Nóra Ágota Felföldi-Szűcs:

LENDING IN CASE OF NON-PAYING CUSTOMER

The credit decision of the bank and the supplier

DEPARTMENT OF FINANCE

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LENDING IN CASE OF NON-PAYING CUSTOMER

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Ph.D. dissertation

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Introduction

The cornerstone of my thesis is the non-paying customer whose effects contribute to a relatively wide circle of financial problems. The topic connected to non-paying customers appear in more dimensions in the dissertation from the additional credit rationing of the supplier to the analysis of a concrete trade credit portfolio.

The structure of the dissertation is justified by an association connected to credit rationing. The first part of the association leads us to the countries of the distant Third World to the poorest of the poor.

Due to micro-lending, and especially due to the innovation of group lending the „unbankable" layer has access to financing, moreover the maintenance of the lending institutes, the MFI's is assured in the long run.

The second part of the association is, that however the Hungarian micro and small- and medium-size enterprises (SME) could function as the engine of economic growth, but the SME's as this sector in the whole region are suffering from sub-capitalization, and the lack of financing. According to many entrepreneurs there are more entrepreneurs who desire to have a loan at the given interest rates, than the number of credit applicants who really receives the loan. Thus the suspicion arises, that the sector faces credit rationing. The relationship of bank financing and credit rationing is already explained by the literature that's why I have stepped forward with one thought in theoretical modeling. The other practical problem of the SME's is – not only in Hungary – the chain debt, the delayed fulfillment of payables. By combining the two problems I have examined how non-paying customers increase the already existing credit rationing at the market of the SME's.

Combining the two parts of my association presented above, I am modeling the question, whether the credit rationing caused by the non paying customer can be resolved by one of the frequent elements of group-lending, by joint liability.

Accordingly the first part of the dissertation is dealing with the main results of micro-lending. The microfinance institutes, (MFI) are usually offering their services to poor micro-contractors, who are forced out from the market of the traditional bank products and are left without financing. Parallel with the financial concerns, at the beginning, the struggle against poverty motivated the actors of the market; they have sacrificed their sustainability for a long time. However in order to reach the double goal of financial sustainability and helping the poor, these institutes had to work out various techniques,

since they had to finance clients who live from an income lower than a dollar each they, without physical collateral. The glory of Mohamad Yunus, the founder of the Bangladeshi Grameen Bank started at this point. The group loans are processed for those clients who were thought not to be able to pay their debt. They are made liable for the loan of each other, while permanently increasing credit amounts are promised as future loans. The construction manages informational asymmetry and moral hazard.

In the second part of the dissertation, firstly I will present the model of Jean Tirole (2005), regarding external financing, when there is informational asymmetry amongst the parties, what gives wide room for moral hazard. The answer of the financers to the situation is credit rationing. Some of the clients will receive a smaller amount of loan, when it is requested at the given level of interest, or not every client who would be able to repay a loan will have access to financing. If there are value producing projects with positive net present value and they can not be founded because of the lack of financing, then we are facing with a harmful situation at the social level, therefore it is economically reasonable to ease the problem.

In my model I am concentrating on firms, who need external financing and have non-paying customers. In their case the informational asymmetry – which is generally present in lending situations – is also increased by the delayed payment of their customers and by the uncertainty attached to the collection of their customer receivable. As a result, moral hazard also rises with the increase of informational asymmetry. Afterwards in a reworked version, I will present as an own theoretical result, to what extent the effect of the non-paying customer is increasing credit rationing. The model can simply be spread to the delayed customers.

Amongst the own results of my thesis, there is the model of conditional joint liability. During the analysis I am examining, whether joint liability is decreasing credit rationing, or the doubled liability is disadvantageous for the borrowers, because this construction puts additional financial weights to them. According to the result of the model this latter effect is stronger, after examining more variations the conclusion is robust.

The content of the empirical research had to be adjusted to the possibilities provided by the database. Thus the third part of the thesis concentrates on a more general aspect of the non-paying customers than previous chapters; I analyze a trade credit portfolio of a given firm. For practitioners, customer relationship managers at a company this kind of information is available, however for external researchers the paying history of

customers is not accessible for research purposes. That's why it meant a special help, and gave me a chance for an analysis rarely seen in the literature, when a claim management company provided me a database.

The trade credit database consists of a customer portfolio (1398 items) of a real-life company. The supplier is trading in construction materials. Besides the open receivables from all the 1400 customers of the company, a record of overdue amounts and an aged balance of accounts receivable was also provided. These being stock variables, the figures relate to one specific day in May 2009. The records, however, also show all open and overdue accounts from one week earlier, as well. In addition to the agreed credit limit, information (partly of a qualitative nature) on the customer, its manager and its payment history also appear in the database. For 905 customers also the financial reports are available.

The empirical analysis consists of three parts. Firstly I am identifying the typical paying habits with cluster analysis; I explore the typical age structure of the open balances of claims. According to the results of cluster analysis, I define the non-payment of customer as a delay longer than 90 days. The definition for the default on supplier payable corresponds to the default on bank obligations, where also the delay of 90 days is used.

As a second question I concentrated on the sub-sample of the self-employed entrepreneurs. I have examined the relationship of their personal track record and their non-payment. I also tested whether non-payment is related to the gender of the borrower. This latter hypothesis was rejected relying on the analysis, on the other hand the behavioral variables showed significant connection with non-payment.

As a third step – using the methodology of bankruptcy forecasting – I have estimated logistical regression models to forecast the non-payment of customers. I have estimated models relying on the literature, merely built on financial indicators; then I extended the model with behavioral variables, and I also estimated models using principal components consisting of financial ratios. Relying on the results, the behavioral variables are always strongly enhancing the classification accuracy of the model, even if they are used without financial variables. However the model built on the principal components and the individual indicators works differently on the training and on the testing sample. On the test sample the principal components are more successful than the financial ratios.

Finally I close the dissertation with the summary of the major results. An interesting finding of the modeling chapters is the quantification of the credit rationing connected to the non-paying customer, and also the model of conditional joint liability.

I believe that the logistical regression models predicting customer non-payment are the most important result of my thesis; since it provides some guidelines to the practice of customer and claim management. It evidently highlights the importance of the behavioral variables in the prediction of non-payment. Thus the more wide-ranged collection and application of these variables can support the decision whether to provide trade credit to a given customer. In the conclusion I am going to present the further research directions and also the most important theoretical and empirical limits of my thesis.

1 Group Lending as a Possibility for Decreasing Credit Rationing

In the first part of the thesis I am going to introduce the revolutionary financial innovation, for which Mohamad Yunus has received the Nobel Price, because his group loans (from which the Grameen Bank from Bangladesh made an effective portfolio) can be important tools in the struggle against poverty. However, there were preludes to Yunus' idea; during the lending he used the informal, accumulated knowledge of the members of the small local communities, while the group of borrowers was commonly responsible for the credit. In the cited sources, more authors refer to the cooperatives of the 18-19th century as a lending technique, which have similar lending technologies. In my thesis I won't elaborate on these constructions (which are only preludes of Yunus' idea in a wider sense), I will only concentrate on the theory and practice of the microfinance and the group lending.

1.1 Micro Financial Institutions and the Lending to the Poor

In 2006 Mohamad Yunus has received a Nobel Price for his work, during which he has been serving successfully the poorest layers (who are marked with the „unbankable" attribute). Experts claim the size of the market, which can be served because of Yunus' innovations, is 250 million dollars. (www.mixmarket.org, May of 2009.) The story began in the seventies, when Yunus, who just returned from the United States is teaching Economics to his pupils in Bangladesh at the Chuttagong University, however he felt a huge controversy (when walking on the streets of the cities) between the pauper crowds, and the taught economical laws. In 1972 he lent 27 dollars to 42 bamboo excrement producing ladies, because he saw the cause of poverty (which stroke 80% of the residents) in the lack of access to credit.

He founded the Grameen Bank of Bangladesh in 1983, which is giving out loans (according to some authors) with a default rate of 1.6%[1], to groups without physical collateral, who earn less than a dollar each day. (Sengupta, Aubuchon, 2008) During the

[1] This data was taken from the years: 1985-1996. (Murdoch, 1999)

past decades at the Grameen Bank and at its followers a group of credit constructions were developed which managed to overcome market failure situations.

The service of those who lived in deep poverty (earning less than a dollar a day), and could only finance themselves from usury and other informal credit sources was accomplished; in the meantime the micro financial sector, which is serving them was born too, which is held to be the most important economical innovation for the last 50 years.

The micro financial cases are tightly connected with the struggle against poverty and other social and developmental political questions. Amongst the successful constructions, the group loans bear outstanding importance, which provided the initial success of the Grameen, when instead of the physical collateral; they built on less materialistic collateral, namely the reputation and the trust of the people.

The statistics of the micro financial sector clearly prove that the institutions working on this field cannot only survive because of their witty ideas. In 2008 only the Grameen Bank served more than 5.5 million clients, managing a credit portfolio of 5.2 million dollar. The total size of the market according to a poll done by Microcredit Summit Campaign was estimated to 67.6 million clients, who are served by 973 MFI according to the data available at the homepage of Microfinance Information Exchange (MIX). The majority of the clients are from the poorest layers of the world, they are those who live under the poverty line, the bottom 50% of the income scale. According to the estimates the MFI services have reached 41.6 million persons from the poorest groups. The cited numbers suggest a serious market, which is proved by the fact, that in 2007 the Standard & Poor published a methodology concerning the classification of MFI. By this the results of the sector can be rated by the aspects of the market and based on the generated profit; this can make it easier for the new investors to enter to this sector. (Sengupta and Aubuchon, 2008)

The thicker and thicker literature doesn't spend too much time by defining the term microfinance. According to Ledgerwood (2000): *„The term (sic. Microfinance) refers to provision of financial services to low-income clients.*" (Ledgerwood, 2000:1.p.) Armanderiz de Aghion and Morduch (2005) in their definition specifically point out the lack of the collateral and the own resources: The microfinance is *a collection of banking practices built around providing small loans (typically without collateral) and accepting tiny savings deposits"*. (Armanderiz de Aghion and Morduch, 2005: 1. p.)

In the definition of Sengupta and Aubuchon (2008) the small loans mean those, which are not higher than 100 dollars. Moreover, they do not mention the own resources and the collateral in their definition. Arch (2005) in his work is referring to the definition of Seibel and Kumar, from 1998, who described the microfinance as a distinct sector. „*Microfinance is defined as a sector of formal and nonformal financial institutions providing microsavings, microcredit and microinsurance services to the microeconomy, thereby allocating scarce resources to microinvestments.*" (Seibel and Kumar, 1998. in: Arch, 2005: 230. o.)

If we stick to the literal definition and do not look at the struggle against poverty and the knowledge on social vocation, with which the reader meets, when she/he is reading the first book on microfinance, then we could list very different practices, which are covered by the mentioned definitions. Sengupta and Aubuchon (2008) are sensing this problem, therefore they immediately cite Muhammad Yunus' (2007) description, according to this, next to the lack of the collateral, another important element of the microfinance is, that it doesn't work because of the legally enforceable contracts, the system is working because of the trust of the parties. But we have to note, that this (the relationships in the small communities guarantee the operation) can be true to the other cooperative forms too, Ghatak and Guinanne (1999) are bringing an example of this from Germany, from the 1850's. Relying on the consensus besides the microcredit many other services are parts of the practice, there are saving possibilities and insurances amongst the services provided by the microfinancial institutions. We have to point that these services are not available only once, there is a permanent supply for the consumers who are ousted from the market of the traditional bank products.

According to my opinion the goal of the institutions at this market – , what is to improve the life of those living in deep poverty, who most often are women; to create the financial potential for self-employment and studying – evidently distinguishes the microfinancial institutions (MFI) from the profit maximizing actors of the economy. Currently the profitability as an aid for sustainability is the primary goal of the MFI's chronologically, but only a secondary goal, if we are looking at its importance for them.

The two basic models which are competing with each other amongst the MFI's is group lending and individual lending. In the field of the loan, specifically within the group lending the Grameen Bank's (which is the most successful at this field) gave out the loans to groups of five people. Since then quite different practices have spread, however

most often the institutions are picking from the following elements, when making a group lending construction.

