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The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Banco de España, the European Central Bank, the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System. Gabriel Jiménez is a senior economist at the Banco de España; Jesús Saurina is the head of the Financial Stability Department at the Banco de España; and Jose A. Lopez is a research advisor at the Federal Reserve Bank of San Francisco.

EAD Calibration for Corporate Credit Lines

Managing the credit risk inherent to a corporate credit line is similar to that of a term loan, but with one key difference. For both instruments, the bank should know the borrower's probability of default (PD) and the facility's loss given default (LGD). However, since a credit line allows the borrowers to draw down the committed funds according to their own needs, the bank must also have a measure of the line's exposure at default (EAD). In fact, EAD is one of the key parameters used for regulatory capital calculations within the Basel II Framework. Yet, relatively few empirical studies of EAD for corporate credit lines have been published, mainly due to a lack of data. A primary goal of this article is to provide calibrated values for use in EAD calculations for corporate credit lines.

Our study is based on the Spanish credit register, which provides a census of all corporate lending within Spain over the last twenty years. The length and breadth of this dataset allows us to provide the most comprehensive overview of corporate credit line use and EAD calculations to date. Our analysis shows that defaulting firms have significantly higher credit line usage rates and EAD values up to five years prior to their actual default. Furthermore, we find that there are important variations in EAD values due to credit line size, collateralization, and maturity. While our results are derived from data for a single country, they should provide useful benchmarks for further academic, business and policy research into this under-developed area of credit risk management.

Definitions and literature review

Bank credit lines are a major source of funding and liquidity for firms. For example, Sufi (2008) found that credit lines account for over 80% of the bank financing provided to U.S. public firms, while Kashyap et al. (2002) found that 70% of bank borrowing by U.S. small firms is through credit lines. For Spanish firms, the subject of our study, credit lines account for an average of 42% of firms' bank financing and 32% of banks' total new lending.

To set our terminology clearly, we define a corporate credit line as a loan commitment in which the borrower has the option to draw down funds up to the commitment amount under certain conditions. For risk management purposes, a bank's EAD through credit line *i* at time *t* for a default horizon τ, which we denote as $EAD_{it}(\tau)$, is the sum of the actual drawn amount at time *t* and a fraction of the undrawn amount, where that fraction takes into account the default horizon. This fraction is commonly known as the loan equivalent amount (LEQ) and is the key parameter in EAD estimation and calibration.[1] Using notation,

$$\mathrm{EAD}_{\mathrm{it}}(\tau) = \mathrm{DRAWN}_{\mathrm{it}} + \mathrm{LEQ}_{\mathrm{it}}(\tau) * \mathrm{UNDRAWN}_{\mathrm{it}},$$

where $\mathrm{DRAWN}_{\mathrm{it}}$ and $\mathrm{UNDRAWN}_{\mathrm{it}}$ represent the monetary value of the drawn and undrawn portions of a credit line at time *t*. The sum of these two values is clearly the total commitment amount. For credit lines with a non-zero undrawn amount, LEQ for a default that occurs τ periods in the future is expressed algebraically as

$$\mathrm{LEQ}_{\mathrm{it}}(\tau) = \frac{\mathrm{DRAWN}_{\mathrm{it}+\tau} - \mathrm{DRAWN}_{\mathrm{it}}}{\mathrm{UNDRAWN}_{\mathrm{it}}}.$$

Since $\mathrm{DRAWN}_{\mathrm{it}+\tau}$ is not observable at time *t*, it must be replaced with a forecast for operational purposes. Hence, the challenge in generating EAD values is to find reasonable LEQ estimates.

Three empirical studies providing calibrated LEQ estimates are publicly available. Asarnow and Marker (1995) present LEQ estimates based on credit lines issued by Citibank to publicly-rated North American firms over the five-year period from 1987 to 1992. They report an average LEQ value of just over 60% with a roughly downward sloping trend from 69% for AAA-rated firms to 44% for CCC-rated firms. The intuition behind this trend is that in case of default, lower-rated firms typically have already drawn down a reasonable portion of their credit lines and are less likely to drawn down as much of their remaining commitment as highly-rated firms.

