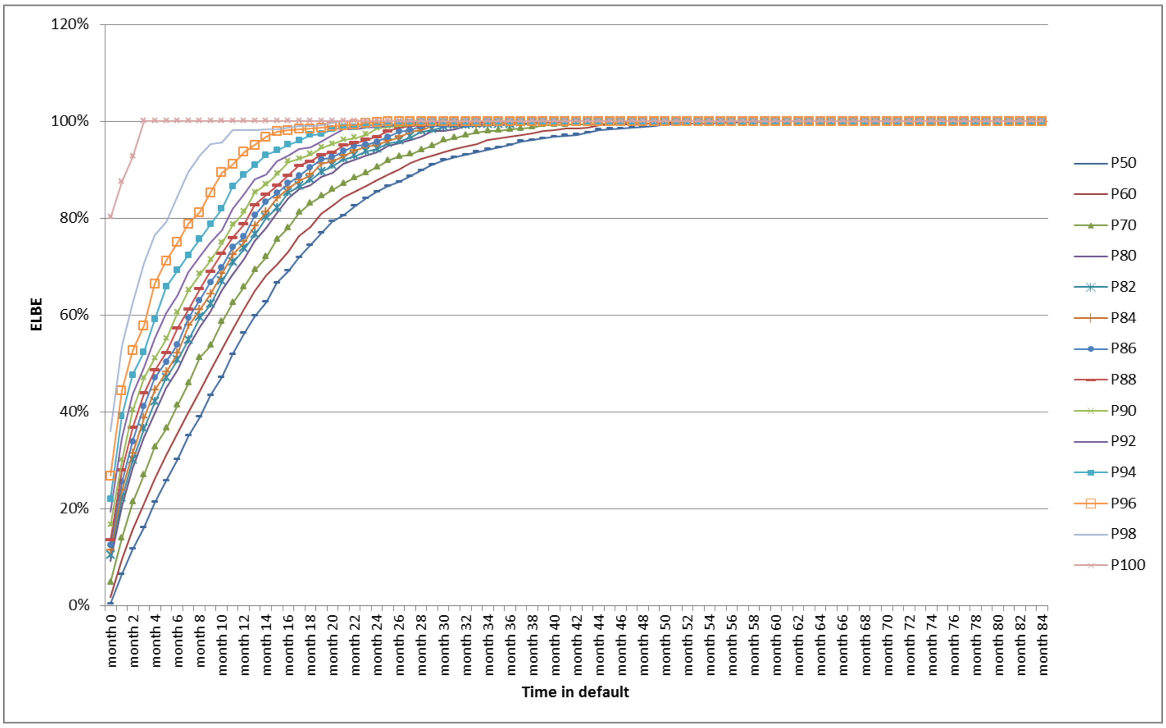
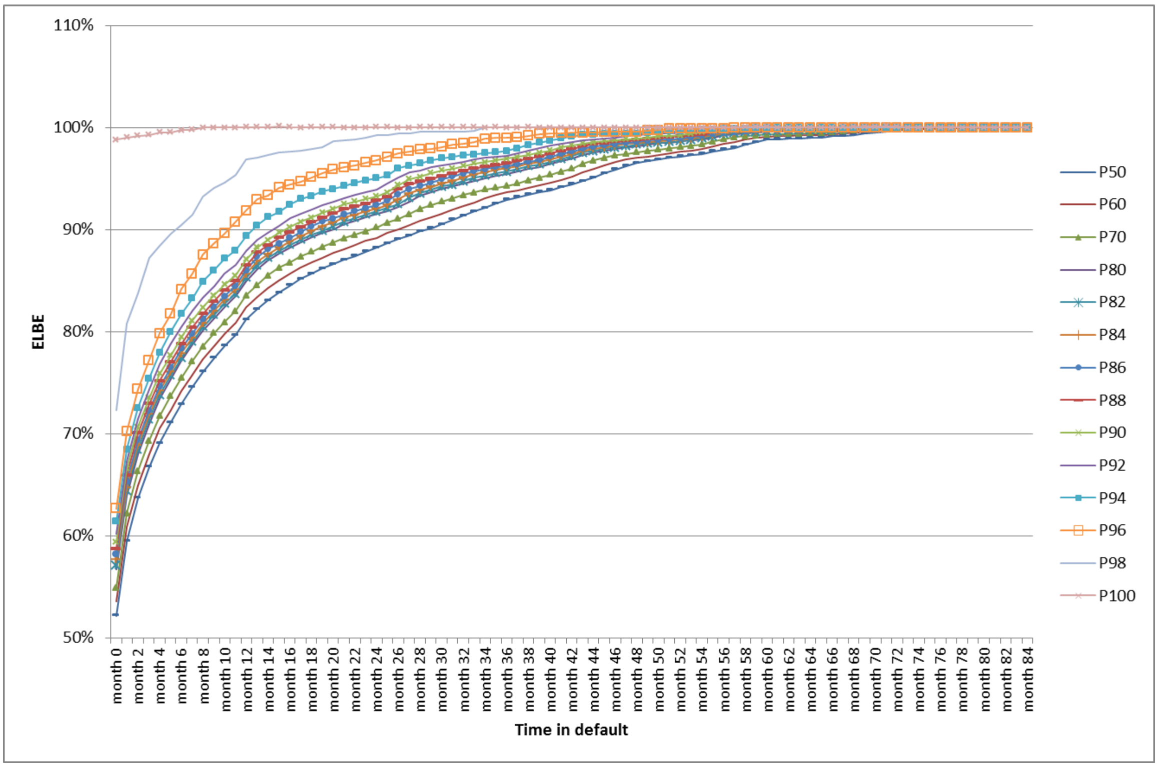


