



# Credit Risk in Banking

TYPES OF INDEPENDENT VARIABLES

Sebastiano Vitali, 2017/2018

# Goal of variables

- ▶ To evaluate the credit risk at the time a client requests a trade burdened by credit risk.
- ▶ To perform monitoring of a client to achieve an estimation of potential threat to his ability to repay his liabilities to the bank.
- ▶ To estimate the recoveries of debts of clients who have problems with repaying their liabilities.

# Credit risk at the time of application

To evaluate the risk of clients we need to divide the portfolio in various groups, because different groups of clients bear different risks and different ways of their evaluation. Division of the clients can be done in various ways, one of the possible approaches is following structure:

- ▶ Foreign clients
- ▶ Domestic clients with legal form
- ▶ Domestic clients - private persons

# Domestic clients with legal form

Legal form is a characteristic of a subject, given by its way of entrepreneurship. Legal forms mostly define the economics and accounting of a client and therefore we need to assess them separately. We may consider the following as the basic division:

1. State administration, state bodies and institutions
2. Financial institutions, leasing companies, insurance companies, etc.
3. Business companies type: general partnership or limited partnership business entity (Kommanditgesellschaft)
4. Business entities type: joint-stock company (JSC, PLC, a.s.)
5. Business entities type: limited liability company (LLC, Ltd., s.r.o.)
6. Self-employed (tradesmen, small entrepreneurs, etc.)

# 1. State administration, state bodies and institutions

- ▶ Can be exclusively seen as entities with relatively lowest risk.
- ▶ The risk of these institutions can be considered as state risk.
- ▶ Risk rating of the country.
- ▶ Models within global macroeconomic models comparing economics of individual states and taking into consideration world trends.
- ▶ Distinguish between
  - ▶ state institutions
  - ▶ business entity owned by the state
- ▶ Necessary to consider legal context and state guarantees for the liabilities of the entity owned by the state.
- ▶ It is always more conservative to understand the entity as a business entity and let the state guarantees to be confirmed by another form of guarantee.

## 2. – 6.

- ▶ They bears higher credit risk.
- ▶ Models to measure credit risk, need to proceed individually for each type, because data about these entities is specific for different types of clients
- ▶ Let's focus on most common cases, for which are models constructed:
  - ▶ 4. namely joint-stock company (JSC)
    - ▶ balance sheet and profit and loss statement
  - ▶ 5. limited liability company (LLC)
    - ▶ balance sheet and profit and loss statement
  - ▶ 6. self-employed
    - ▶ tax declaration and demographic data
  - ▶ private persons
    - ▶ tax declaration and demographic data

# Account sheet as input for the models of credit risk

Entrepreneurs registered in business register (joint-stock company (JSC) and limited liability company (LLC)) are according to Czech law obligated to keep double-entry bookkeeping.

Output of double-entry bookkeeping are two basic reports:

- ▶ Balance sheet:
  - ▶ serves to capture economic characteristics of a company and to present economic condition of a company
- ▶ Profit and loss statement:
  - ▶ serves to understand the production of profit or loss
- ▶ Cash-flow, which explains financial flows in a company



# Balance sheet

- ▶ It serves to capture economic characteristics of a company, which describe the structure of its assets:
  - ▶ Tangible and intangible property,
  - ▶ Cash
  - ▶ Accounts in banks
  - ▶ Receivables of clients
- ▶ and the source of funding for these assets – liabilities:
  - ▶ entrepreneur's deposit (registered capital)
  - ▶ Profit
  - ▶ Loss
  - ▶ liabilities to other entities



# Balance sheet – Example

Entrepreneur starts a business TEST, Ltd. with 200k capital deposited on bank account.

We have 200k available cash and that this amount is the input capital of the company.

- ▶ On assets side, there is an item called Accounts in banks, which equals 200k.
- ▶ On liability side, there is an item called Registered capital, which equals 200k.

# Balance sheet – Example

Entrepreneur withdraws 100k from the bank to have cash. In this case he does not perform an operation affecting profit and loss statement, he just transfers 100k from the item Accounts in banks to item Cash.

- ▶ On assets side, Accounts in banks, decreases by 100k.
- ▶ On assets side, Cash, increases by 100k.

# Balance sheet – Example

Entrepreneur buys a computer for 100k cash and software for 80k on invoice

- ▶ On assets side, Cash, decreases by 100k.
- ▶ On assets side, Tangible assets, increases by 100k.
- ▶ On liabilities side, Current liabilities, increases by 80k.
- ▶ On assets side, Intangible assets, increases by 80k.