If the credit is not given out in one payment, however the clients can receive it in packages following each other, but only if the group members were repaying punctually, then what we are speaking of is sequential lending. The literature for a long while has only seen (within narrow limits) this as the model of group lending: the members of the group, after all of them have used their loans are jointly liable for paying back the installments on time. If there is only one group member, who doesn't pay on time, the bank will take the whole group as if they were all default. Therefore for those members who cannot pay transitionally, the other members have to pay the installment.

Both the group and the individual lending contain the following element, if the borrower (in our case any of the loans of the group) doesn't pay back the loan, all of them will lose the potential for later loans (with contingent renewal). The group members are always paying back the installment together, usually, when more groups meet up.

The ***individual lending***, which is amongst the services of most MFI's doesn't have to be introduced, similarly to the practice of the commercial banks the borrower is only responsible for her/his own loan. Naturally in this construction it is also true, that the loan can only be renewed if it was successfully paid back.

Besides the differences of the basic models, which arise from the differences between the group and the individual lending there are many common elements, which can be found in the functioning of all of the institutes. Sinha (2003) has collected the attributes, with which all of the MFI clients may meet.

- The practices of the different institutes are not alike, whether they permit the clients to use the loan for consumer purposes, but in most of the cases starting or already functioning micro companies have to spend the judged amount of money on working capital or on fixed assets.

- One of the difficulties of the microfinance is that from the traditional, commercial banking's point of view the MFI's clients are not credit worthy and they do not have collateral. Thus the MFI's are providing the micro loans without physical collateral. It often happens that during the time, while the borrowers are paying back the loan can gather some savings, so later on; they

are accumulating some collateral for the loan. It is a spread method both in the individual and in the group lending constructions that the reputation of the client in front of the community, and her/his social relationships are taken as one sort of collateral. They do not possess value for the bank, which they could change for money, but their information content can be important during the lending process. What is more important, that the collateral is not only enhancing the recovery rate, but also increasing the paying rate too, because it is important for the borrower, therefore she/he is afraid of losing it. Therefore in some of the cases the banks are asking for collaterals, which are only important for the borrower, the MFI cannot gain valuable money from it; however its incentive effect is advantageous even for the bank. (This could be for instances the only goat, or cow of the family, or a furniture, what is very important for them) (Sengupta and Aubuchon, 2008)

- The amount of the loans is often lower, than what the clients have applied for. However if they are applying several times for a loan, the amount they can receive is growing each time they are doing so. This means, that the loans can be renewed depending on the achievement of the earlier loans. When the amount of money is calculated not the traditional creditworthiness is the basis, but the history of the borrower with the MFI.

- The interests, in cases when commercial banks are involved are containing the profit of the institute, and also compensating the lender for the expected loss on credit risk. Therefore according to the practice, the expected credit loss is countered by the interest. The MFI's face with a higher expected loss, than the commercial banks, therefore their interest rates are higher too. Based on data, from 2006 10% and 85% annual interest rates appeared at the supply of different MFIs, but the typical rates were between 20-40% for a year. (Rosenberg, Gonzalez and Narain, 2009) (I am going to write of the debates on the interests rates in later passages, regarding the sustainability of the MFI's.)

- If the borrower is not paying back the loan, the institute will not give her/him a loan again.

- The relationship is not restricted to the lending. Before receiving the loan those who apply for the loan have to participate at trainings or meetings. At these

appointments the future client can speak about her/his project with the employee of the bank, or can improve her/his business skills. Where it can be important, they also talk about the equal rights of women and of social problems.

- There are also many meetings while the clients have to pay back to loan. Every client has to present how she/he proceeded weekly, fortnightly, or monthly, they also have to pay their fix sized installment at these meetings. At the beginning there is a short moratorium for the clients to pay back the loan, but they have to begin to pay it back in couple of weeks. Usually the maturity of the loans is maximum one year.

- As I have written earlier, while paying back the loan in many cases the clients have to gather savings too. The experiences tell us, that individuals who earn only a small amount of money like to keep their money in liquid forms, they are using it to defend themselves from the „income shocks". But in the practice of some of the MFI's the capital gathered this way, cannot be accessed by the borrower for one or two years, thus the borrower is producing one sort of collateral, while she/he already has a loan.

- On the other hand in special cases (accidents, sickness), or when great problems are arising from the state of life (education, wedding, funeral), the borrower can get a support from the common capital according to the practices of several institutes.

The example of the Grameen Bank, who was the first institute to help those in need were followed by many others, especially in the developing countries. The largest institutes are working in Bangladesh, India, Indonesia and Thailand. We can see a very colorful picture, when looking at the supply side of the MFI sector.

The palette of the specific country is very wide from the development agencies, foundations, traditional, profit based institutes, for instance departments of commercial banks who are only dealing with micro financing to informal initiatives. Arch (2005) is dividing the supply side of the MFI's to formal, semi-formal and informal groups. Because I haven't found any other systematization in the literature, I am going to introduce his not too informative typology. Amongst the formal institutes we can find financial companies, for instance insurance companies, residential and commercial banks, whose activity is regulated. The most important members of the semi-formal

group are usually agencies, which are responsible for non-state supported improvements, or special, development banks. Village moneylenders even loan sharks and other money lenders belong to the informal group.

In Europe the Union was the donor of many micro loan programs, it has mainly financed loans for SME Improvements. The USAID worked in the U.S.A with similar goals. Both the U.N. (United Nations) and the World Bank have micro financial initiatives. The latter has created the CGAP (Consultative Group to Assist the Poor), many initiatives are connected to the U.N., for instance the United Nations Capital Fund (UNCDF), the Microloan and the United Nations Development Program. The EBRD is giving out loans for companies, which are in countries on the way of industrialization. (Arch, 2005) (The detailed introduction of the specific programs and initiatives are not part of the thread.)

After I have wrote on the functioning of the MFI in this subchapter, I am going to deal with one specific kind of the microloans, to the group loans. Not because I have processed all of the diverse and very exciting literature on microfinance, since there is a rich literature on the successful struggle against poverty, the financing of the MFI's, the fairness and rightness of the interest rates, not to mention other topics. We can find the detailed introduction of this topic in the following books: Ledgerwood (2000): Microfinance Handbook: an Institutional and Financial Perspective; Armanderiz de Aghion and Morduch (2005): Microeconomics of Microfinance. However in the further parts of my thesis, I am going to concentrate on the group loans, because afterwards, I am going to use the logics of group lending to model the lending of the companies in debt-chains.

1.2 The Group Lending and the Group Loans of the Grameen Bank

Amongst the micro financial services group lending has an important role, and it is also the target of professional debates, which are fused with the name of the Grameen Bank, which was established in 1976. The world found its activity so important, that the founder Muhammad Yunus received the Nobel Price for Peace in 2006, for the struggle against poverty. Perhaps, that's why the news exploded like a bomb, that Yunus hasn't used the 100 million dollar donation of the Norwegian donating organization, NORAD, as it should have been used, according to the original contract. (Fülöp, 2011) The details

and the motivation of the attacks against Yunus are not clear yet; both of these factors have strengthened the professional critiques of the constructions of the Grameen. Despite that the professional literature has not decided yet whether the group lending is more advantageous than the individual, but in practice the supply of the institutes moved towards the individual loans. (Hermes – Lensink, 2007a) Even if we take into account, what was said above, the importance of group lending is indubitable, and it could be the first step in the lending to the poor, which is coming before the individual lending.

Although I have delineated the elements of the group lending constructions in the previous chapter, the survey of a practical model can be necessary, to see how the major statements of the theoretical literature work. Thus as an illustration, I will introduce how the group lending works at the Grameen Bank, then with the overview of the literature I am going to examine, what sort of explanations were stated, to verify the success of the model.

Muhammad Yunus returned to his home to Bangladesh, after receiving his Ph.D. and teaching for years in the U.S.A. However there was a huge controversy between the theories which he studied at the universities and the circumstances in his home country, what he could not explain to his pupils with his current knowledge. Thus he began to search for the reason of the fact that 80% of the country lives under the poverty line. The answer is, that they won't get any external sources, therefore they cannot get loans either, with which they could burst out of the vicious circles of poverty. At that time Yunus lent 27 dollars from his own money to 42 women, who were manufacturing bamboo products. After many falls and pitfalls a model was developed, with which, the financial institution established with the aid of the government, the Grameen Bank began to work. (Sengupta and Aubuchon, 2008)

In the group lending constructions the clients of the bank are making up groups of five people, where the bank let's its clients to choose the members of the group. The only requirement is that they have to be living in the same village, but closely related relatives cannot be in the same group. In accordance with the norms of Bangladesh, the women and the men are separated. Then all of them will go to trainings for weeks, where the employees of the bank will prepare them to start the business, what is going to be financed. The clients are obliged to save a smaller amount of money weekly even during the weeks of the training. If they have managed to pass the training two group members will receive the loan. The duration of the loan depends on the size, but usually

it is one year, where the repayment of the principal and the interest happen together weekly at the group meetings. If the repayment is appropriate to the contract, then another two members of the group can get his/her loan, then at a third time the fifth member can get the loan too. If one of the group members cannot pay the installment, then the whole group is classified as non-payers, thus they the Grameen Bank will deny to give loans for them in the future. (Ghatak and Guinanne, 1999).

The groups are compressed in to greater units, to centers; the primary task of the centers is to treat to Group Fund and the Emergency Found. The Group Fund is made up by the obligatory savings, the disbursement fee (5%), and by the contingent penalties, which have to be paid if the rules are broken. This accumulated capital can cover loans, what the members can use for special family events, like funerals and weddings. The Emergency Fund is made of one part of the interest's extra charge, and works as one sort of an insurance, for instance it can be used in case of natural catastrophes and in the case of the death of the client. These Funds together are suitable to cover the loss caused by the non-payers, if the members of the specific group cannot do so. (Ghatak and Guinanne, 1999)

The practices of other banks, empirical works in the theme of group lending helped to investigate the needs of the poor layers, with very low income. Also the Grameen has renewed its services, under the name Grameen II; it has offered loans and savings with more flexible conditions. The duration of the loans can be renegotiated, if difficulties arise, they can be lengthened, what also means the unlocking of the group responsibility, while keeping the dynamic incentives. The clients, who have a higher loan than 138 dollars can join to the pension fund of the bank. To their monthly 0.86 dollar contribution, they will get an annual interest of 12% during the 10 years of mandatory duration. With this, the bank is providing long term resources to itself, which's interest expenses, are lower, than the interest revenue on the outstanding loans. Besides all this, the group loan still exists at the Grameen; it is an important part of the bank's activity. (Sengupta and Aubuchon, 2008.)

The literature is describing the Grameen Bank's original loan by saying it is using joint liability, whereas the bank's lending practice is much more complex than this. The group lending is working parallel with dynamic incentives (sequential lending, conditional loan renewal), permanent monitoring by the lender, where the clients are making up their own savings during the duration, for the expected losses.

In order to see, by what sort of theoretical considerations the Grameen Bank and other financial institute's loan constructions are working, I will introduce the model of group lending,. After this I will briefly sum up the literature of the group lending, and the critique of the model.

1.3 One Period Models of Group Lending

The principle of the literature is going to be the market failures occurring in lending situations, because each of the authors thinks that the key of the success of the group loans is that they can successfully treat or decrease at least one of the following mentioned market failures. Stiglitz (1990) is attaching the problem of monitoring to the enumeration below, which is introducing four market failures relying on Ghatak and Guinanne:

- **Adverse selection**: it is hard to distinguish between the low and high risk applicants for loans, what can even lead to the breakdown of the market. (See also: Akerlof (1970) , Tirole(2005))

- **Monitoring**: Permanently getting in touch with the client and controlling can help the bank to collect information on the actual performance of the client. In case of small loans this sort of monitoring can be hardly carried out because of the lack of capacity and the high average expenses. (Stiglitz, 1990)

- **Moral hazard**: after receiving the loan, it is uncertain whether the contractor is going to use the loan to increase the net present value of the project.

- **Auditing costs**: if the borrower reports himself/herself to be bankrupt, it is expensive for the lender to make sure of the real financial situation of the client and the efficiency of the project.

- **Enforcement**: if the borrower doesn't want to pay, especially if we are talking about poor clients, without property, the bank cannot force him/her to do so.