Fig. 5. Percentile distributions based on the Spanish entity



When selecting the percentile that optimises the approach, the RMSE and the MAI are calculated for some previously selected p percentiles. The Table 1 contain both the results based on the RMSE method and those based on the MAI, for the French and Spanish institution.

Table 1. Root Mean Squared Error and Mixed Adjustment Indicator values

p	$RMSE_p$		MAI_p	
	French entity	Spanish entity	French entity	Spanish entity
50	11.5%	10.2%	24.1%	20.8%
60	**9.2%**	9.0%	18.9%	18.2%
70	9.6%	7.6%	**17.2%**	15.4%
80	13.7%	5.9%	18.3%	12.0%
82	15.1%	5.5%	18.8%	11.2%
84	16.5%	5.0%	20.5%	10.2%
86	18.1%	4.5%	20.5%	9.2%
88	20.0%	3.9%	20.9%	8.0%
90	22.5%	3.3%	22.5%	6.7%
92	25.7%	2.5%	25.7%	5.1%

94	29.3%	**1.8%**	29.3%	**4.4%**
96	34.2%	2.6%	34.2%	5.0%
98	41.9%	7.6%	41.9%	7.6%
100	59.1%	21.0%	59.1%	21.0%

Based on the output of the RMSE method reflected in Table 1, the 60th percentile is chosen for the French entity while the 94th percentile is the right one for the Spanish institution for the calculation of unexpected losses, since the minimum RMSE value is reached at those percentiles. Nevertheless the selected method is the MAI since it ensures higher conservativeness as it is clearly evidenced in the French case. According to the results of the MAI the 70th percentile at the French institution and the 94th percentile at the Spanish institution are eventually chosen. Therefore, the variables required to obtain the LGD in-default are available. The Fig. 6 and Fig. 7 charts reflect the results of both ELBE and LGD in-default parameters for exposures in default of both institutions.