# Balance sheet – Example

Entrepreneur pays 80k of the invoice

- ▶ On assets side, Accounts in banks, decreases by 80k.
- ▶ On liabilities side, Current liabilities, decreases by 80k.

# Balance sheet – Example

Entrepreneur must carry out depreciation, which means lowering the value of assets for the reason of amortization of property. In this case entrepreneur realizes loss because the decreasing value of the property. Let it be 25k for the value of computer and 20k for the value of software.

- ▶ On liabilities side, Depreciation, increases by 45k.
- ▶ On P&L, Net Income, decreases by 45k (-45k).

# Balance sheet – Example

The Equity is the sum of Registered Capital, Net income for the previous years and Net income for the current accounting period:

- ▶ Equity is equal to  $200k - 45k = 155k$

# Balance sheet – Example

The entrepreneur start his business by writing a newspaper article on the computer and sends it to the publisher through email. Let us omit the internet provider fee for the moment, which would otherwise be a standard accounting entry, and let us look at the receivables for the article. The publisher has commissioned the article in advance for 10k. The entrepreneur sends the article and issues a 10k invoice. The day he issues the invoice, his accounting changes. Since he hasn't received the money yet (requested bank account transfer), he has a receivable from the publisher

- ▶ On assets side, Short Term Receivable, increases by 10k.
- ▶ On P&L, Sales Revenue, increases by 10k.



# Balance sheet – Example

This value changes the Net Income to -35k and influences liability entries corresponding to revenue, as well as equity.

At this moment the entrepreneur applies for a bank loan, because he wants to hire an employee so that he does not have to write the articles all by himself. The bank has just adopted a new small business support strategy and lends him two millions for covering operational needs for two. The loan is payable in one installment, interests payable monthly, interest rate is fixed at 10% p.a. The entrepreneur dutifully lists everything in the liabilities as Bank Credits. On the assets side, he sees an increase on his bank account, i.e. on the entry Bank Accounts, to 2020k. It is important to understand that entering a debt does not result in any operations within the Profit and Loss Statement, because it does not influence the net income.

# Balance sheet – Example

The entrepreneur hired an employee and monthly paid his wage, social security, and then interests to the bank. Let us first go through the wage and related social security expenses accounting. At the end of the month, the entrepreneur has to record an expense of 10k (employee wage) in the entry Wages Expense of the Profit and Loss Statement, and an expense of 3.5k (35% of wages expense) in the entry Social Security Expense. Both of these entries reduce the Net Income by a sum of 13.5k, meaning that on the liabilities end we will see an entry in the accounts for wage expenses, and thus decrease in Equity overall. Accordingly, we will not be compensating this change within the assets, but within the liabilities, where entries Employee Payable and Social Security Payable will be increased by the mentioned amounts. When these liabilities are balanced out, a corresponding decrease on the assets entry Bank Accounts ensues, usually during the following month.

# Balance sheet – Example

This example clearly demonstrates the basic principle of double entry accounting:

- ▶ each operation is recorded either
  - ▶ only in the assets (plus and minus),
  - ▶ or only in the liabilities (also plus and minus),
  - ▶ or in both the assets and the liabilities at the same time with the same signs.

# Balance sheet – Example

We have introduced some basic Balance Sheet and Profit and Loss Statement entries. Let us point out an important difference between revenue and income, costs and expenses.

- ▶ Revenue means anything that generates profit, i.e. what leads to a positive economic result in the Profit and Loss Statement.
- ▶ Income does not have to be a revenue. Income through a bank loan is not a revenue, however income through a realized service is, of course, a payment for a receivable generated during revenue recording.
- ▶ Not every cost lowers the profit, for example a cost generated by property purchase is not an expense, it is just an asset transfer.

# Financial indicators

We are going to present some items of the so-called short form financial statements.

Long form version exists, too.

Statements and accounting regulations change according to Ministry of Finance instructions.

Due to financial statements' figures being strongly influenced by the size of the company, it is much more appropriate to evaluate the mutual ratios of the individual entries to judge company's economics.

These ratios are called financial indicators.

We will go through the basic indicator groups and their significance for the company evaluation procedures.