Similarly to this, the literature is giving the following general answers to the above enumerated market failures, even though in the particular questions there is no consensus amongst the authors.

- **Screening**: In the local society and communities relying on the information, what is accessible for everyone, the clients can usually estimate the creditworthiness of their companions better, than the banks.

- **Peer-selection**: the applicants after previously assessing each other are organizing themselves into groups. Several authors claim, that the groups made this way are homogenous regarding the risk of the loan. Thus, the risky client is making a group with the risky ones, while the good client with other good individuals, (this is called assortive matching), therefore it is easier for the bank to separate the clients.

- **Peer-monitoring**: the members of the group get noticed of the activities of the other members, because of the similar way of life and the village community, and this converts the spontaneous information gathering to a conscious activity.

- **Group pressure**: The non-paying client in case of common responsibility is delegating the weight of repaying to the other group members, for which he/she can be punished by the group, the local community and the society with social sanctions.

- **Remission of the moral hazard**: the more successful monitoring, along with more effective enforcement are decreasing the moral hazard.

Ghatak and Guinanne (1999) mention the decreasing of the transactional costs in case of group lending used for instance by Hulme and Mosley (1996.) However according to Ghatak and Guinnane the lowering of the transactional costs can only be an advantage if the projects have similar growth opportunities, income structures and are at the same area; in this case it is an addition to their argument.

The theoretical model of screening is not described separately in the literature; it is incorporated in the models of assortive matching. On the other hand the formation of the groups with homogenous risk has a very wide audience. The summaries in the literature all begin with the work of Stiglitz and Varian from 1990, who introduced that the moral hazards arising from asymmetric information can be dealt with, if the bank is building in the joint liability to the contract. The idea of the homogenous groups appears first in their works; the **peer selection** (between "good" and "bad") is done by the clients with joint liability instead of the bank, because of their own interests. Ghatak's

(1999) own and his common works with Guinnane present a similar result, which is supported by Morduch (1999) and Gangopadhyay, Ghatak and Lensink (2001). (The latter three authors are cited by Fedele (2005).) Furthermore Armendariz de Aghion and Gollier (2000) have published similar conclusions. At this time the bank only has to choose from homogenous groups. It can do it by giving out loans to different clients with different interest rates. Then the "good" borrowers are getting loans, with the joint liability and low interest rate, and those who are realizing risky projects with low joint liability are receiving the loans with high interest rates. Fedele (2005) derives, that this sort of lending is leading to separating equilibrium at the market. The possibility of the market breakdown can only be thwarted by the group lending, because the bank is encouraging its clients, to use the accessible, but hidden information, and to enunciate it implicitly towards the financer.

On the other hand Sadoulet (1999, 2002) and Sadoulet and Carpenter (2001) claim, that those who apply for the loans are resolved to heterogeneous groups, what appears as insurance and also as a diversification for the parties. Chowdhury's (2006) work seem to solve the question, who by using multi period models said that in cases of high discount factor, i.e. low interest rate, the homogenous groups are attractive for the actors, in the opposite case we can expect that heterogeneous groups will be created.

The **composition and the formation of the groups** bare primary importance for the success of lending programs, because the other solutions of the market failures are supposing an awareness between the participants and a tighter social connection. That is the reason why the method of group formation is connected to the suggestion of the homogenous groups. There is almost a consensus amongst the author in the following: it is a mistake from the lender to form the groups in an administrative way and to thwart the functioning the presently described mechanism. Naturally, all of this presupposes that the applicants have sufficient information from each other, what is usually the attribute of the communities of the small villages. (Ghatak and Guinnane, 1999) Kevane (1996) are referring to the failure of the programs examined by them (Burkina Faso), where the group creation was directed by loan administrators. On the other hand the too strong social ties between the group members should be avoided, the groups containing family members, or those living in one household led to lower repayment rates, because of the possible collusion according to the paper of Ahlin and Townsend (2003). Meanwhile the composition of the group and the importance of the acquaintances are not as emphatic at Armendariz and Morduch (2000), according to whom group loan

projects can work in city environments too, if there is a mechanism which can attract the „good" clients to the market. This can be achieved for instance with the lower interest rate. It is true though, that the too low interest rate can endanger the sustainability of the institute (Ross and Savanti, 2005). The selection of the group members and the tightness and the quality of the relations between them is leading us to the papers dealing with the effect of social capital on group lending. I am going to discuss this issue in another sub chapter.

After the group was formed from the applicants, the micro financial institute is sending the money, and the borrowers are using it to the purpose, what they have applied for. Many institutes are giving out the loans to finance current assets to the family business of the borrower strictly, however at other MFIs loans are allowed to be spent on consumption too. (Amendariz de Aghion and Morduch, 2005; Giné, Jakiela, Karlan and Morduch, 2006). In the first case the bank faces with **moral hazard**: the applicant for the loan can use the loan for other activities, which are not improving the business, or the paying back of the debt.

We meet with the theoretical derivation of this phenomenon in one of the model of Ghatak and Guinnane (1999) build in the framework of game theory. According to their result the problem of the moral hazard can be solved with peer monitoring. The model proves that better repayment rates can be achieved with the group lending, than with the individual, but the joint liability doesn't work in itself, the defining of the common strategy is also a requirement of the high repayment rate. Even in a case where the two borrowers can only examine costly whether their partner is following their common strategy, it is still possible, that group lending is better than individual lending. The necessary condition of this is also deducted by Ghatak and Guinanne: the social sanctions have to be strong enough against the not cooperating partner, or the expense of the monitoring shall be low. The discussion of moral hazard can be found both at Stiglitz (1990) and at Varian (1990), most of the literature summaries are originating the deduction of this aspect from them.

An incremental topic connected to the moral hazard is the riskiness of the loan applicants. Stiglitz (1990), Sadoulet (2002) and Giné, Jakiela, Karlan and Morduch (2006) all claim that the joint liability compared to the strategies chosen in the cases of the individual lending is decreasing the **risk-taking willingness** of the participants. Safer projects can also mean more advantageous repayment rates, however if the borrowers are taking a lower risk, they may be restricted to have a lower income too.

Giné, Jakiela, Karlan and Morduch (2006) claim that the level of risk taking is suboptimal, the borrowers are choosing too frequently the safe projects. Thus it can be said, that the hazarding with the money of the bank, the extreme risk taking, is an appearance of the moral hazard, which can occur in individual contracts without collateral, but it can be decreased by group loans, however the extent of the reduction is too high, it is suboptimal.

The unlocking of the moral hazard can be explained at all of the authors with the free or low expense **monitoring**. The monitoring in case of group lending is moved from the lender (who would fail with this task) to the borrowers, who are taking this lending task. The main question of Stiglitz's (1990) *„Peer monitoring and credit markets"*, what was published in the *World Bank Economic Review* is whether peer monitoring as the benefit of the joint liability can countervail the additional expected expenses, namely the non-payment of group members what activates the joint liability of borrowers. According to the answer the clients with lower risk taking shall apply for group loans with a smaller extent of joint liability. They can gain on the reduction of the credit rationing, and the increased amount of credit.

Besides the works of those, who I have referred to (Stiglitz, Varian, Ghatak and Guinnane) the Banerjee, Besley and Guinnane (1994) trio's relatively older writing is unavoidable in this topic. According to their result, group lending is encouraging the members for peer monitoring. It is important to note, as Karlan (2004) is doing so, that monitoring in itself is only a possibility. It contains the potential, that the group members will be able to decide who "shall" be punished, relying on their past information of the others and the information gathered until the maturity. Thus monitoring can only solve the moral hazard, if credible and exemplary sanctions are accompanying it. It can be explained with monitoring, that the literature is reporting of cases, where the partner, who could not pay - because of reasons, for what he was not responsible for - wasn't punished.

Following Karlan (2004), only the **sanctions** coming after monitoring can solve the problem of moral hazard. The sanction according to Ghatak and Guinanne's deduction should be formed in a way, in what the co-borrowers can expect a high level of inconveniences originating from the punishment ex ante, already when they choose their behavior. On the other hand in practice it can happen that it is unpleasant for the group members to punish the others, it cannot be complied with the local, social norms. Ghatak and Guinanne (1999) are mentioning an example from 1894, from Ireland,

where the members of the loan construction haven't punished each other for the rule breaking behaviors. According to Chowdhury's (2006) dynamic model the punishment expectably is going to be carried out by the community, if the non-payment is endangering the "safe" loan of the others.

1.4 The Multi-Period Models of Group Lending

The group lending with the suitable construction elements doesn't only mean a higher repayment rate to the bank, but the clients will have a higher net cash flow too, as worked out in the model of Lublóy, Tóth and Vermes (2008). However none of the authors who are criticizing the group loans forget to cite that in 2001 the Grameen Bank, whose name used to be a synonym for the group loans, made its loan construction more flexible, and like the other institutes (the ASA Group from Bangladesh, or the Indonesian Bank Rakyat Indonesia), it has created a portfolio with dynamic incentives but without joint liability. The example of the Grameen is fitting in well to the tendency, according to which besides the group loans, the market is offering individual loans in a much greater proportion.

Unspokenly the conviction can underlie this, the poorest layers, whose ascent is served by the micro financial market, in case of group loans can only access to one unit of credit at an extremely high price.[2] The traditional arguments, that for the fast, and relatively save loan it worth to pay these high expenses, because the group loan programs are usually not the alternative of the cheaper individual loans, but the more expensive usury loans, or the functioning without loans. The joint liability, one of the central elements of the constructions, has worked with very different efficiency in each program, while a non-paying partner put new weights to the other participants. It is not surprising that, the joint liability is causing huge debates, whether it is advantageous, or should it be used at all.

The connected literature is mainly concentrating on two questions. Firstly, what are those necessary elements of the group loans, which are making successful the programs besides joint liability? Secondly, most of the authors – whether at a theoretical, or at an empirical level – are seeking for the answer, that how can the incentives used in group

2 At this point, I reckon it is important to refresh the concept of group loans. Although the joint liability is an important and frequent element of the constructions, it is often supported by dynamic incentives. Thus it is misleading to concentrate only on the joint liability, when criticizing the group loans. On the other hand, joint liability is an emphatic element of the group solutions, the expansion of individual loans compared to group loans can be explained by the lack of joint liability.

lending be kept, if joint liability is taken out. The answers for two questions, which have to be satisfying from the aspect of financial sustainability too, are more or less covering each other. The answers introduced here are exceeding the already referred works because these are modeling the examined problem within a dynamic framework, and building multi period models. At the following pages I am going to discuss this sphere of thought, referring to the works of the most important authors.

Chowdhury (2005) emphasizes the role of sequential lending and lender's monitoring. According to him these rarely cited aspects, which are also present in the practice of the Grameen Bank, play important role in the success of the bank. Duly to the sequential lending in the groups (containing five members) of the Grameen at the start only two members can receive the loan, then in couple of weeks another two, and finally the last group member can get it, if his/her partners have already began to repay the installments precisely. The lender's monitoring is taking place at trainings before granting the loan, then during the whole duration at the weekly meetings. According to Chowdhury (as we also know it from other authors), the requirement of the application of individual liability is, that the expense of the lender's monitoring should be low.

When speaking about the application of the group loans, the experts claim, that peer monitoring is much cheaper, than bank monitoring, however relying on Chowdhury (2005), it doesn't mean, that it is going to be realized at the optimal level. In his model, he derives, that peer monitoring is going to be realized at a suboptimal level, therefore as an addition lender's monitoring is needed. Monitoring with too low intensity can be avoided, if the bank is using sequential lending alone, or applies both joint liability and bank monitoring. If only sequential lending is applied, lower repayment rates can be expected, which can naturally be improved, by building in joint liability to the construction. Thus relying on Chowdhury (2005) joint liability is not the only way to encourage the clients for monitoring, the problem of moral hazard can truly, only be solved if sequential lending is also applied.

Chowdhury (2005) is summing up his results in three normative suggestions, with which he would like to give operative help to the creation of group-loan constructions:

- The group loans can be built on sequential lending, or joint liability and lending monitoring. If it can be supposed that the monitoring level would be too low (for instance if there was a too loose connection between the group members, see earlier references), then joint liability alone will result in low repayment rates, and can cause the collapse of the program.