The LEQ estimates provided by Araten and Jacobs (2001) are based on 408 credit facilities to 399 defaulted U.S. borrowers issued by the former Chase Manhattan Bank over the six-year period from 1994 to 2000. Their reported average LEQ is about 43%. They examined LEQ values at several default horizons and found $\mathrm{LEQ}_{\mathrm{it}}(\tau)$ to be an increasing function of τ, ranging from 33% at one year prior to default to 72% at five years prior. The intuition here is that as default approaches (i.e., as τ decreases), borrowers that eventually default are more likely to have drawn down more of their credit lines earlier. They also found that LEQs declined with risk ratings, but that a variety of other variables, such as

[1] See Moral (2006) for further technical discussion. Note that we ignore any net accrued, but as yet unpaid, interest and fees in this study.

commitment size and borrower industry, did not impact their estimated LEQ values.

The study by Jacobs (2008) is the most comprehensive of the three, encompassing 3,281 defaulted instruments from 720 U.S. borrowers with public credit ratings over the period from 1985 through 2006. In addition to providing univariate analysis of the relationship between LEQ values and other variables related to the firm's balance sheet and the credit line's characteristics, the author estimates a multivariate model based on generalized linear regression. The average LEQ measure for the complete sample is 39%. Across default horizons, he found that $LEQ_{it}(\tau)$ was a generally increasing function of τ, ranging from 33% at one year prior to default to 48% at four years prior. However, the LEQ value declined to 26% at five years prior to default, perhaps in part due to the few datapoints available in the sample. Credit ratings also had a negative relationship with average LEQ values in this study, ranging from 76% for BBB-rated firms to 22% for D-rated firms. While commitment size and collateral rank had positive, but relatively small, effects on LEQ values, other firm characteristics, such as profit, did have a statistically significant effect.

Our data and calibration methods

Our LEQ estimates are based on the Spanish credit register, which is known as the *Central de Información de Riesgos (CIR),* and is maintained by the Banco de España. The CIR contains information on all corporate loan commitments of more than €6,000 granted by any bank operating in Spain over the twenty-year period from 1984 to 2005; see Jiménez et al. (2008) for a more detailed description of the database and its coverage of corporate credit lines. The definition of default used in the CIR database is that the borrower has loan payments overdue by more than 90 days, which is the legal definition of default in Spain, or that it has been classified as a doubtful borrower by the bank (i.e., the lender believes there is a high probability of non-payment). As shown in Table 1, the number of defaults rose sharply during the recessionary period of 1993 and declined at a relatively slow pace until 2005.

Our database consists of new corporate credit. Despite the fact that most credit lines nominally have a maturity of one year or less, it is common to find them in the database again the following year with exactly the same characteristics (in particular, their commitment size) and changing only in the amount drawn. For our analysis, we assume it is the same credit line, and we classify the observations as having both short maturities and line ages greater than their recorded maturities. After filtering the data, our sample includes 696,445 credit lines granted to 334,442 firms by 404 banks. The commitment size has an interquartile range of between €30,000 and €150,000 with a median value of €60,000. Our sample clearly contains more small business loans than examined in the previously noted studies. Of these lines, 4,289 of them were granted to 4,094 firms that defaulted; these lines have an interquartile range of between €30,000 and €96,000 with a median value of €48,000. Figure 1 presents the histogram of our credit line usage rates across firms and time, where the usage rate $RDRAWN_{it}$ is calculated as

$$RDRAWN_{it} = \frac{DRAWN_{it}}{DRAWN_{it} + UNDRAWN_{it}}.$$

While just over 23% of the credit line-year observations amass at the endpoints, the remaining 77% are distributed almost symmetrically around the median value of 50%.

When analyzing credit line usage rates, we find that firms that default on their credit lines draw down more funds than firms that do not default, even up to five years before the default year; see Jiménez et al. (2008) for complete details of this analysis. At five years prior, the average usage rate for defaulting firms is about 25% higher than that of non-defaulting firms. As default approaches, these firms draw down their credit lines at an increasing rate. At the default year, the average usage ratio for defaulting firms is 75% larger than that for non-defaulting. The empirical insight that defaulting firms exhibit higher usage rates up to five years prior to defaulting suggests a potentially important link between PD and EAD modeling.

