On measures for illustrating credit risk assessments: the case of heat maps, risk matrices and cubes

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"Everything should be made as simple as possible, but not simpler."

Albert Einstein

1. Introduction

Credit risk is the most important of banks' financial risks. As far as the largest Swedish banking groups are concerned, 60 per cent of their assets consist in lending to the public. Consequently, measures for mitigating credit risk are of significant importance for banks in their risk management. During the financial crisis, credit risk in the financial system has become of focal importance for central banks to assess and manage. A precondition for central banks being able to promote a safe and efficient payment system[2] is that they have executed the necessary assessment of credit risk in the system. The assessment, in turn, requires access to relevant data. Further, as a result of banks' credit portfolios becoming increasingly diversified in terms of both asset types and geography the ability to assess, illustrate, and communicate credit risk has become more complex and challenging[3].

The purpose of this paper is to describe different novel ways of illustrating the Riksbank's assessment of the credit risk in the Swedish banking system and contribute to assessing systemic risk originating from different categories of borrowers and regions and thus different institutional settings. The different ways of illustrating this risk can be described as "models" in the shape of a risk matrix as well as a risk cube, or alternatively labelled, heat map. It is worth mentioning that the purpose of the paper is not to elaborate on the reasoning behind the assessment but rather to explain a manner in which to simplify an illustration of the assessment and an approach for helping keep track of the development of the different variables that are determining credit losses.

2. Model

2.1 Credit risk matrix (2x2)

The point of departure for the illustration is the expected loan losses (EL) for borrower category $_i$ and region $_j$, calculated as a product of the banks' exposures (E), the probability of default (PD), and the expected level of loss given default (LGD); see equation (1).

$$EL_{ij} = E_{ij} \times PD_{ij} \times LGD_{ij} \quad (1)$$

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[2] Example of the case of the Riksbank; as spelled out in The Sveriges Riksbank Act, Chapter 1, Art. 2.

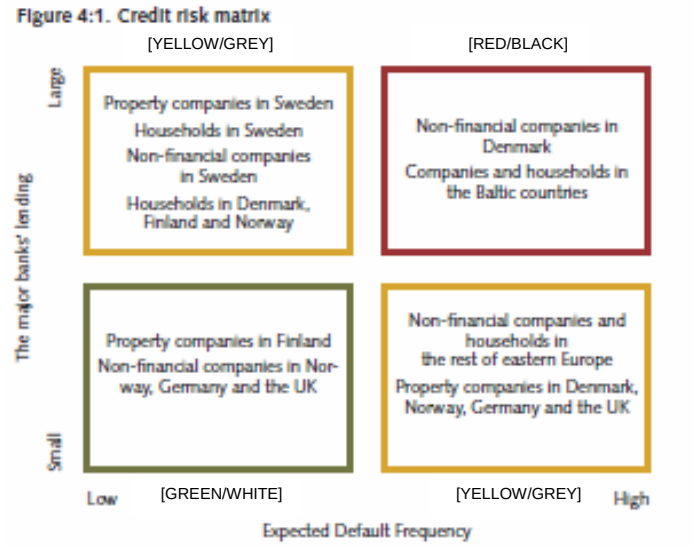
[3] E.g. as much as 50 per cent of the Swedish bank groups' lending goes to borrowers abroad.

Ex-ante borrower default, the variables of largest interest need to be 1) the probability that the borrower will default, 2) how much of interest this default is for the bank in question, i.e. the potential impact of the default, and finally 3) at default, the size of the losses, i.e. conditional on the probability of default, the impact of the default will amount to the product of the loan volume and the loss ratio at default.

Figure 1 illustrates the two-dimensional type of credit risk matrix that was applied in the Riksbank's Financial Stability Report (2010). The purpose of the figure is to illustrate an overview of the credit risk assessment of the Riksbank. The two dimensions applied are the major banks' lending to the different categories of borrowers on the y-axis and the borrowers' expected default frequency (EDF/PD) on the x-axis.