- If the rate of bankruptcies related to business risks (independently from the moral hazard) is high, then joint liability is forcing too high expenses to the actors, and will lose its encouraging effect. Therefore the group-loan program should only contain the sequential element!

- If contrary to the previous point, the number of not intentional bankruptcies is low, then application of joint liability is suggested in group constructions because of its positive, encouraging effects. (Chowdhury, 2005)

Chowdhury in one of his later works, from 2006 - like many other authors - is spreading the one period models to a two period one making his analysis dynamic. Due the built in dynamic his results are serious innovations at the level of modeling, however intuitively they are not surprising. Counter to his earlier paper (2005), besides the sequential lending he is examining the role of conditional loan renewal, this time regarding peer monitoring and the formation of homogenous groups. The author starts by saying, that in the one period model the joint liability is the only device, which enables the non-payment of the individual to affect the other members too. In dynamic games, there is a potential created for the conditional loan renewal, and for the analysis of the sequential loan, which will result – without joint liability – that the individual bankruptcies will cause group level consequences.

According to Chowdhury (2006) in case of homogenous groups, the low expense of the group lending is giving the bank the power, to investigate the riskiness of each of the groups. By using sequential lending, it is enough to give a loan to only one of the group members, and with his/her paying habits, the behavior of the whole groups attribute is covered. The formation of homogenous groups, which problem is not cleared in the literature are solved elegantly in a dynamic framework: besides the conditional loan renewal the high discount factor is making the possible, future loans attractive, therefore the safe clients are forming groups with their own kind, while the risky clients can only select members from each other. High interest rate, thus low discount factor is strongly decreasing the credit renewal's encouraging effect, and then the formation of heterogeneous groups can be expected. At this time the bank cannot use the group construction to cheaply measure the paying habit of the clients. Sequential lending is an important part of his model, since within the given period it works as an incentive. Since the referred author is only examining two periods- therefore the validity of his result is limited-, he can only guarantee with this condition, that groups which are in the

second period and won't apply for new loans, -in the model- are encouraged to pay back their loan.

According to his model the role of conditional loan renewal are not evidently positive. Its application is only purposeful, if the discount factor, what is used by the applicants to discount their cash flow, is high. It is purposeful to use it along with sequential lending, if the discount factors are high, in the opposite case sequential lending should be used alone. If the conditional loan renewal is the only element of a construction it can easily lead to collusion. (Chowdhury, 2006).

Also de Aghion and Morduch (2000) have worked out a dynamic model; they have concentrated to the role of credit renewal. They have agreed, that in case of individual lending it is expedient to maximally use the conditional credit renewal, thus in case of even one non-payment, the loan shouldn't be provided, and the successful clients shall get a permanently growing amount of money. With this statement they reach a different result, from what Chowdhury (2006) had. Their model level conclusions are thinkable because, the seriousness of the sanctions of the conditional credit renewal are strongly weakened by the competing MFI's, who are present at the market, or by other accessible financing forms. They, themselves are also writing about this. (Of the effects of the competition at the market of the MFI's see a detailed writing: McIntosh and Wydick, (2005).) Their connected suggestion, the introduction of other sanctions is needed in order to keep the incentives, because the duo have created a two period model, therefore in the second period only the suspension of the further loans are not too threatening. As they have shown with the Russian and the Albanian example, the physical collateral can be the suitable, additional sanction.

It's not by accident, that the two authors have built a model relying on individual liability; because the abstract conditions (for instance one period) of the group lending models deriving joint liability are not realistic according to them. According to their suggestion if we leave joint liability, along with individual liability it worth's to build group constructions. They claim that the advantages of the group loans, apart from joint liability can be summed up in five points:

- In front of the audience of the group meetings, the non paying borrower will be ashamed, like in the case of join liability. The protection of good fame is still going to be an incentive.

- According to logistical aspects (at one time, at one place, many clients), the collection of weekly payments could be more effective.

- At the group meetings the bank officer is still an important person, he/she can gain informal information, while they are jointly discussing the results of each of the participants.

- Those who are not experienced in business are getting advices and aid from their partners and from the bank, during the meeting. It is easier to organize trainings for the groups too.

- Finally with group loans, the banks can reach individuals, who wouldn't apply for loans otherwise. It is especially important in the case of women, that they can face the potential difficulties of the lending process together. Reaching women is not only important because of social considerations, but also because it is sufficiently improving the repayment rate of the loans, if there are women in the portfolio.

(de Aghion and Morduch, 2000)

Guttman (2007) like Chowdhury and the de-Aghion-Morduch duo has also created a dynamic model, in which, like Chowdhury (2006) is examining the homogeneity and the heterogeneity of the groups. His results are also confuting, that joint liability used in group loans would always cause the formation of homogenous groups. He agrees with the simple, one period model of Ghatak (1999, 2000), and van Tassel (1999), but within the two period framework, where contingent loan renewal appears the separation of the good and the bad clients not necessarily happens. If there are high project incomes, with low extent of joint liability the result will be heterogeneous groups working like the Sadoulet cross-insurances. The explanation is, that the loss of future credit possibilities is threatening the "bad" clients more, therefore for them a safe, "good" partner possess a higher value. Thus they are willing to pay more to a "good" partner to be in the same group with that client, than a safe client, who because of his/her high probability of success will receive loans with better chances in the future, for his/her financing.

1.5 The Results of Empirical Research

In the past decades, many theoretical models were created to describe microfinance, and within this sphere, group lending. However regarding empirical research many authors

believe, that the systematic tests of joint liability and the other technical solutions connected to group lending (such as sequential lending and conditional credit renewal) have not been investigated in the literature yet. All of this does not mean that there were no interesting and valuable works published on micro financial institutes (MFI's) and on the functioning of the group loan programs. After presenting the theoretical results in this subchapter of the dissertation I will include some of the practical aspects of group loans. First of all I am going the examine the results concerning group formation, then after testing the above mentioned theoretical claims I am going to describe writings, which are analyzing the necessity of joint liability. A particular subchapter is dedicated to the social capital.

1.5.1 The Process of Group Formation and the Composition of the Groups

The special task of group loan programs, which cannot be built on experience from other constructions, is to form a group. Many questions arise from the number of the group to its composition. Ross and Savanti (2005) are presenting the practice of the Activists for Social Alternatives (ASA) which is serving 76.000 clients in India, and of CASHPOR, which is covering several countries in Asia. In the mentioned programs, before the loan would be sent to the person applying to the target group, he/she has to participate in training; the groups are also formed here. The groups formed at both of these MFI's can only join to the loan program, if they passed on the so-called Group Recognition Test. Thus, there is a kind of client screening from the side of the bank, only its devices are more limited, than those of the traditional commercial and residential banks.

1.5.1.1 The Mode of Group Formation

After finishing the trainings, or often during them happens the **group formation.** Primarily the institute has to decide whether it is going to support **spontaneous or administrative group formation**. There are many arguments supporting the former. The theoretical literature doesn't have a unified opinion of the result of the order, however its claim is, that the future group members will decide how to form the group on the riskiness of the others.

Independently of the fact, that the particular authors are expecting the creation of homogenous or inhomogeneous groups, the model of spontaneous group formation is desirable. This spontaneity can guarantee that the ties are tight enough within the group to perform the monitoring, and the execution of the possible sanctions should be exemplary, because of the risked social connections. Ahlin's and Townsend's (2003) results are not supporting to put the members of one family to the same group, i.e. the too tight relations should be avoided. Armendariz and Gollier (2000) are examining the contrary case, when there was no previous acquaintance between the group members. According to his result the lack of previous acquaintance has not influenced the repayment of the loan.

However several authors have said that if the bank is forming the groups in an administrative way, it can lead to the failure of the loans. Regarding the group lending program realized in Burkina Faso Kevane (1996) and Paxton (1996) both emphasize, that it was a wrong decision to form the groups in an administrative way. During the interviews made with the clients of CASHPOR – which is an institute like the Grameen, functioning in Asia – Ross and Savanti (2005) met such situations, that the group-members did not pay out the loans of the others, or joint liability has failed. The given reason was that the groups were formed by the bank, and according to the participant, they did not have the possibility to choose their partner, therefore they did not pay instead of them. Another reason was that the borrower, who fell behind with the repayment, was from a lower caste, that's why he was not helped by the group. Sharma and Zeller (1997) are suggesting the spontaneous formation of the group relying on the experiences of three MFI's from Bangladesh. According to the researches done by Giné, Jakiela, Karlan and Morduch (2006) in Lima if the spontaneous formation was allowed, the payment rate of the simulated loans, were much higher, than in the opposite case. Kritikos and Vigenina (2005) reached a similar result by using the example of the group loans from the Georgian Constanta.

During the group-formation, the next decision is how many individuals should be in each group. The successful example, the Grameen Bank is giving loans to spontaneously formed groups of five borrowers, but the literature is describing cases of groups containing from 5 to 100 individuals. The extreme group, with a 100 individuals is cited by Ghatak and Guinnane from a relatively early work, (from 1982), from the Owusu and Tetteh duo, who wrote on the loan program of Ghana. It is also them who say, that even the groups containing 20 individuals are too big (Devereux and Fishe,

1993 in: Ghatak and Guinnane, 1999). The experiences were in accordance with the expectations that the smaller groups are working with higher efficiency. On the other hand the usage of larger groups is understandable. In case of normal business, when the borrowers are paying, the other members of the group can monitor the activity of the others more easily, if there is only a few of them, but the additional expenses related to a defaulted group member can be very high. The exchange between these two aspects was avoided by the practice of the Grameen Bank, by creating a dual level hierarchy, and the groups were ordered into centers, which in the case of the default of the whole group are secondarily responsible for the loans taken by their members.

1.5.1.2 The Composition of the Groups

Finally, the last topic from the theoretical works is assortive matching. We could see from the previous chapter that the literature is not unified in this topic. The model predicting the formation of homogenous groups seems to be confuted by the work of Sadoulet. Sadoulet and Carpenter (2001) in Guatemala were examining 210 groups of the Génesis Empresarial credit institute in a survey carried out in 1995. The research was trying to find the answer whether the heterogeneity appearing during group formation is the result of matching frictions, or is it the result of more than coincidental effects, the result of systematically worked out decision of the clients. The 2/3 of the clients of the examined program using their freedom to choose, decided to choose group loans. During the group-formation from the aspect of riskiness heterogeneous groups were created, what can be explained with the clients' need for insurance. The risky clients are buying insurances from their group mates. The goal of this transaction is expressly mutual profit from the high interest of the risky project, and not the covering of the shocks arising from sickness, weather and other exogenous shocks.

Sadoulet and his partner collected this anecdote during the query. The leader of the group, who had been running a small clothes store for 26 years, was in one group with three young adults, around the age of 25, who were to pay his installments too, if they had enough income to do so. The leader of the groups, in every case when any of his three partners couldn't pay back their actual installment paid the bank the difference. Besides the anecdote, according to Sadoulet and Carpenter the result – that in the half of the groups they group members have helped each other in the actual money deficit – is also supporting the idea of the insurance. However this latter argument can be attacked,

since the data do not mean, that the groups were created with ex ante insurance purpose, it only means, that ex post was better for supporting the partners, than the default of the whole group. Although as it can be noted from the sample, in case of homogeneous groups delayed payments are more frequent, than within heterogeneous groups, and significantly less members of the heterogeneous groups can access other credit sources, than from the members of the homogenous group.

Thus some of the practical examples confute the phenomenon of assortive matching, therefore the separation of the "safe" and the "risky" clients is not necessarily solved by group contracts instead of the institute. It is advantageous that the empirical result in the examined sample, has not worsened, but improved the punctuality of the re-payments. On the other hand the recorded anecdote is warning us, that in case of group loans, the free-rider behavior of certain group members can slow the poor members out breaking of poverty.