LEQ calibration results

As mentioned previously, generating reasonable EAD values for credit risk management purposes requires accurate LEQ estimates.[2] Using the defaulted credit lines in our dataset, we generate average LEQ estimates for several default horizons and other relevant categories. Note that the LEQ values for certain credit lines may fall outside the unit interval (i.e., be negative or greater than 100%) due to data issues, and in these cases, we round these values to the appropriate unit interval endpoint.[3]

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[2]Note that another methodology frequently employed by practitioners is to generate LEQ estimates as the coefficient of a linear regression without a constant term of $\left(RDRAWN_{it+\tau} - RDRAWN_{it}\right)$ on $\frac{UNDRAWN_{it}}{COMMIT_{it}}$; see Moral (2006) for further details. The patterns of the LEQ values derived from this procedure as applied to our dataset are similar to those presented here, although their level is roughly ten percentage points higher.

The average LEQ value for the entire dataset is 59.6%, which is in line with the value reported by Asarnow and Marker (1995) and higher than that reported by Araten and Jacobs (2001) as well as Jacobs (2008). Looking at our $LEQ_{it}(\tau)$ estimates for $\tau \in [1,5]$ as presented in Figure 2, we find an upward sloping pattern, as in Araten and Jacobs (2001) as well as Jacobs (2008). However, the magnitudes of our estimates are higher and range from 48% at one year prior to default to 76% at five years prior to default. In other words, in our dataset, firms that will default on their credit lines in five years time can be expected to draw down, on average, about three-quarters of their undrawn commitments, and this value declines to 50% in the year prior to default.

We also find that the commitment size, collateralization and maturity of the credit lines has an effect on the calibrated $LEQ_{it}(\tau)$ patterns. As shown in Figure 3 and Table 2, the largest credit lines (i.e., the fourth size quartile) have the lowest LEQ values at all default horizons, perhaps since the larger firms that can get larger credit lines from their banks have access to other funding sources and are less likely to use their credit lines, even as default approaches.

Regarding collateral, higher-quality borrowers should be willing to provide collateral as a signal of their confidence in their repayment ability, as discussed by Jiménez et al. (2006). This assumption would suggest lower LEQ values as these borrowers would be less likely to draw down their lines, even if they eventually default, in order to protect their collateral from being seized. Figure 4 and Table 3 present empirical results that support this hypothesis. While the average $LEQ_{it}(\tau)$ values at the longer default horizons are essentially the same, they are significantly different at the 1% significance level for the default horizons from one to three years. The difference is particularly stark at one year prior to default where uncollateralized lines see over half of their available commitments drawn down, whereas collateralized lines only experience a 30% drawn rate, on average.

Figure 5 and Table 4 present the LEQ estimates for credit lines with maturities greater than and less than (or equal to) one year. Again, the average $LEQ_{it}(\tau)$ values at the longer default horizons are indistinguishable, but they are significantly different for the shorter horizons. The LEQ estimates for the longer-term credit lines are lower, suggesting that higher-quality firms that are able to get such longer commitments from their lenders are less

[3] See Jacobs (2008) for further discussion of alternative LEQ methods.

likely to draw down these funds, even in light of a pending default. In contrast, lower-quality firms that can only access shorter-term funding are much more dependent on these funds and thus more likely to draw down these credit lines.

Conclusion

Corporate credit lines are a key product for banks, and the management of their inherent credit risks requires calibration of their EAD parameters. Using the credit register maintained by Banco de España, we construct an extensive database of defaulted corporate credit lines over a twenty-year period to calibrate the key LEQ component of these EAD values at various default horizons. Our results show that a variety of factors – such as commitment size, collateralization and maturity – influence the LEQ calibrations. Our conclusion is that banks must address these factors in their EAD calibration processes, even if regulatory capital guidelines do not explicitly require it. Our results should provide reasonable starting values for most of these calibrations, but future work across different countries and time periods is necessary.