Figure 1

Credit risk matrix; two-dimensional, two levels (2x2)



Source: Sveriges Riksbank, 2010, "Financial Stability Report 2010:1" (figure 4:1)

The size of the different variables serves as an indication of why a certain category of borrower in a certain region is of interest from a financial stability perspective. For example, it explains why the Riksbank analyses the credit quality and debt servicing ability of the Swedish property sector because this sector represents a proportionally large part of the banking system's total lending, even though, due to its rather limited probability of default, it may not be as alarming from a financial stability perspective. The Swedish property sector does hereby represent a potential threat to the financial stability of the Swedish financial system due to "the size of its E", and is therefore categorised as "yellow" and therefore high on the y-axis. Similarly, this is why the Riksbank has previously analysed borrowers in Ukraine; the Swedish banks' lending to Ukrainian borrowers has not been that large, but the exposure has been subject to a high probability of default, i.e. far to the right on the x-axis.

Likewise, when particular asset markets come under pressure, such as the property market, it is usually of interest to track the impact of this development on the LGD-parameter in the loss equation. Another aspect of the matrix is development over time; depending on which of the variables is changing or needs to be acted upon, the different borrower categories in each region may migrate between boxes of varying importance.

The quality of a two-dimensional approach is its simplicity in providing an overview of the credit risk in a banking system. At closer scrutiny, however, one may start to wonder about the more quantitative requisites behind the "small" and "large" exposures as well as the "low"

and “high” PD, and consequently which “colour of attention” the portfolio in question should have. Thus, *the two-dimensional matrix may be “simpler than possible”, too simple*.

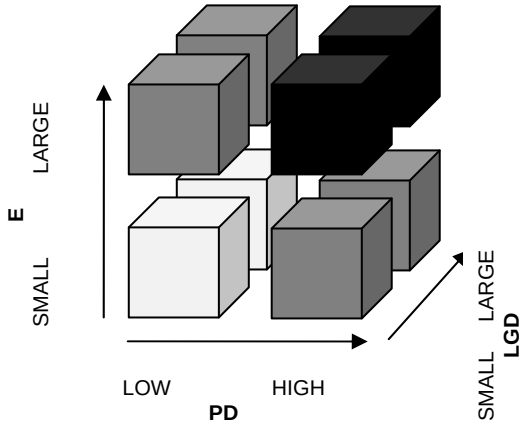
To conclude, attempts have been made to develop the risk matrix by adding more dimensions and levels. An explanation of these will be given in the following.

2.2 Credit risk cube (2x2x2)

In the credit risk matrix, no specific attention is being paid to the LGD in equation (1), i.e. the third parameter in the credit loss equation. In order to illustrate also the impact of the LGD in the credit risk assessment, a third dimension may be added to the figure and heat map. This may be illustrated as in ***figure 2***, a three-dimensional, two-level “credit risk cube”.

Figure 2

Credit risk cube; three-dimensional, two levels (2x2x2)



In order to make the illustration more granular and the valuing of “severity” more quantitative and thereby transparent, the rest of the example will be given by a three-level cube. That is, three levels of size of exposures, probability of default, and loss given default; 3x3x3.

2.3 Credit risk cube (3x3x3)

Tables 1-3 describe the particular quantitative levels according to which the different credit loss variables are to be labelled “low”/”small”, “medium”, or “high”/”large”.

Table 4 illustrates a risk appetite or tolerance that means that specific borrowers should be subject to a “credit risk alert” (red) from a systemic bank risk perspective, that is, on the aggregate level, only if and when the probability of default is “medium” or “high” (that is, larger than or equal to 1 per cent; see table 1). Such requisites for a “credit risk alert” status depend on the level of risk aversion of the assessor, such as a central bank. Accordingly, it is subject to the extent to which low/small, high/large exposures, probabilities of default, and loss given default should be weighted against each other, i.e. if e.g. a high exposure per se is more alarming than a high probability of default or loss given default.

Figure 3 illustrates the sum of tables 1-4, the total “credit risk alert”, depending on the level and combination of each credit risk variable in equation (1). That is, out of the 27 different combinations (3x3x3 boxes) each specific exposure (in turn subject to the granularity of the credit risk assessment) belongs to a specific one.