Ross and Savanti (2005) partially and Wydick wholly (2001) claimed a conflicting view, compared to the results cited so far, according to which the participants of the programs are estimating each other's risk taking ability during the group formation, regardless of the result, which can be a homogenous or a heterogeneous group. According to the examination of Ross and Savanti (2005) the clients of the Indian ASA and CASHPOR are not doing anything to estimate the financial state of the others (future group members) before forming a group. The explanation is, that they have known each other from before (it is true for 95% of the examined cases), they have information on the income sources of the others (60%), and in 27% of the cases they also know the size of the previous loans of the others. Wydick's (2001) results recorded in Guatemala found slightly different awareness. Relying on the interviews those who choose to be group members, in 17.4% of the cases were previously business partners, in 63.8% friends, in 27.5% neighbors and in 14.5% they were distantly familiar to each other. Wydick is interpreting the numbers, by saying that the group-members do not know of the financial state of the others satisfyingly at the moment of group formation, their relationships are from the other areas of life. But in order to access to the loan, he even accepts the not optimal group-composition, as one sort of expense of the group loan. Wydick in his work states that the screening of the group members by each other is ex post, it only happens after the group formation, and not before that, as the theoretical models claim.

Before however I would discuss the moral hazards, a short comment is needed on the composition of the groups. More works prove, that women- for example because of their lower risk taking level, and because they are exposed to social sanctions at a higher level, I will refer to this at the suitable topics- will result in loan with better quality. Kevane and Wydick (2001) in their work, which is relying on data from Guatemala, claim that the loans given to women are raising the well-being of the family better, as the loans of men, who are often using it to aggressively extend their business. The result can be in relation with the risk taking willingness.

1.5.2 The Moral Hazard and the Extent of Risk Taking

The next widespread achievement of the theoretical works is that moral hazard can be decreased along with the incentive system of the group loans (Stiglitz, 1990) or with the repeated interactions between the concerned clients (Armendariz de Aghion and Morduch, 2000). It can be diagnosed without the empirical works, that the reason can be one sort of risk-transfer, the loss arising from moral hazard is dedicated to the clients by the bank, but they have the advantage, compared to the bank, that they can motivate each other better to the „appropriate" behavior and to reach the repayment rates.

1.5.2.1 The Ex Ante Moral Hazard – The Project Selection

Many authors identify the moral hazard with the fact that the actors are carrying out the riskier project. In case of micro loans an example can be, when the shop keeper buys a higher level of inventory, and hopes that he/she can sell it, and the loan won't get stuck in the working capital. At this time, we are speaking about an ex ante moral hazard, the project selection is done, when the loan is received, not during the future duration. In the cited model of Ghatak and Guinanne the selection of the effort is the object of moral hazard. In Tirole's (2005) model we are getting closer to the result of the empirical works, when he claims, that the selection of projects, which are making private benefit, therefore they mean higher default probability is when moral hazard appears. Relying on his researches done in Guatemala Wydick (2001) is noting the contradiction, that the poor clients, who are well-known for avoiding risk are not choosing risky projects – according to other authors in some cases they are only willing to take lower risk, than the optimal level-, instead in their case the moral hazard appears, that they might spend

one portion of the loan given for investment for immediate consuming, or spent to other not revenue producing activities

The ex ante moral hazard was examined by Ross and Savanti (2005) by looking at the selection of activities, which are financed from loans. During the interviews neither the clients of ASA or CASHPOR said that anyone should have resigned from his/her original project, because of the pressure of the group, because the others did not like it. Struggling for diversification can also not be seen amongst the group members; however it happened that within one group everyone chose the same activity. The interest in the value of the loan of the others however is much higher: the group members discuss in detail, how much loan they think would be realistic for each activity.

Godquin (2004) relying on a relatively older survey (from 1991-1992), which was examining 1798 households in Bangladesh is describing the moral hazard regarding project selection. According to his results the difference between the loan's duration and the project's expected pay off period is the appearance of the moral hazard. He found that most of the loans, which seemed to be defaulted on the day of the expiration, were paid back by the borrowers within a year. That's why he concluded that moral hazard appears, because projects with a high profit margin have a longer payback period than the loan's duration in order to achieve a higher profit.

Giné, Jakiela, Karlan and Morduch (2006) as part of their research in Lima have conducted games, which belong to the methodology of experimental economics, where the typical decision making situation of the MFI clients were simulated with different conditions in their contracts. The authors examined amongst others the risk taking willingness and how can the appearance of moral hazard be decreased.

Both with individual and joint liability, the repeated one-shot and the repeated dynamic games were both carried out, in some cases allowing monitoring, punishment, cooperation and spontaneous group formation. According to the experiences of the paper, unlike the individual contract, the building in of the joint liability to the game has increased the risk taking willingness by 1-2%, while the repayment rate – compared to the individual contracts – increased from 68 to 88%. The explanation is the insurance, which was also diagnosed by Sadoulet - if at least one of the members is choosing the safe project; it is already worth for the other to choose the risky one. There is a similarly advantageous upswing is in the repayment rate (from 68% to 82%) if future loans are contingent on the successful repayment in the case of individual loans. This latter

contract is decreasing the extent of those who are choosing the risky project (amongst the players to nearly 30%). If we build in the dynamic incentives into the game, besides joint liability, then at the level of the repeated games we will meet a repayment rate of 94%, and the risk taking rate of 49% will be higher than that of individual repeated games (34%). Thus their results due to the contract elements of the group lending, show the increasing of moral hazard.

This harmful effect could be countervailed with the spontaneous formation of the groups by the authors; therefore they believe that the formation of groups with homogenous risk is more probable. (I wrote of the questionability of this result on the previous pages.) On the other hand, this latter solution causes a much lower risk taking willingness than that of the micro contractors of Lima. The clients did not want to expose their personally chosen partners - who are bounded to them with tight social ties - to payment of additional money. Since if the risky project is chosen, it can easily cause the selected partner to pay instead of the late borrower. While according to Sadoulet's and partially Gine's results the cross-financing can work between the participants, the partners who are fair with each other are resigning from the profit of this insurance, and of the enhancement of the group income, when choosing the two safe projects. This strategy is basically threatening the social goal of the micro loans, the outburst from poverty.

Thus according to the researches the group loans can both cause excessive risk taking, like the appearance of moral hazard , and also suboptimal risk taking. This Gordian knot was cut by Giné and his partners, by showing that a high repayment rate can be reached by individual liability and conditional loan renewal, like in the case of group loans, thus the problem of group loans and moral hazard can be avoided by making the individual contracts dynamic.

On the other hand relying on the data of Table 1.1., at least in the cases of the participants from Lima it can be said, that the group loans were not followed by bad repayment rates, besides monitoring and dynamic incentives a repayment rate of 94-95% is reached. Thus the conclusion of the researches cannot be the failure of group lending.

	Percent of Participants Choosing Risky Investment		Repayment rate (Percent)	
	Repeated one-shot games	Dynamic games	Repeated one-shot games	Dynamic games
Individual games	61%	34%	68%	82%
Joint liability	63%	49%	88%	94%
Joint liability – Monitoring	61%	47%	90%	95%
Joint liability - Monitoring - Communication	68%	58%	87%	91%
Joint liability - Monitoring - Communication - Partner choice	69%	53%	89%	94%
Joint liability – Monitoring – Punishments	NA	53%	NA	94%

Table 1.1.: Risk taking and repayment rate in different constructions

Source: Giné, Jakiela, Karlan and Morduch, 2006 : 33. p

1.5.2.2 The Ex Post Moral Hazard

Ross and Savanti (2005) instead of looking for the ex ante moral hazard, were seeking the examples of moral hazard after the financing was decided, this included 105 interviews with the clients of ASA and CASHPOR in India. One of the aspects of this can be, that the non-paying clients are becoming insolvent due to their own mistakes. According to their results the cause of these bankruptcies were never intentional, an event arising from moral hazard, instead it was caused by illness, extreme weather, death within the family, or the income generating family members traveled away. In the majority of the cases the group obeyed to joint liability and paid off the missing amount of the loan. When the paying problems of certain group members became too frequent, they left the group either from their own will, or because of the pressure of the group.

The ex post form of moral hazard is **strategic default**. Besley and Coate (1995) built a theoretical model, as I have referred to this earlier, what is explaining this phenomenon. When those borrowers, who can and are willing to pay back the loan in case of individual liability, due to the default of the other group members won't pay back their loans, thus joint liability is decreasing the repayment rate. This phenomenon in Besley's

and Coate's work can be prevented, if the ties are tight between the group members, i.e. the „social collateral" is valuable. Then even those will pay back the loan to avoid social sanctions, who would have gone bankrupt in the case of individual liability.

The study of Kritikos and Vigenina (2005) claims that the effects of strategic default are not important in Georgia. Columba, Gambacorta and Mistrulli (2008) examined the appearance of strategic default in a sample of Italian firms with less than 20 employees. If the firms activities are correlated, then they can monitor each others' efficiency especially well, so at an appropriate level of solvency the willingness to pay can be increased, and the appearance of strategic default be decreased.

The result given seems exciting at the first glimpse, because we would expect that joint default is more frequent in correlated projects. All of this can be explained well with the common, systematic shocks. Moreover if the borrowers are aware of this, then in case of the default of only one member, many of them could feel to temptation to use the existence of correlation to report default, because it will seem credible for the outside. Paxton (1996), who examined the groups of Burkina Faso in his dissertation, found similar results during the interviews, however the strong solidarity within the groups examined by him has caused a better repayment rate overall, than at the heterogeneous groups.

All of this however does not mean that the strategic default did not cause a great problem for the whole program. Praxton is also referring to the model of Besley and Coate and concludes, that in Burkina Faso the groups are containing five persons, therefore the income threshold, above which it worth's for a participant to also pay off the loan of the other group members is extremely increased. Therefore it is not surprising, that strategic default had a significant, negative effect on the repayment of the loans in Burkina Faso. The explanation could be the empirical example of the model of Besley and Coate. Because the participants thought that the village's peaceful social life is more important than using serious sanctions against the non-paying borrowers, therefore there was no such negative incentive, which could have scared away the borrowers from strategic default. Many of the borrowers had correlated activities, thus they used the opportunity to report default in a credible way, and the strategy of non-paying equilibrium was formed within the participants of the program. With this group loans became unsustainable, as it was predicted by Besley and Coate.

Hartarska, Caudill and Gropper (2006) in their study on the East-European MFI's claim, that amongst women the strategic default is less popular. Their explanation was that

within that specific society women usually are less mobile, than men. Because they probably have a strong tie with the local community, therefore risking these relations are especially expensive for them.

1.5.3 Monitoring and Sanctions

After examining how the appearance of moral hazard can be decreased no other topic can follow, than the investigation of monitoring, sanctions and punishments. The concepts are closely connected to each other, because the knowledge gathered during monitoring makes it possible for the community to decide who shall be punished with social sanctions. One of the often mentioned advantages of the group loans is that in this way the monitoring, what would be hard to carry out for the lender is given as a task to the borrowers.

1.5.3.1 The Mode and the Intensity of Monitoring

The common element of group loans, which is present in every program, is that the repayment happens at the weekly, fortnightly or monthly meetings. The purpose of these group trainings and discussions is evident. The formation of group consciousness is helping the strengthening of the social bonds between the members, and creates an opportunity for monitoring too. Their advantage is that the paying difficulties are going to be clear soon, when the probability of a successful intervention is higher. At this time the group can use the experience of all of its members to solve the problem. At least, but not last the group will be notified of the possibility (in time) that it can happen, that they will have to pay off the loan instead of their members (wholly or partially). Although the literature does not emphasize this aspect, but the frequent meeting with the presence of the credit administrator makes the passive monitoring possible for the lender.

The frequency of the meetings is partially influencing the extent of the passive monitoring of the lender and the intensity of the peer monitoring of the borrowers. Both the weekly, fortnightly and monthly frequencies appear in practice. Field and Pande (2008) were examining the repayment rates of clients, living in cities in India; they have found that the mentioned repayment frequency did not influence the repayment rate. However there were advantageous changes at the clients, they could avoid turning to money-lenders, usurers to produce the weekly installments, if they could produce it within a fortnight or a month. According to the authors further researches are needed in

this topic, but they claim if both the lack of conditional loan renewal, and the replacement financing met at the same time, then the decreasing of the repayment frequency cannot decrease the repayment rate.