Fig. 6. Final ELBE and LGD in-default based on the French entity

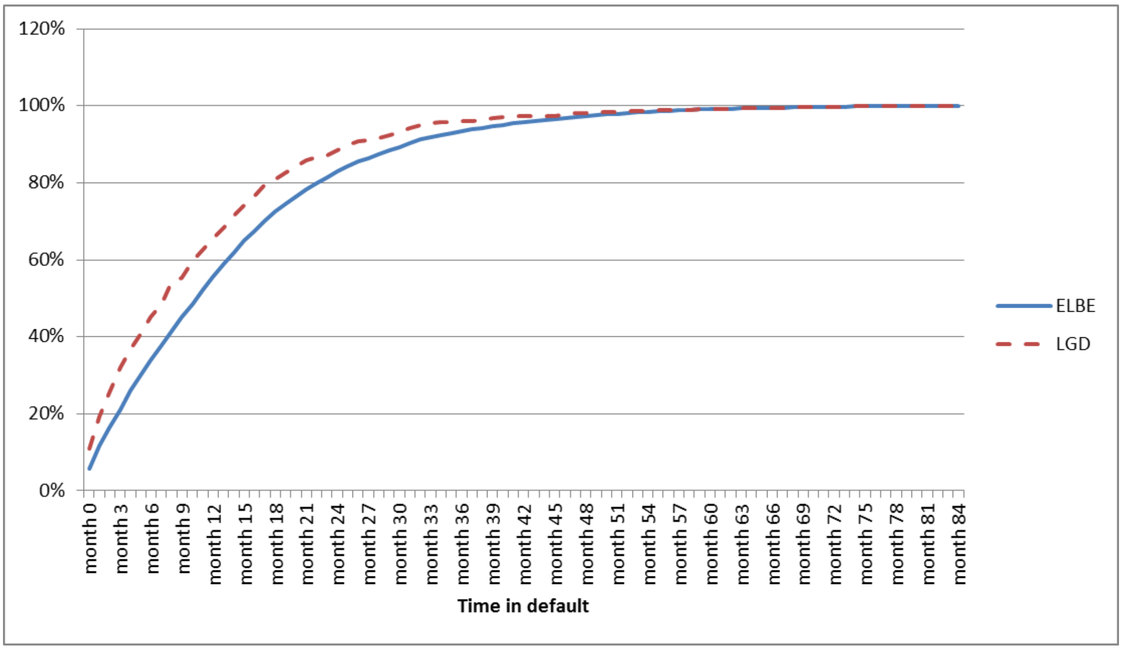
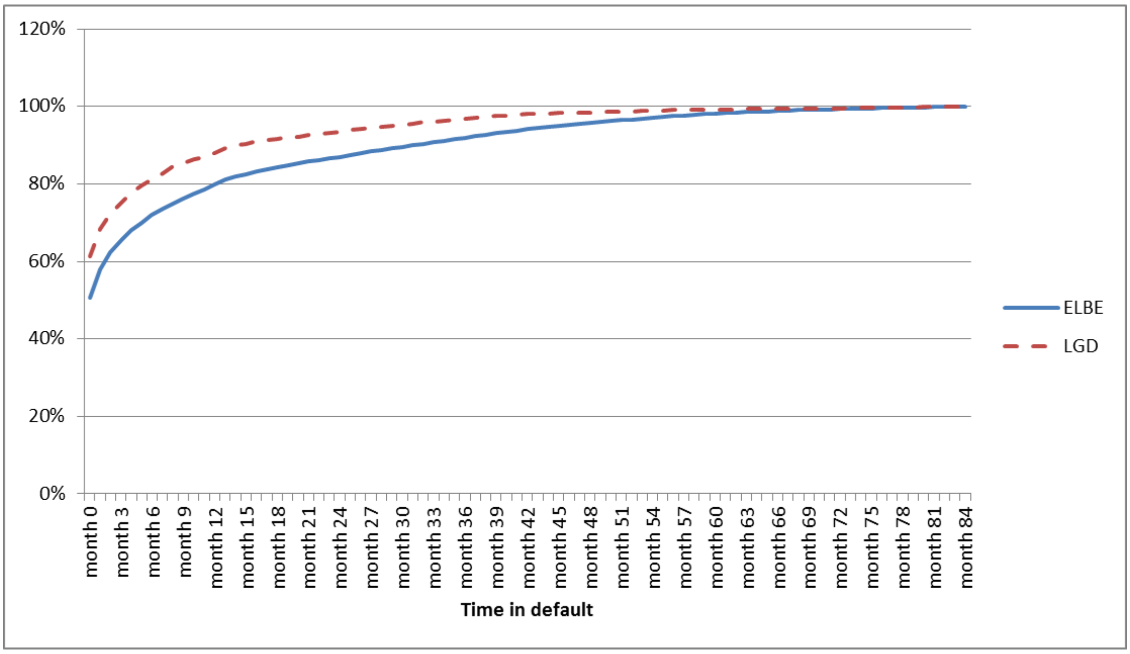