Table 1

PD (EDF)

High:	>10 %
Medium:	1–10 %
Low:	<1 %

Table 2

E; size of lending volume (individual bank/four large banks, x4)

Large:	>100 billion SEK/>400 billion SEK
Medium:	10–100 billion SEK/40–400 billion SEK
Small:	<10 billion SEK/<40 billion SEK

Table 3

LGD

Large:	>10 %
Medium:	1–10 %
Small:	<1 %

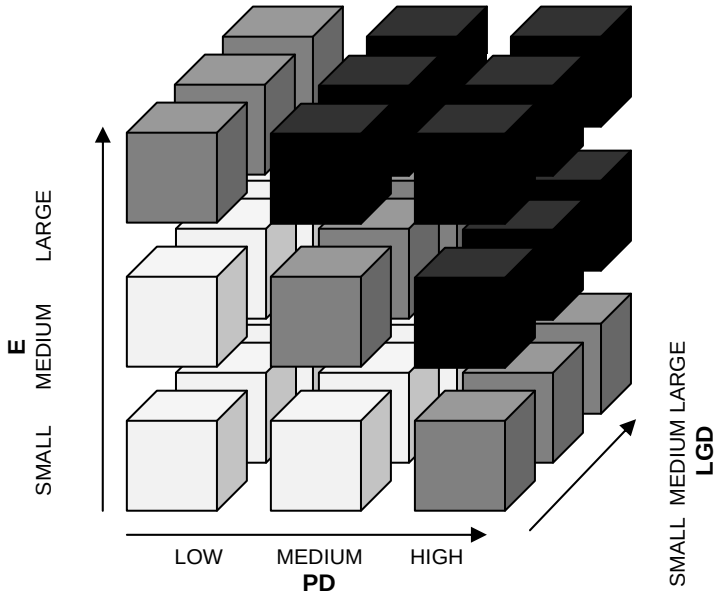
Table 4

“Credit risk alert”

Highly probable and severe loss
Medium probability and severe loss
Not probable, no severe loss

Figure 3

Credit risk cube; three-dimensional, three levels (3x3x3)



3. Example

Assumptions behind the “credit risk cube” in this example include LGD of the different categories of borrowers being identical irrespective of bank and region. That is, the LGD is sector-specific but not country- or bank-specific. Further, the EDF as a proxy for the actual PD of each borrower’s credit in each bank’s portfolio is primarily an indication of the credit quality of the different borrowers and is thereby not specified for the different banks’ borrowers and exposures in question. Additionally, no attention is being paid to the provisions already made by the banks for potential future losses in the different credit portfolios.

Table 5 describes the borrower categories and regions used in the example to which the banks are exposed. For simplification and for illustrative purposes, the example only takes into account the categories and regions on which the Riksbank has data available on EDF and LGD through Moody’s KMV CreditEdge. That is, not all of the categories of borrowers and regions described in figure 1 are included.

Table 6 and ***figure 4*** sum up the credit risk assessment according to the three different credit risk variables in equation (1) and the different “credit risk alert” requisites.

Table 5

Borrower categories *i* and regions *j*

Region $_j$	Category $_i$	Borrower abbreviation
Sweden	Non-financial corporations	SENF
	Property companies	SEPR
Norway	Non-financial corporations	NONF
	Property companies	NOPR
Denmark	Non-financial corporations	DKNF
	Property companies	DKPR
Finland	Non-financial corporations	FINF
	Property companies	FIPR
Germany	Non-financial corporations	DENF
	Property companies	DEPR
UK	Non-financial corporations	UKNF
	Property companies	UKPR

Table 6

"Credit risk alert"