Regarding Ross and Savanti (2005) I have partially touched the topic of monitoring, when I wrote on screening during group formation. According to their research amongst the clients of ASA and CASHPOR, 92% of the borrowers know what their group members spend the loan on. They can enumerate, how much loan was received by each group member, and officially what he/she is planning to spend it on. The data collected during the interviews is supporting the advantages provided by the group meeting, mentioned in the previous paragraph. According to the borrowers' answers, they were speaking about their business, their problems and of their future loan plans. 89% of the women asked said, that the leader of their group is visiting their stores and checks whether they spend their loans an appropriate way. One type of this monitoring is when not only the group leader but also the leader of the centre or the group members are visiting the clients. Whether the visit is done especially with this purpose or during spontaneous, everyday situations is not unified. Unlike during the group-formation when the preliminary screening relying on the common knowledge takes place, during the duration of the loan the group-members are following each other's activity, i.e. they are carrying out active monitoring.

The paper on the researches in Lima, written by Giné, Jakiela, Karlan and Morduch (2006) was already cited previously. Although their results are from simulated games, and not from the clients of real MFI's, it worth's to get to know their reasoning. They are interpreting the building in of monitoring to their researches according to a dual aspect. Because the strategic decisions of the actors concerning the riskiness of the project are known by the partner at the end of the game, therefore an originally risk averse player can switch to a risky project, after he/she has experienced that his/her partner is also avoiding risk taking. The contradictory effect of monitoring during the researches is that it is giving enough space for the sanctions; the selection of the risky project can be avenged by the partner in the next games. Relying on the date from Table 1.1., this latter affect, causing the reduction of moral hazard is stronger, thus altogether monitoring can decrease the taken risk and can improve the repayment rate.

Praxton (1996) relying on his experiences in Burkina Faso reports, that monitoring can help to find the reasonable sanctions. Because the members of the group knew each other's business well enough, they were not punishing each other for bankruptcies

arising from not foreseeable reasons, or because of financial difficulties. In the sample of Alhin and Townsend (2003) from Thailand the easy monitoring and the repayment rate were in negative connection, to which the duo did not find a sufficient explanation.
Gomez and Santor (2003) belong to the few empirical works, who were studying the effects of the lender's monitoring. Their interest in lender's monitoring can be explained by the fact that in the chosen country, in Canada the processing of micro-loans were carried out in slightly different environment, than the original MFI-target groups. By studying the samples of the clients of Calmadow Metrofound from Toronto and the Calmeadow Nova Scotia (MFI's) from Halifax they found a not significant, but positive relation between the lending monitoring and the repayment rates.

1.5.3.2 Sanctions towards the Non-Paying Members

The appropriate level of monitoring makes it possible for the group members to identify those who broke the rules of the MFI or the informal norms of the specific society and so they can use sanctions towards them. According to the professional literature this sanction has to be ex ante credible and exemplary, in order to have a retentive force to prevent the rule breaking behavior. The sanction can be the breaking or loosening the relationship with the individual, as a result it is going to be more difficult for the entrepreneur to get access to any kind of resources, and the members of the community will be less helpful with him/her.
However the author reports, that the sanctions can fail, which can have many reasons. On one hand relying on the information gathered during monitoring it can be found that the group member went bankrupt not because of his/her own fault, on the other hand it can be against the local, social norms, or inconvenient for the group members to punish one of their partners. It frequently happens that the jointly liable borrowers believe that the maintenance of the peace and the social network of the local society are more important, than the punishment. Thirdly the distribution of the social capital influences the mode and the strength of the punishment (Rai and Sjöström, 2001). It is hardly credible that the community would exclude or break every contact with the member, who they are depending on economically, or from some other aspects, for instance religious ones.
However besides the fail of the sanctions Ghatak and Guinanne (1999) also mention the problem of excessive and aggressive sanctions, referring to the works of Montgomery,

Bhattacharya and Hulme (1996). According to the study cited it happened amongst the clients of BRAC (in Bangladesh), that the group members demolished the house of their non-paying partner, and destroyed his/her assets, for instance the vegetable garden, which was producing for the market. This behavior has consequence beyond the actual physical damage. It is risking the social capital, the cohesion of the local community, which as collateral is enabling the group lending. The erosion and the drastic restructuration of the social relationships can lead to the disintegration of the local social order. (Montgomery, Bhattacharya and Hulme, 1996)

1.5.4 The Alternatives of Joint Liability

Due to the restructuration at the market of the micro loans the empirical literature was broadened with a new topic. Like many other MFI' the Grameen Bank started to offer loans with individual liability. The expansion of the individual loans is decreasing the market share of joint liability. Mainly those group loans give their space to the individual constructions, where the group members were connected with joint liability. Thus the empirical research has to investigate the advantages and the disadvantages of the group loans, firstly. The answer has to be found to the following question: why is the repayment rate of group loans showing a multi-colored picture? From the failed program of Burkina Faso to the 1.6% default rate of the Grameen Bank the group constructions can end with various results. After the studies have shown, what are the criteria of success besides joint liability in group lending, then the question arises: can a properly incentive construction be defined without joint liability what is considered to be too expensive?

1.5.4.1 The Transformation of Group Constructions after the Start of the Lending Program

Firstly I am going the present the disadvantages of the group loans, where I am going to refer to the work of Karlan and Giné (2007). The author duo also carried out researches with real MFI clients, amongst the clients of Green Bank of Caraga at the Philippines. The data of the games was recorded during 2004-2005, and was supported with surveys. According to them the alternatives of joint liability are important, but they enumerate different arguments than other authors use. Amongst the disadvantages of group liability they claim that the worst is the tension between the group members, which can

lead to the erosion of the social ties within the group, and to the weakening of the social network of the particular society. It is easy for the risky clients to chose the free riding behavior, because there is a good chance that their safe partner are going to pay instead of them, which on the other hand makes joint liability very expensive for the "good" clients. Thus besides joint liability the client recruiting can be difficult; since it is less profitable for the „good" clients to join than it is for their riskier partners.

According to their result by only taking out joint liability from group constructions, but keeping the frequent group meeting, the publicity, and the mandatory savings, the repayment rates are not decreasing, while the institute can reach a wider circle of clients. This claim of them was supported after gathering data for another three years (Karlan and Giné, 2008) In case of individual liability the tightness of the relationships within the groups changed. Surprisingly the newly joined members had a tighter previous relationship with the group, than in case of joint liability. The explanation could be, that by taking out joint liability the participants were not afraid any more to bring in family members or business partners to the program, with whom their relationships would probably deteriorate in case of a possible non-payment, if individual responsibility was present. However, all of this according to the authors did not lead to a decrease in the repayment rate.

Giné and Karlan in one of their latter works (2008) claimed that the examined groups were originally financed by the bank with join liability; they were only converted into constructions with individual liability for the sake of the research after the loan was granted. Giné and Karlan (2008) suppose that this aspect can not be neglected. However the experiences collected between the first researches presented in the original paper (2004-2005) and 2008, proves that newly joined members produced similar results in both of the researches. Their explanation is that the norms of those groups, which began with joint liability, were followed by the new members. As a further research question they appoint, after how much time, in what sort of social and macro-economical environment can the programs with joint liability be successfully transformed into individual contracts, and they would also examine whether the application of individual liability is possible already at the beginning of a program.

1.5.4.2 Individual vs. Group Loans, as the tools of Client Differentiation

While examining the advantages of the individual and the group loans and comparing the two constructions, many authors have reached an interesting result. Accordingly clients are not necessarily forced by the lender or by any other circumstances to choose group loans, but these applicants are coming from different segments of the market, than those who apply for individual loans. Therefore with the supply of both of these constructions more segments of the market can be covered, thus it is reasonable to sustain the supply of group loans.

Gomez and Santor (2003) examined whether the group or the individual loans will lead to higher repayment rates, amongst the clients of the Canadian Calmeadow. Firstly the concluded that different clients apply for the two constructions. Group loans are primarily chosen by women, clients with Spanish origin and amongst migrants. Individual liability is mainly preferred by men, black people and those who were born in Canada. They usually have a lower education, but a higher level of business skills. The incomes of their households are higher than the incomes of the group loan clients, and they are relying much more on the incomes generated by self-employment, they usually do not get any support from the state. Their starting volume of assets does not differ significantly from that of the group loan clients. The authors found many start-up firms amongst them, however usually they were the owners of older and bigger micro-firms, who had reached higher profits. Their average monthly income was a bit under 5900 dollars, whereas with group loans the average monthly income is around 2600 dollars.

After identifying the clients of the two constructions, Gomez and Santor (2003) screened out the effect of endogen construction selection, they then examine the development of the paying obedience. The frequency of non-payment at group constructions was by 17% lower, than in case of individual liability. The result is stable, if the effect of the different client circles is controlled by the calculations, since the borrowers of group loans have such a loan size and socio-demographical attributes, which leads to a low probability of default even in a simple scoring model. If however the default occurs, then the losses connected to group loans neither in absolute value, nor in percent (what basically the loss given default (LGD) indicator describes) are lower, than as it was examined at individual contracts. In the analyzed MFI's portfolio,

the expected losses therefore can be lower in case of group constructions, because the probability of nearly identical losses is lower besides joint liability.

The cautious conclusion of Gomez and Santor (2003) is, that group loans are selected by those contractors, who are risk averse, and tend to invest in safer projects, while their risky partners freely choose the individual programs to avoid the sanctions in case of a possible default. It also happens that risky borrowers are not accepted by safe borrowers as a group member and they do not have other possibility to find financing than individual contracts.

Ross and Savanti (2005) carried out interviews amongst the clients of the Indian ASA and CASHPOR. According to their results group loans were not selected by the clients due to pressure, for many of them the individual contracts were also available. From 45 women – who were asked – 36 said that they do not want to switch to an individual contract later on, even though they were planning to apply for larger loans. They claim it is advantageous to share the risk within the group; they can speak about the successes and the failures of their business. If they get into momentary money troubles, they do not have to look for informal lenders, since their partners - as from ex officio - will finance their installments temporarily.

Vigenina and Kritikos (2004) are comparing the models of individual and joint liability relying on the example of two MFI's working in Georgia, the MBG Batumi (Microfinance Bank of Georgia) and the Foundation of Costanta. Their main question is besides what conditions is one construction more advantageous, than the other. Like before they are identifying different target-groups amongst the clients of the individual and the group loans, and they have not found any signs, what would suggest that the clients only chose the group loan construction, because they did not have any other choice.

In their work they are presenting the model of individual liability trough the usual incentives of the individual contracts. The client selections and the maintenance of the paying obedience is solved by physical collateral and gold deposit by the already presented MBG. One of the most frequent critiques of individual liability is connected to this practice, because the requirement of the expensive collateral is excluding the poorest from the loans program, thus many authors suggest that in the toolkit of the MFI's it shouldn't be applied. The examined MBG also has a practice for information gathering to broaden the circle of formal, financial data, even in the case of individual liability, which concern both the firm of the applicant and his/her private income. The

visit of the bank administrator at the borrower's household, the data from the repayment of the earlier loans can both help to bank to screen the client. Although Vigenina and Kritikos (2004) do not mention how the bank has all this kind of information, when the first loan to the client is granted.

Relying on their results in case of individual liability the efforts done for screening will pay off, and will decrease the further cost of monitoring. Thus according to their suggestion the client-differentiating effect of the costly collateral does not suffice, instead the lender should gather information about the applicants with the help of the MFI's employees. Besides the physical and the gold collateral the conditional loan renewal is also increasing the repayment rates at the examined institute, with which the MFI is promising to grant larger loans in case of punctual repayment.

The comparison of the individual and the joint liability is beginning with the presentation of the construction of Constanta by Vigenina and Kritikos (2004). Here the clients are forming the groups, thus the future borrowers are screening each other. Instead of the physical collateral the group pressure is the incentive for the punctual payment, and also the conditional loan renewal appears, which usually promises the same amount of loan instead of a growing loan size, like the individual contract. The authors conclude that physical collateral can successfully be replaced by joint liability, but in case of individual liability it is a necessary accessory of the contract. The size of the loans in the group Constanta institute is 220 Euros, and at the MBG, which is providing individual loans: 965 Euros, at the examined time. Their interest rates are at the same level, which means that in order to apply joint liability, where the institute is realizing the same interest rate on a smaller amount of loans, only smaller expenses can be added.