Fig. 7. Final ELBE and LGD in-default based on the Spanish entity



3.4. Discussion

In recent years, a significant period of recession has occurred in most European economies. By focusing on France and Spain, we considered two of the most significant[10] macroeconomic indicators, unemployment and growth of annual GDP, as represented in Fig. B.1 and Fig. B.2 of the Appendix, where the trends recorded in these countries can be clearly seen. Unemployment grew in these economies in the considered period, with this growth being much higher in Spain compared to France. With regard to GDP evolution, the behaviour was also similar, albeit more evident in the highs and lows in Spain up to 2014, when this indicator widely exceeded the one registered in France for the very first time after 2008. It is important to emphasise that both indicators were generally performing positively until 2008, when they showed a significant worsening of the situation, which has steadily improved from 2013 onwards. They thus evolved consistently with what has been observed for the analysed institutions as explained below.

First, we can see in the chart of the ELBE for the French institution by default year (Fig. 1) that the curve converges faster towards 100% for 2007 and, primarily, 2008. This means that

[10] According to World Bank data (data.worldbank.org).

clients that entered into a default situation during these years returned the remaining debt in a notably deficient manner. The unexpected loss that is expressed by the difference between the ELBE and the LGD in-default (Fig. 6) is not very significant, since the worst-case scenario of the economic cycle observed is not much more adverse than the most-probable one. A total loss near 40% of the exposure value is estimated in month 5, where 10% represents the unexpected loss.

In the case of the Spanish institution, very significant changes were observed in the ELBE curves per year of default (Fig. 2). For the most recent years, from 2008 to 2012, the deterioration of the recovery capacity can be clearly seen. The extreme case is represented by defaults in 2012 that, after 7 months of recorded evolution, have already achieved 100% loss. With regard to the estimated unexpected loss, on this occasion it was seen that, although the estimated ELBE curve is already quite high, a significant supplement of unexpected losses is estimated (Fig. 7) so that from month 5 of default, a total loss of over 80% of the exposure value has already been estimated, where the unexpected loss represents 10%.

4. Conclusions

The considerable increase in the volume of non-performing assets of the financial institutions affected by the recent crisis has shown the need for an appropriate measurement of the associated risk. This appears to not be properly covered by current regulations; there is a significant lack of methodological precision in the Advanced models required for defaulted exposures. This situation may cause great variability in terms of RWA between institutions with Advanced models already implemented. The need to propose methodologies for ELBE and LGD in-default estimates adapted to the regulatory guidelines that enable model comparability and can be easily adopted by most institutions is evident.

With this purpose, a methodological proposal is presented that responds to the problems put forward, in line with current regulations and EBA recommendations and through an approach that is suitable for the databases commonly used by these institutions as indicated in the following:

- A preliminary treatment of multiple defaults is performed in the database so that, if several default events are recognised in a single facility and the time between returning to non-defaulted status and defaulting again for each two subsequent events is less than one year, all the information is considered to belong to a single default event, i.e. to a single recovery process.
- The ELBE estimation is given on the basis of current economic circumstances, including the main risk drivers, namely, the time in default and the recoveries realised so far. The latter is implicitly introduced via estimating on several reference dates.
- An add-on is computed, based on the aforementioned risk drivers, to account for the unexpected losses that might occur during the recovery period. In particular, the proposed estimation is sufficiently conservative to consider possible adverse changes in the economic conditions. The proposal at least allows including downturn conditions observed in the business cycle.
- To achieve said conservatism an indicator that we call MAI is proposed, which is an adjusted version of the well-known RMSE, and it is evidenced that it leads to higher level of conservatism than the RMSE itself. The MAI allows to select a significant high level among the percentiles of a variable reported per each reference date which is correlated with the losses of recovery processes at each reference date and is calculated on the basis of recent historical data as well as data collected in periods of economic downturn.
- The LGD in-default is thus calculated as the sum, per each reference date, of the ELBE plus the supplementary add-on.