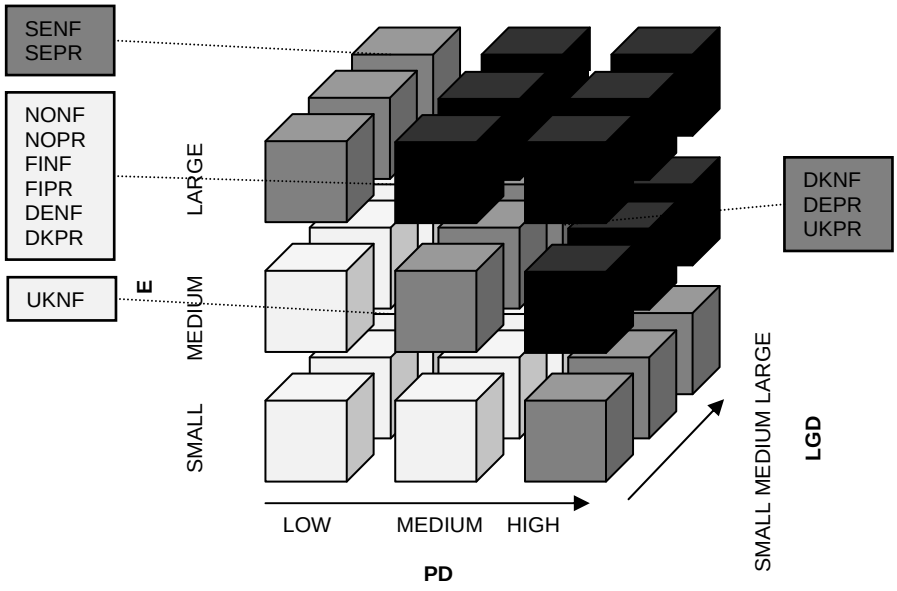
Aggregate, four major banks

Borrower	E (small, medium, large)	PD (low, medium, high)	LGD (small, medium, large)	"Credit risk alert"
SENF	Large	Low	Large	
SEPR	Large	Low	Large	
NONF	Medium	Low	Large	
NOPR	Medium	Low	Large	
DKNF	Medium	Medium	Large	
DKPR	Medium	Low	Large	
FINF	Medium	Low	Large	
FIPR	Medium	Low	Large	
DENF	Medium	Low	Large	
DEPR	Medium	Medium	Large	
UKNF	Small	Low	Large	
UKPR	Medium	Medium	Large	

Note. Subject to addition and in order to illustrate the loss absorption capacity of the banking system or individual banks, another column could be added with, e.g. Tier 1 capital ratio, or core-Tier 1 capital ratio for each exposure and borrower category. Note that in this particular example, the assessment of e.g. PD for each borrower category is simplified and not all aspects are taken into consideration, which explains why some borrower categories in the example may not be on as high a "credit risk alert" as depicted in figure 1.

Figure 4

Credit risk cube; three-dimensional, three levels (3x3x3)



4. Model elaborations; subject to development

- The example is based on illustrating an assessment of the four major Swedish bank groups together (see table 2 for separating size of lending volumes) and the sources of credit risk as threats to the stability of the whole financial system. An alternative or supplement to this approach would be to apply it for each of the banks individually. This is due to the fact that each of the major banks is seen as systemically important and every risk each of them is exposed to consequently is a potential risk to the financial system as a whole.
- The “low/small”, “medium”, “high/large” grading of the different variables could be subject to further scrutiny and should be modified to suit each banking system.
- A relevant point of departure in deciding on the relevance of each borrower category would be to calculate the Tier 1 ratio for each borrower for every bank. As a measure of the loss absorption capacity of the banks, this could serve as a supplement to separating the different exposures and borrowers according to size of exposure or size of lending. Additionally, each bank’s lending to the different categories of borrowers could be measured as a proportion of the bank’s total lending, as a means for deciding on the borrower’s relevance from a “credit risk alert” perspective.

5. Concluding remarks

As is usually the case when data need to be analysed and explained, the most suitable approach depends on the purpose of what is to be explained. Consequently, the level of sophistication when applying figures such as the ones described above when illustrating different assessments will vary. Sometimes, a simpler model or figure is to be preferred, and sometimes a more granular and transparent one is needed. From the central bank perspective, the 2x2 matrix may be sufficient for describing and motivating the analysis of bank credit portfolios and the debt servicing ability of borrowers. The 3x3x3 cube may on the other hand provide better understanding of the underlying analysis.

References

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