This was accomplished when the selection, the monitoring and the forcing of payment was transferred to the clients. All of this puts a lot of expenses to the clients, thus it's questionable whether they are choosing this construction freely, or not. According to the author duo the group loan is not only chosen by those contractors, who cannot offer any assets as collateral. According to their results the two institutes have different segments of clients. The individual loans were chosen by those individuals, who had a dynamic business (and were able to lead these), higher business skill, for whom the growing loan size is important. They are sensitive to the expenses of the loan, thus also to the transactional costs connected to the group loans. The group loans are advantageous for those, whose business is static, and who are carrying out projects of the same size,

because of the quality of the activity or because of their own business skills. Those future, dynamic firms, which do not possess physical collateral actually can only turn to Constanta, what is only offering group constructions. However it can seen, that when they have collected enough collateral, they will switch to individual loans. The group loans are specifically making it possible for them to be part of the loan programs, by bursting out of poverty, and be able to grow after they were in the stagnating phase. Their result is identical to Madajewicz's study's, according to which those firms are growing dynamically, which were taking individual loans, however he also presents, why group loans shall exist.

Vigenina's and Kritikios' (2004) message, which is of great importance, and what is the conclusion of their paper, and the finishing thought of this chapter too is, that the common presence of the group and the individual liability at the Georgian market is making the path of the local contractors independent from their starting wealth.

Relying on these the joint and the individual liability are lending techniques following each other, thus till there are clients on the market, who cannot be financed by individual liability, or there is a MFI-target-group, who prefer joint liability, because according to them its a safe way, till this time joint liability is of a device of great importance in the struggle against poverty and for improvement.

1.5.5 The Role of Social Capital

During the lending process of the MFI's (micro financial institutes) the level of the repayment rate is a rudimentary issue. The riskiness of the loan portfolio can be measured with the expected loss (EL). EL is made up of three constituents: the probability of default (PD), the ratio of loss in case of non-payment called loss given default (LGD), and of the size of the loan called exposure at default (EAD).

The institutes in their constructions are using elements which influence one ore more elements of EL in a positive way. This could be the required collateral from the borrower; its form can be property, cash, stocks, or a valuable object. The primary function of the collateral to reduce the loss in case of default is evident. However the accomplishment of the collateral need - what is also a sign towards the bank - helps to select the potentially good clients.

If the collateral is valuable for the borrower, then the paying probability of the client is increasing too, since he/she is carrying out serious efforts, in order to keep the

collateral. The innovation of the MFI's is, that if the two latter functions of the collateral are fulfilled, then such a construction can be made, which is screening the clients, and increasing the repayment willingness of the selected clients. Therefore the banks in certain cases are asking for collaterals which are only valuable for the clients. This could be the family's only goat, cow, or furniture, which is important for the family (Sengupta - Aubuchon, 2008). However most frequently the collateral is not even a physical object, instead it is the reputation of the borrower, the honor, what is surrounding him/her in the small village community, his/her social and family relationships.

Usually the social environment of the borrowers is primarily important in case of group loans. This valuable, but not physical form of collateral is referred by the authors as : „social capital", „social ties" and „social connections". It is not the purpose of this short sub-chapter to define social capital in a detailed way, however this sort of basic works can be Coleman (1988) and Portes (1998), and we can also read about the network of social ties in Scott's (1981) work. On the following pages instead of definitions used in sociology I am going to use the definition from Karlan (2005)'s work. He defines „social connections as the links and commonalities that bind a group of people together and determine their social interactions." (Karlan, 2005:2.p.) In Karlan's work the information on the others, the possibility of information gathering and the ability to influence the behavior of others can be all forms of the social capital. Although Karlan is using the expression: social capital, other authors have used the tightness of the social ties in their papers. These are different concepts, but even without sociological definitions we can feel the tissue of society, its strength, and its density is giving the environment, what is surrounding the incentives of micro lending, it also fulfills the criteria system of the model (which has spread in the literature), or it is confuting it before modeling could even start.

Social capital appears from three different aspects in the literature. Relying on Cassar, Cowley and Wydick (2007) there are three points of view: the tightness of the ties between the participants is an important dimension of the social capital; the social capital connected to the flow of information helps the group loans; and the social capital from the aspect of the success of the program is only secondary. Thus social capital contributes several ways to the success of group programs. If the group can be formed by the clients themselves, then the social capital is effecting the selection. During the duration of the loan monitoring gets as easier as tight the (informational) relationship

between the members in their ordinary life. Moral hazard decreases because borrowers want to avoid the informal sanctions based on the information gathered during the monitoring, and they do not risk losing complex connection network, which is one possible form of sanctions.

According to the results of Karlan (2004), who carried out researches amongst the clients of FINCA in Lima, if the social capital is strong then the selection done by the clients and the monitoring cost less. Relying on his ascertainment the strength of the capital helps the poor to get access to the loans in total. The amount of social capital each client has determines to what extent his/her activity can be monitored, and how effectively can he/she follow the business of the others. On the other hand it causes higher repayment rates in case of already processed loans, because cumulated savings of borrowers helps the participants to meet the repayment requirements. The reason why social capital, just like the physical objects, or other valuable, material things can serve as collateral during the lending, is that the participants are as afraid of losing them, as if it was a physical asset.

Those borrowers who possess more social capital are more likely to pay back their loans, and their payments are also more punctual. However non-payment does not mean that the social capital is lost. As I have cited before, the group members can differentiate whether their partner went bankrupt because of an external shock, or because of his/her own mistake, and the sanctions are carried or not carried out accordingly. The phenomenon is explained again by the social capital which connects the group members, and it makes risk sharing possible between them.

On the other hand Karlan (2004), referring to Rai's and Sjöström's (2001) work is telling us, that according to the author duo those individuals who have a higher amount of social capital are punished in a weaker way, as a result for them the motivation system of the group loans is not as effective. An explanation can be that the punishment of these individuals would weaken or cut the advantageous social connections of the group members, which are bonding the members to the punishable, but socially embedded individuals. Thus the sanction would become excessively expensive. Relying on Karlan (2007), following the sanctions the social relationships transform. The non-paying borrowers lose from the trust of the others and from their business connections to a small extent, but more frequently than their appropriate paying borrowers.

The Canadian researches of Gomez and Santor also report, that the individuals in a group with a low trust level towards the other members had a lower repayment rate,

than those clients, who were filled with trust already before the loan program. Their result is limited, because the research did not examine why the group members selected each other, and they do not analyze whether the higher repayment rates can be caused by some latent factor, what correlates with social capital.

Relying on the sources the high level of social capital is influencing the repayment of the group loans, and at many point the lending process itself. Ghatak and Guinanne (1999) report the contrary case, of the low level of social capital. In the rarely inhabited areas of Canada and Arkansas, the level of group solidarity within the group loan programs where very low, because next to the evident difficulties of monitoring, the relationship between the members was looser too. In these cases it is important to find, what common motivation determines the behavior of the members. In Malaysia for instance the AIM program built in the common religion to the incentives. Thus the repayment of the loans got a transcendent importance. (Ghatak and Guinanne, 1999) Wydick's (1999) results from Guatemala also attribute only a small importance to the previously existing social relationships between the group members. He states that these relationships will be formed during the monitoring.

By examining the data of BAAC (from Thailand) Ahlin and Townsend (2007) report of the negative effects of the tight social ties. Their result that there is a negative correlation between the repayment rate and the social capital can be hardly explained. They have found if the tightness of the social connections and the cooperation between the members prevents sanctions, then social ties influence the group loan-constructions in a negative way. If the social network of the group is made to serve the punishments (by the participants), then the social connections can cause the improvement of the paying obedience.

The specialty of these sources is, that they do not use the multi-dimensional meaning of social capital, they do not differentiate its various levels and accordingly they have different conclusions. The work of Cassar, Crowley and Wydick (2007) is filling this gap, and examines the effect of the several elements of social capital separately. The trust in the whole society, the trust toward the group-members, the trust relying on the positive payment experiences, and the strength of the actual relationships, which existed previously amongst the group members is the four, which makes up the dimension of social capital in the cited work. Cassar and his partners carried out researches in South-Africa and in Armenia. In their games the trust between the participants was measured, they only began the game simulating the group loans afterwards. According to their

result the high level of trust amongst the group members, which was measured by the question: “Would you lend (person x) 1000 drams?”, is of great importance from the aspect of the repayment rate of the group. The usual trust in the other members of the society compared to this is negligible. The groups with homogenous social position were usually paying back their loans at a higher rate, than the heterogeneous groups. In South-Africa those who belonged to the same clan, in Armenia those who had been living in the same area close to each other were taken homogenous by the authors from social aspects. The mere connections did not influence the appearance of the group, thus according to Cassar and his partners the potential of social sanctions does not belong to the important constituents of the social capital. Their conclusion was derived from the following: the minimal requirement of the execution of the sanctions is a loose connection with the punishable person, which is called „my acquaintance” category by the authors.

1.5.6 The Realization of the Group Loan Programs in the Developed Countries

From the aspect of the thesis it is an important question, whether the models of the group loans which were successful in the Third World can be applied in the more developed countries. Since in the second part of the thesis my own model contains certain elements of the group loan-constructions; I am going to examine, whether it worth’s to apply the joint liability developed for Third World entrepreneurs for the Hungarian micro and small- and medium sized enterprises (SME). Relying on the previous chapters of my thesis there are pro and contra arguments and therefore it is an emphatic question, whether there is a possibility to apply joint liability relying on empiric researches, to communities which are not rural communities any more, and there are not any traditional social framework and dense connection network.

Anyhow there can be a need from the countries, whose industry is much more developed than the Third World Countries’, but whose market economy is at a very low level compared to the western countries. For instance de Aghion and Morduch (2000) have shown trough the example of Russia, Albania, China and more post socialist countries nearly 10 years ago, thus not only the poverty of the potential clients can cause the lack of collateral. There can be institutional limits of the bank requiring costly physical collateral from its clients, who can signal this way that they are going to be

„good" clients, the collateral incites them to pay, and in case of non-payment it decreases the loss of the bank.

If any of the followings is missing: rules concerning property rights, the bankruptcy laws, or any laws concerning the functioning of the bank, or if it's not appropriate, than the banks cannot effectively use the potential of the collateral. The same result arises, if the appropriate laws exist, but their processing is slow and difficult, therefore the rightful validation becomes contingent. Besides the wealth of the potential clients the institutional limits can also be the reason, why instead of physical collateral the innovative lending techniques are applied, thus it is an important question in any case how to apply the group loans outside of the Third World countries.

Conlin (1998) sums up in the following five points, why is it difficult to transfer those constructions, which are working well in the Third World to more developed economies. It was easy to attach the more important elements of group loans to his five aspects:

- In those societies, where group loans usually work well, the level of mobility is minimal; the members of society usually live their lives within the same village, where they were born. Thus group pressure and the fear of sanctions is a serious motivational force.
- In the examined countries the members of the specific society are doing very similar economical activities, their micro firms are working on similar projects.
- The future group members know each other from before; they can be connected to each other in the local community by many ties. These two latter aspects help to select the „safe" or „risky" partners for the particular participant during the monitoring and group formation.
- The firms in the Third World are acting at a transparent market; their business is simple, while their companions from the developed world have to face with more complex environmental effects. Thus in the original constructions there is a strong connection between the success of the firms and the efforts of the contractor. In this case it is easier to eliminate moral hazard, because the not appropriate behavior will come to light at a high probability, due to the probable failure of the project.

- On the other hand in the developed countries the lending history of the firms is available for the banks, what is encouraging the banks for a more traditional credit approval.

As many authors mention there are many unmapped topics about group lending waiting for empirical researches; there are even less works written so far of the realization of the programs outside of the developing countries. Thus I can only refer to a few authors when I present how the five enumerated aspects prevent the transformation of group loans, or to what extent the models have to be adapted in more developed countries.

A relatively earlier study from 1998 was written by Michal Conlin, who based his studies on the results of the loan programs of Canada and the U.S.A. He has built theoretical models, which are in harmony with the economical circumstances, and the local empirical results of his own country, and thus the models are able to explain even these special, local aspects. When the study was born there were nearly 250 micro loan programs running in the U.S.A., amongst these 51 also used group loans. Conlin presented only five programs, and he has determined the most important differences from the Grameen model, which is used as a reference point.