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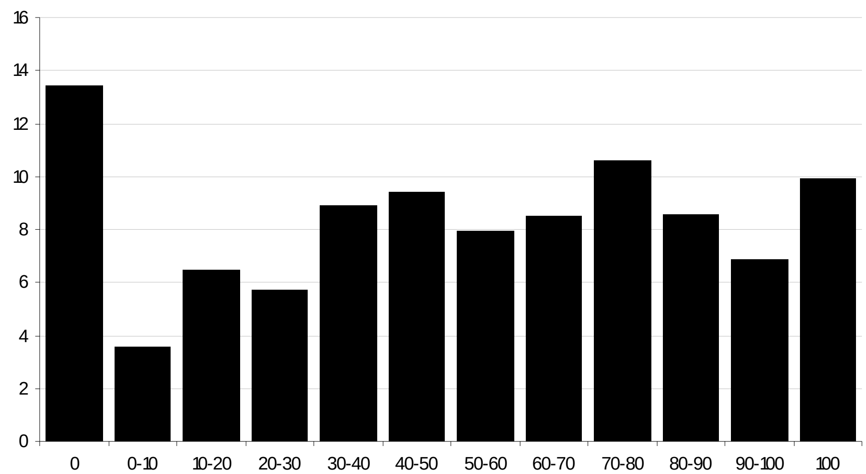
Table 1.
Number of defaulted credit lines in our sample

Year	# of defaulted credit lines
1986	45
1987	58
1988	97
1989	110
1990	167
1991	210
1992	350
1993	485
1994	434
1995	377
1996	356
1997	267
1998	262
1999	204
2000	224
2001	125
2002	124
2003	121
2004	110
2005	173

Figure 1.
Histogram of the corporate credit line usage rates



$RDRAWN_{it}$ (%)