The methodology leads to an estimation of parameters for defaulted exposures that preserves the crucial risk sensitivity of capital requirements and it undoubtedly addresses the regulatory requirements and recent recommendations issued by EBA. This scrupulous compliance of the proposed defaulted exposures models has not been observed in any investigation reported in the literature so far. Besides, the empirical estimate of the parameters based on the database of two institutions shows that the proposed methodology performs adequately within the macroeconomic context of certain jurisdictions of diverse nature, namely France and Spain, and enables the viability of the proposal for its successful implementation.

Appendix A: Heteroscedasticity analysis

To construct the Fig. A.1 and Fig. A.2 charts that appear below, the mean ELBE was obtained by default date, and each of the calculated means was represented. They correspond to the French institution and to the Spanish institution, respectively.

Fig. A.1. Heteroskedasticity analysis of the French entity

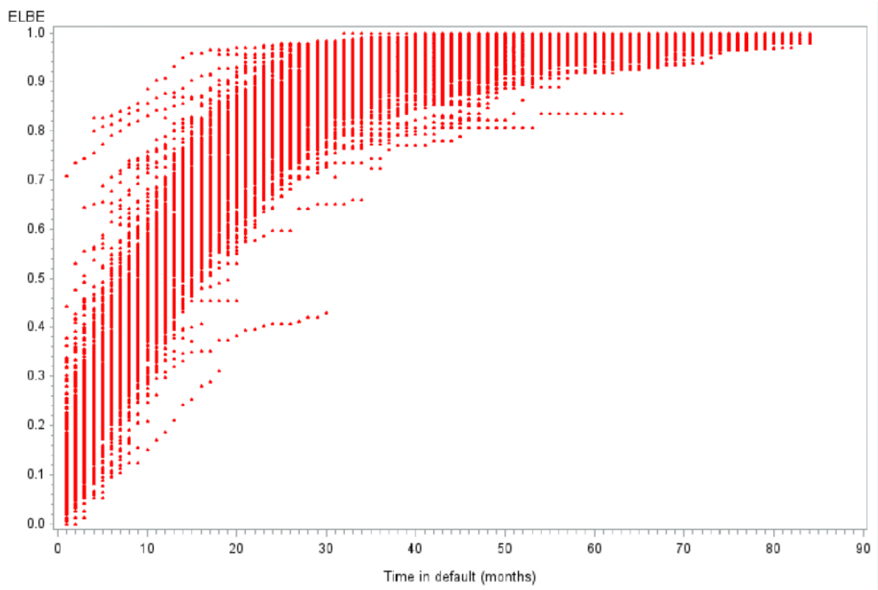
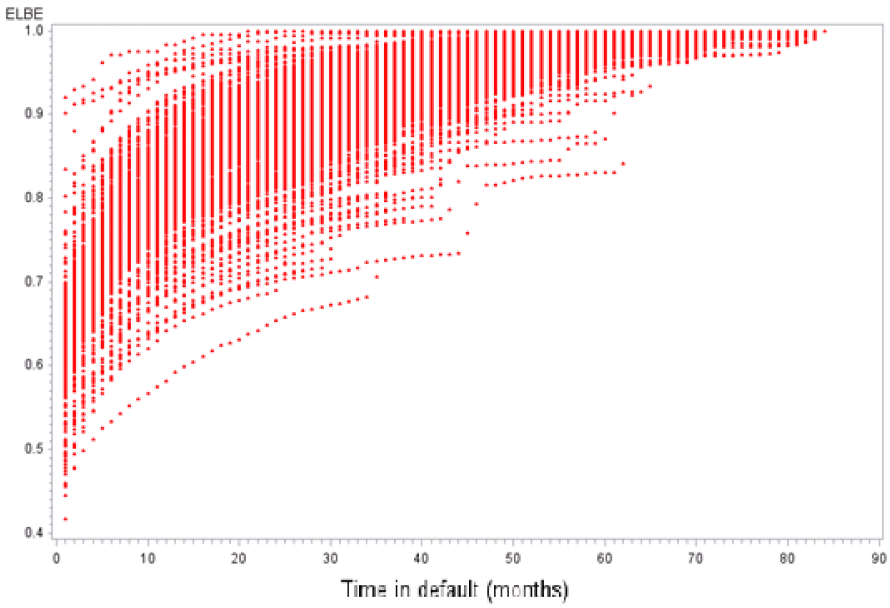


Fig. A.2. Heteroskedasticity analysis of the Spanish entity



While it is seen more clearly for the Spanish institution (Fig. A.2), in both charts we can see that volatility falls as the time elapsed since the default increases, enabling the heteroscedastic nature of the ELBE distribution to be confirmed. In this case, the theory that an ELBE estimate method based on a regression would have been inappropriate is upheld.