# Financial indicators

- ▶ Liquidity Indicators
- ▶ Debt Indicators
- ▶ Activity Indicators
- ▶ Profitability Indicators
- ▶ Assets and Liabilities Structure Indicators



# Liquidity Indicators

Liquidity indicators specify company's ability to settle its ordinary short-term payables. Liquidity indicators include

- ▶ Current Liquidity

- ▶ this indicator is the ratio between Current Assets and Short-Term Payable, i.e. current assets divided by short-term payables. Values close to 1 are dangerous, because the company might not be able to settle its short-term payables. On the other hand, values significantly higher than 1 tell of inefficient resource allocation. It is recommended to stay within the 1.5-2.5 bounds.

- ▶ Quick Liquidity

- ▶ it is the same as Current Liquidity but for the deduction of entries that cannot be quickly converted into cash from the numerator. This concerns mainly companies with longer stock turnover periods (more on this later).

- ▶ Cash Liquidity

- ▶ it is the ratio of short-term cash divided by short-term payables. When analyzing liquidity, we also evaluate current assets and short-term payables by using a ratio of revenue divided by mean stock, for receivables we use a ratio of current receivables divided by mean daily revenue, etc



# Debt Indicators

Generally, debt indicators characterize the ratio between a certain part of payables and certain source of capital.

- ▶ Debt Ratio

- ▶ it is defined as outside sources and other liabilities divided by total assets. Young companies tend to have higher debt ratio because of investment loans.

- ▶ Debt-Equity Ratio

- ▶ again a comparison of outside sources, but this time with the company's equity.

- ▶ Self-Financing Ratio

- ▶ tells how well is the value of assets covered by the value produced by the company.

# Activity Indicators

Activity indicators measure company's ability to make use of invested capital. Measures capital's fixation to individual types of assets or liabilities.

## ▶ Asset Turnover Ratio

- ▶ it is defined as a ratio between total revenue (Sales + Financial Revenues + Extraordinary Revenues) and total assets. Here the entries from Profit and Loss Statement come into play, influenced by the length of the chosen time period. We will assume a period of one year. Long turnover period signifies bad asset allocation, 0.5 to one year are acceptable values. Turnover period is then reciprocal to turnover.

## ▶ Receivables Turnover Ratio

- ▶ represents the average receivable collection period. It is measured as a ratio of a certain type of receivables (towards clients) and operating revenues for the year.

## ▶ Accounts Payable Turnover Ratio

- ▶ represents the average payable payment period. It is measured as a ratio of a certain type of payables and operating expenses. Higher receivable turnover ratio than accounts payable turnover ratio indicates potential problems with liquidity. Mathematically it is a mixed indicator, plus probably correlated with liquidity.

## ▶ Inventory Turnover

- ▶ measured as a ratio between stock and sales. Different businesses can be characterized by different inventory turnovers. For example agricultural subjects' inventory turnover should not exceed a year.

# Profitability Indicators

These are indicators featuring characteristics tied to the economic result in the numerator and certain type of capital or sales in the denominator.

- ▶ The economic result is usually measured using a characteristic called EBIT (Earnings before Interest and Taxes), as a gross profit plus interest expenses. Its purpose is to show the company's production capability with zero credit and tax burden.
- ▶ Characteristic EAT (Earnings after Taxes) is EBIT minus tax, meaning net profit plus interest expenses.
- ▶ Characteristic EBITDA (Earnings before Interest, Taxes, Depreciations and Amortization Charges) is EBIT plus amortization charges.

# Profitability Indicators

- ▶ Return on Equity ratio (ROE)
  - ▶ is the net income divided by equity, in other words how much is the company able to make a year in relation to its own capital.
- ▶ Return on Registered Capital
  - ▶ concerns net income as above, but this time it is divided by the registered capital.
- ▶ Return on Assets (ROA)
  - ▶ is a ratio between EAT and total assets.
- ▶ Profit Margin
  - ▶ is a ratio of the net income and sales (commonly minus unrecoverable receivables).

# Assets and Liabilities Structure Indicators

- ▶ Fixed assets
  - ▶ Fixed Assets divided by Total Assets
- ▶ Current Assets
  - ▶ Current Assets + Receivables tied to the subscribed own capital + Other assets divided by Total Assets
- ▶ Financial Assets
  - ▶ Financial Assets divided by Total assets
- ▶ Current Liabilities
  - ▶ Accounts payable + Regular bank credits + Short-term financial assistances divided by Total Liabilities
- ▶ Long-Term Payables
  - ▶ Own capital Long-term payables + Long-Term Bank Credits + Reserves + Other Liabilities divided by Total Liabilities

# Financial indicators – Conclusions

- ▶ We presented a whole range of diverse indicators characterizing various economic relations within the company.
- ▶ The indicators can be combined into mixed indicators.
- ▶ The indicator values may differ across businesses and are characterized by them.
- ▶ There is no easy and straightforward way to determine whether a company is doing well or poorly, explaining financial statements' specifics requires substantial experience and specific knowledge of the company.
- ▶ Because banks need fast and effective decisions, mathematical models need to be constructed in order to ease and quicken the decision-making process, together with the ability to prevent potential losses.