Figure 2.
Average $LEQ_{it}(\tau)$ for defaulted credit lines

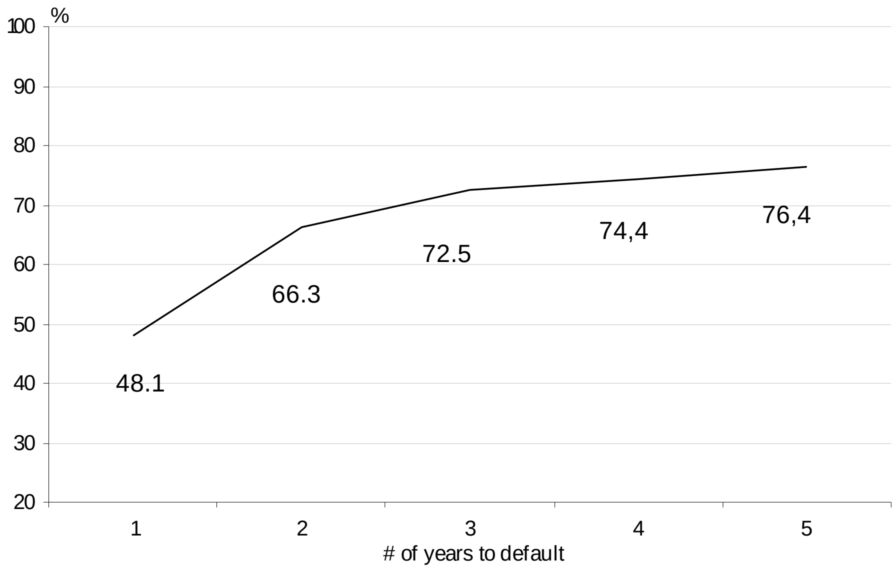
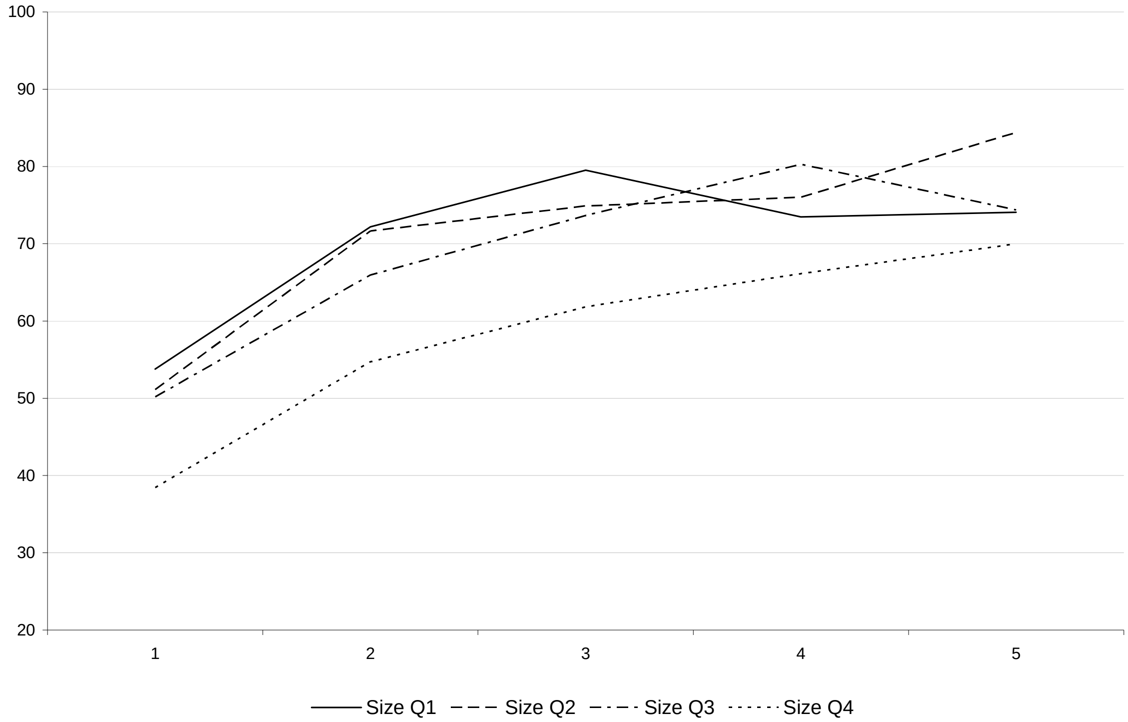


Figure 3.
Average $LEQ_{it}(\tau)$ (%) for defaulted credit lines depending on total commitment size



Note: Q_i denotes the i^{th} quartile of the total commitment size of the credit line. The endpoints of the four quartiles are [€6,000, €36,000] for Q1, [€37,000, €65,000] for Q2, [€66,000, €139,000] for Q3, and [€140,000, €69,513,000] for Q4.

Table 2.
Average $LEQ_{it}(\tau)$ (%) for defaulted credit lines depending on total commitment size

.

# years to default	Size Q1	Size Q2	Size Q3	Size Q4
1	53.8	51.1	50.2	38.4
2	72.2	71.7	65.9	54.7
3	79.5	74.9	73.7	61.8
4	73.5	76.0	80.3	66.1
5	74.1	84.4	74.4	70.0

Note: Qi denotes the i^{th} quartile of the total commitment size of the credit line. The endpoints of the four quartiles are [€6,000, €36,000] for Q1, [€37,000, €65,000] for Q2, [€66,000, €139,000] for Q3, and [€140,000, €69,513,000] for Q4.

Figure 4.
Average $LEQ_{it}(\tau)$ for defaulted credit lines depending on pledged collateral