Appendix B. Macroeconomic data

Fig. B.1. Unemployment (percentage of labour force)

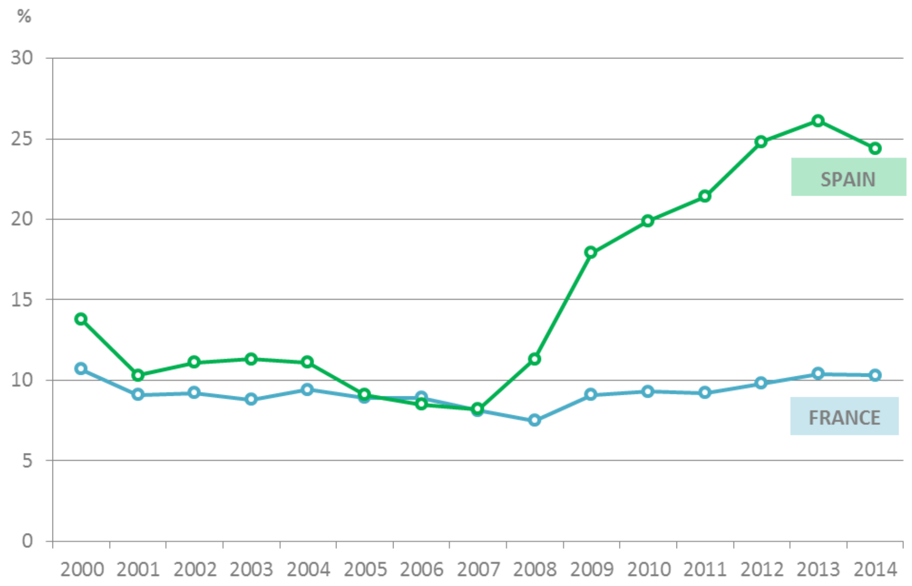
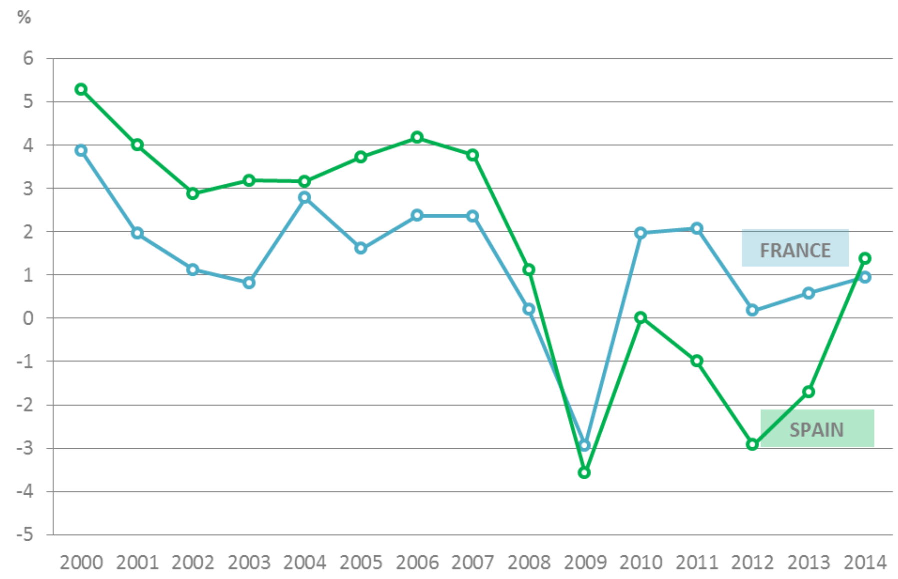


Fig. B.2. GDP growth (annual percentage)



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