# Financial indicators – Conclusions

Before we use the mentioned financial indicators, it would be useful to transform their values in some way, mainly because of situations where the denominator would contain a zero or a value close to zero. This leads to a significant skewing of the indicator values distribution and can ruin a logistic regression or any other statistical method.

Besides standard normalization transformations (logarithmic, square root, square, etc.) we often see a transformation based on order. If

$$X_i^u, i = 1, \dots, n$$

are values of a certain indicator  $u$  for all clients, we put them in order and define the ordering

$$R_i^u = |\{j \in \{1, \dots, n\}, X_j^u \leq X_i^u\}|$$

Then,  $R_i^u$  serves as an independent variable instead of  $X_i^u$ .

Moreover, we can define

$$Z_i^u = \left\lfloor L \frac{R_i^u}{n} \right\rfloor + 1$$

with  $L$  being a sufficiently large constant (ten or twenty). By employing this transformation, the estimates become more robust, but we achieve different interpretation of the logistic regression coefficients.



# Private persons

The only significant difference in the processes between private persons and business entities is in the fact that instead of financial statements we look at client's personal data to evaluate his creditworthiness. By personal data we mean especially:

- ▶ Age
- ▶ Gender
- ▶ Address
- ▶ Type of employment
- ▶ Job title
- ▶ Duration of current employment
- ▶ Size of the resident city
- ▶ Size of the household
- ▶ Income
- ▶ Household expenses

# Private persons

We need to realize that, unlike financial indicators, majority of these variables are discrete, but they are also not ordinal.

An ordinal variable is a variable whose values are in some way ordered.

- ▶ For example job title is usually codified in some way, but it does not necessarily have to be an ordered model.

This is why the logistic model is constructed in a way so that each value of a non-ordinal variable has its own special parameter, which means all the procedures examined in the logistic regression need to be slightly modified.

When we are testing for the significance of some variable, we need to test a vector of the parameters pertaining to the values of the examined variable.

- ▶ This is especially important with recursive or gradually widening regressions, where elimination or addition of variables is based on the zero-value testing of not only one variable, but of a whole vector of variables pertaining to the given variable.

# Private persons - Example

Suppose a trivial model where we are aiming to determine the significance of region for the client's inability to pay installments. For every region value we introduce an auxiliary variable (let us assume the old region division, i.e. 8 regions: Prague, Central Bohemia, South Bohemia, West Bohemia, North Bohemia, East Bohemia, North Moravia and South Moravia, numbered in this order). Auxiliary variables are designated as  $D_1, \dots, D_7$ .

All variables being equal to zero mean Prague, as a reference region.

$i$ -th value equal to one and others zero means  $(i - 1)$ -th region.

Such variables are valuable for the test of significance of the model parameters. To test whether we can eliminate influence of the regions on the client's inability to pay installments we need to consider all parameters corresponding to the auxiliary variables  $D_1, \dots, D_7$  equal to zero, meaning we perform a zero-value test on the vector and the corresponding  $\chi^2_7$  statistic will have 7 degrees of freedom.

# Other predictors



Sometimes, other predictors influence risk.

These can be bound to the parameters of the loan - credit amount, interest rates, overpayment, etc.

Even though that these predictors do not relate to the specific person being scored.

It can be seen that for instance interest rates correlate with observed risk.

# Behavioral Scoring



For clients, which have some history with the bank, their historical behavior usually turns out predictive for future loans. Some examples of behavioral predictors:

- ▶ Historical delinquency in some period of time
- ▶ Share of installments paid on time
- ▶ Ratio of successfully repaid principal
- ▶ Historical annuity

# External databases

Even for new clients, predictors from the previous section could be obtained from external databases.

Then, the basic source is Credit Bureau, which records historical performance on loans with other banks.

Other sources include

- ▶ social security databases,
- ▶ identity verification,
- ▶ data verification through company registers of social networks.