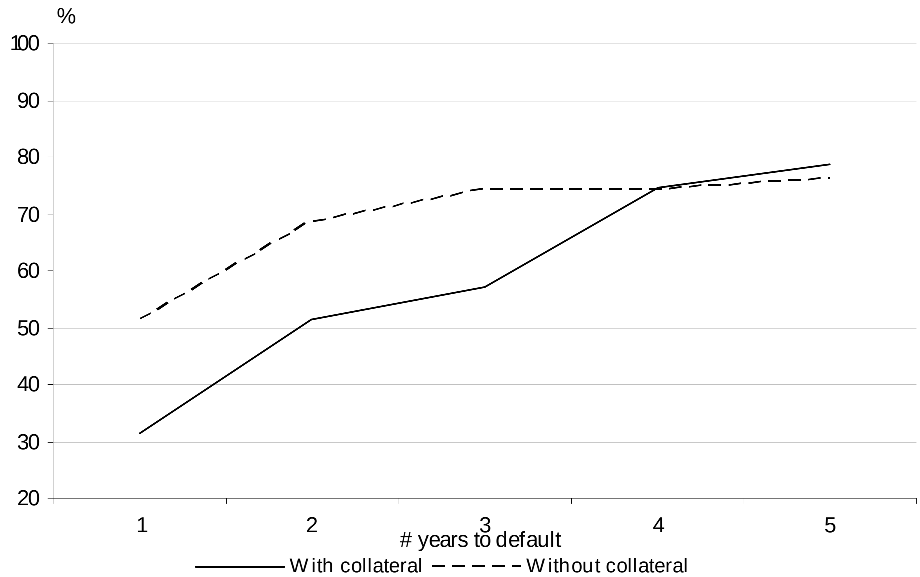


Table 3.
Average $LEQ_{it}(\tau)$ (%) for defaulted credit lines depending on pledged collateral

# years to default	Without collateral	With collateral	Mean test		
1	51.5	31.4	9.14	0.00	***
2	68.6	51.5	5.13	0.00	***
3	74.4	57.1	3.36	0.00	***
4	74.4	74.5	0.00	1.00	
5	76.3	78.9	-0.17	0.87	

Figure 5.
Average $LEQ_{it}(\tau)$ for defaulted credit lines depending on maturity

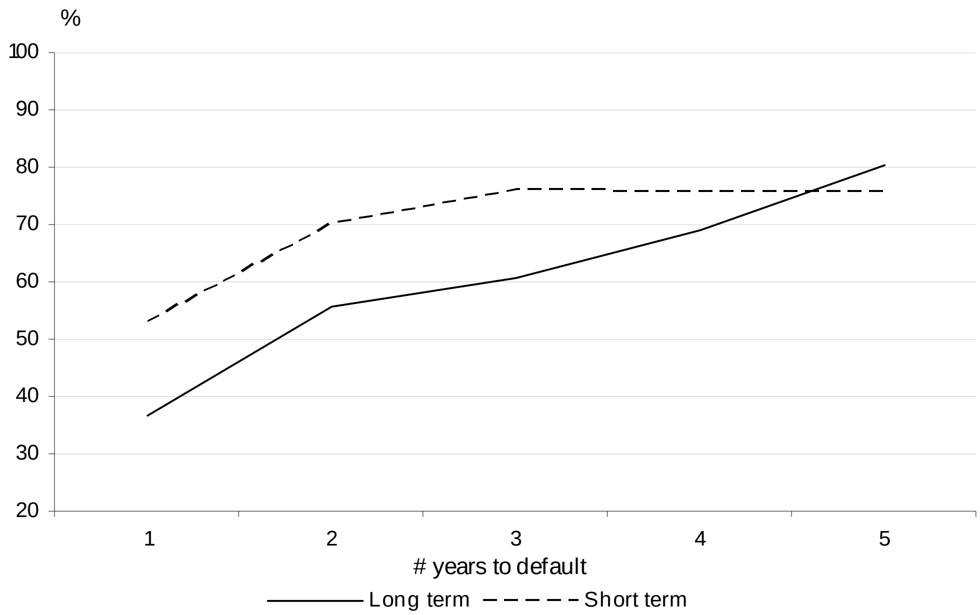


Table 4.
Average $LEQ_{it}(\tau)$ (%) for defaulted credit lines depending on maturity

# years to default	≤ 1 year	> 1 year	Mean test	
1	53.1	36.7	8.74	0.00 ***
2	69.9	55.6	5.42	0.00 ***
3	75.9	60.6	4.05	0.00 ***
4	75.7	68.9	1.25	0.21
5	75.8	80.4	-0.65	0.52