While the financing of the Bangladeshi clients is a device in the struggle against poverty, where the access to the basic health and educational goods, and the improvement of the quality of life and the outburst from poverty is the goal; on the other hand the Canadian and the American programs want to increase the level of self-employment and the willingness to entrepreneurship of the contractors. The most important difference of these constructions is, compared to the Grameen model that every examined program decreased the weight of joint liability - either already from the start, or during the duration because of high default rates (40%). In a case where one of the group members does not pay back his/her loan, the conditional loan renewal won't be applied for the other group members. Because these contractors have very different businesses with complex environmental conditions, therefore the training programs are more emphatic before the processing of the loan, and the employees of the MFI's are providing a permanent possibility for consulting for their clients.

As the time has passed, the requirements towards the future borrowers became greater. Besides the participation on the trainings and the formation of the groups participants have to prepare a business plan which has to be approved by the group and/or the loan administrator. In certain cases full loan application documentation has to be turned in,

with which the future client is encouraged to structure his/her business plans. In parallel with all of this the expense level of the American and the Canadian MFI's is much higher, than their counterparts' in the Third World. Because the decrease of the expense level is a basic requirement of the long run sustainability, thus many of the examined programs make the groups organize their weekly, fortnightly or perhaps monthly meetings, and also provide a place for this. It points towards this direction too, that the group members are deciding about each other's loan applications, even if it can be questionable from the aspects of incentives and moral hazard. (Conlin, 1998).

Gomez and Santor (2003) are examining whether the repayment rates at the group constructions or at the individual loans is more advantageous trough the examples of Calmeadow Metrofound from Toronto, and Calmeadow Nova Scotia from Halifax. In their work they do not write about the realization of the programs and about the details of the particular constructions, however from their study we might know that 21% of the clients of Calmeadow were already registered as non-payers within a group program, while the same figure was 41% in the individual constructions. 8% of the whole loan portfolio was written off because of non-payment, which is a high number amongst the MFI's, however in North America, we could say it is the average rate. Thus a cautious conclusion can be derived from the data, that the MFI'in the North American societies are working with a greater loss, than their counterparts in the Third World. The reason can be, that in America the constructions can be only applied in a limited way. The loan amounts, just like in Conlin's (1998) case, where much higher than the amounts in the Third World. The group loans vary from 500-5.000 dollars, the magnitude of the individual loans is 1.000-15.000, and the averages were always 1.000-3954 dollar. The duration can be from one year up to 60 months.

For Europe and the post communist countries there are studies (Hartarska, 2003; Hartarska, Caudill and Gropper, 2006), which touch on the question of group loans. In East-Europe and in Central Asia the MFI's faced with unusual difficulties, when they began to work in the '90's. In these countries entrepreneurship and the business culture was unknown, and the financial system also had many gaps, the donation institutes were not restarted their activity in the society yet. The state was mistrustful with the entrepreneurs, instead of encouraging the business attitude; the state has over regulated the firms' functioning. Thus the entrepreneurs had to face financial and institutional limits at the same time. Meanwhile the banks of the area had to work within a strict frame, because the bank sector was also regulated due to their important economical

goal, which made the financing of the smallest firms harder. The MFI's had to begin their existence in this economical sphere, and additionally they were financing themselves from loans in a much higher proportion than the MFI's in the other parts of the world, thus there sustainability and profit had an important role from the beginning.
Perhaps this is the reason why despite their young age (usually five yeas) the MFI's in East-Europe and in Central Asia, had a higher return on in their loan portfolio (annually 35%) and why their operational self-sustaining-ability is better than the international average. The return on the world wide industry portfolio was 29%, while the institutes of the whole industry were usually older (9 years old) than MFI's in East-Europe and in Central Asia , but their self-sustaining ability was 8% lower than that of the examined region.
To sum up, in the examined regions the micro financial models can be successfully applied, although Hartarska and his partners are not presenting the concrete constructions of the MFI's of their examples. They examine how group lending helps the success of the MFI's, and according to their analysis the fact of group constructions significantly decrease the expense level of the examined institutes, and contribute to the profitability. This latter claim is, why their results were mentioned in this sub-chapter, what support the idea, that group loans can successfully be adapted to more developed countries, and they are amongst the factors, which are providing success.
However the construction of group loans in these highly industrialized countries can differ from, what most of the people mean by it, inappropriately, i.e. the exclusive model of joint liability. Joint liability is only one element of the Grameen model, sequential lending, conditional loan renewal are both important incentives in the Bangladeshi construction. In their paper de Aghion and Morduch (2000) claim that by leaving out joint liability, by group meetings and paying in front of each other the group pressure can be kept. Besides conditional loan renewal the growing amount of the loan is increasing the expenses of a possible default for the individually liable borrowers. The expenses of the bank can decrease if the trainings are organized for large group of borrowers and the bank employees can contact a large number of borrowers at the same training. Using this modified concept of group loans, group lending is a well-working practice in Macedonia, Bulgaria, Croatia, Romania and also in Poland and Russia with those clients, who apply for loans smaller than 1.000 dollars.
Lublóy, Tóth and Vermes (2008) present four group financed models, of which I have presented the Grameen's loans earlier. The failure of the group based student loans of

the Yale University is explained by the high standard deviation of the future income of the participants, thus the repayment schedule was wrongly defined. Because the borrowers – who were cross-financing each other's loans - did not know the other participants, thus they could not encourage each other to pay back their loans. The Hungarian Mikrohitel Rt (Microloan Share Company) adopted the Grameen model, and the program achieved a default rate of 30%. The authors explain the failure of the program with the lack of the social network and the project control. The model of students loans can be described with logic similar to that of group loans, a detailed description of the topic is the Ph.D. thesis of Berlinger (2003).

The recent local initiative is connected to the Kiútprogram Zrt. ("Egress Program" Privately Held Share Company) non-profit organization. In the pilot period of the program (June, 2010 – June, 2012) the Raiffeisen Banks is the partner in lending, the bank is granting the resources and providing the lending service. The financing partially made up of the Új Magyarország Mikrohitel Program (New Hungary Microloan Program), is also supported by the European Union and the donation of private enterprises. 20% of the lending losses is taken by the Raiffeisen Bank, the other 80% has to be covered by the involved guarantee funds (Újlaky, May, 2010).

The target-groups were narrowed to four areas with different geographical attributes:

- Budapest, the VIIIth district, Magdolna quarter
- the most disadvantaged agricultural areas - Hodász
- less disadvantaged agricultural areas with infrastructure - Igric
- small villages close to Miskolc and Ózd, where the population used to work in the heavy industry (especially in mining) of the two cities

(Source: www.kiutprogram.hu Downloaded: February, 2011)

The construction is providing both savings and loans for its clients, where those who are applying for the loans for the first time can only use the loan for income producing investments. The amount of the loans is changing according to the needs, the repayment starts immediately in weekly payments which has a form of an annuity. The annual interest rate of the loans is 20 %, on the savings the interest is lower with 5 percentage points. The lending process is built on the Grameen paradigm, as shown in Figure 1.1. It's important however, that joint liability is not part of the construction; only conditional loan renewal is built in to the program. Like the other MFI's the program tries to form some non-financial basic norms among the borrowers. Besides the

avoidance of usury loans, the active participation in social life, solidarity towards others, conscious treatment of their own cases or self-training (if it's possible), studying are all values, which are mediated by the program toward the participants.
(Újlaky, May, 2010 and www.kiutprogram.hu - downloaded in February, 2011)

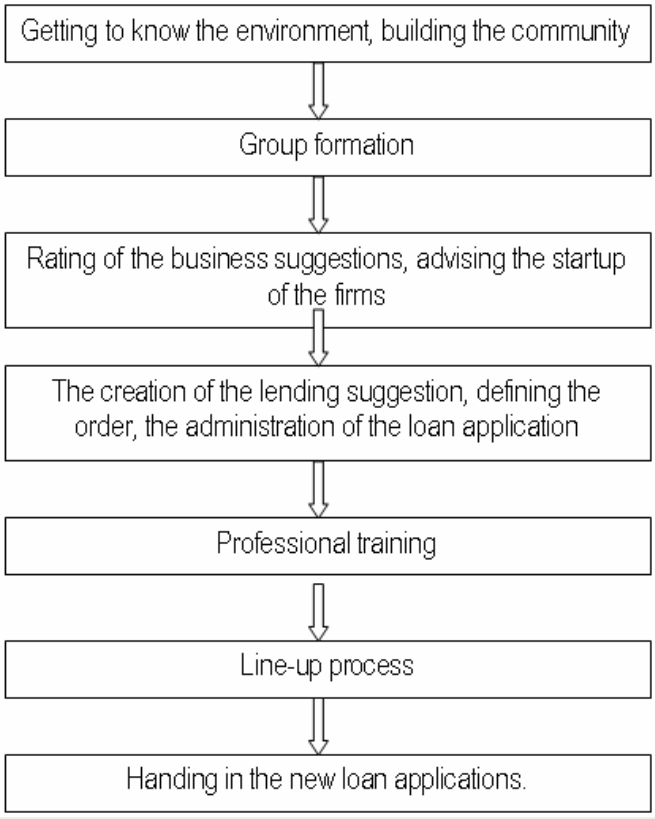


Figure 1.1.: The lending process of the Kiútprogram ("Egress Program")
Source: http://kiutprogram.hu/rolunk/konstrukcio (downloaded: February, 2011)

According to the interview with the program leaders, the local realization met several unexpected obstacles. For instance it turned out that one of the most successful looking clients has tens of millions of debts towards the Hungarian Tax Administration, because years ago he gave home to a „bill factory" at his permanent address (Újlaky, May, 2010.)
About the edification of similar cases the program's homepage also reports:

- The members of the target-group had much more (mostly expired) bank debts, than it was supposed.
- The expired debts of the target-group exceed the expected level.

- None of the firms can be started without formal adult education; this excludes those from the target-group, who did not pass the first 8 grades of school. (http://www.kiutprogram.hu/files/doc/88/beszamolo.pdf 3 pages, Downloaded: February, 2011)
- The providing of the legal framework is putting such financial weight on the borrowers (for instance the financial implications of the employment), which hardly enables to plan the business, even only theoretically. Local contractors are unable to meet the administrative obligations without the support of the field agents of the program. (Újlaky, May, 2010.)

For all of the above listed reasons the formation of the groups happened later than expected, however in January, 2011 nearly 30 groups were functioning in the country.

The forecasted repayment rate of 75% is not met; in 2011 thee default rate reached 44%. (http://www.kiutprogram.hu/files/doc/311/interim-report-2011-june-submitted-to-the-european-commission.doc - Downloaded September, 2011)

1.5.7 Critiques and New Tendencies in Group Lending

In the growing literature of group loans the critics have an important role. In chapter 1.5.6. I will sum up the more important theoretical and empirical critics, and I will present what tendencies can be seen in this topic.

Group loans as one type of micro-financial services are often accused, by saying that it doesn't realize Yunus' goal effectively, namely it does not realize the struggle against poverty. These critiques are usually at a more average level than group loans and they are connected to the whole field of microfinance. Results are difficult to judge because there is not any accepted index to measure poverty; therefore its decrease can hardly be interpreted. The MFI's are often accused by the following charges: they put too high interest rates to their clients, and they only finance the "*better-off-poor*" layer. A counter example is provided by Wenner (1995), who has experienced amongst the clients of the Costa Rican FINCA that the "better-off-poor" layer tends to honor the group loans of FINCA less, because they have access to other possibilities. All of these problems concern microfinance in general, thus I have only mentioned them in the beginning of the paragraph. I am concentrating on the factors which are specifically connected to the group loan program.

During the realization of the group loans several frequent client-complains were registered in the literature. Although the constructions really decrease the expenses of monitoring and screening at the particular institute, these expenses – originally taken by the lender in an individual liability construction – have to be taken by the clients. If the residence of the clients is far from the location of the weekly meetings, then the traveling cost, and the time spent with traveling and the fatigue's alternative expenses mean high extra expenses for the clients. de Aghion and Morduch (2000) regarding three micro-loan programs in China report, that 8% of the clients had to walk for more than an hour to get to the group-meeting. The time spent on traveling and on group meetings was usually over a 100 minutes. But to interpret the figures it is important to know that the weekly meetings were also designed to measure the willingness of the clients, and they function as a screener too. The MFI supposes that those firms will spend their time on meetings and will pay the expenses, who are expecting high income from their projects, thus it worth's for them to have access to external financing, even if the transaction costs are high (Kritikos and Vigenina, 2005).

According to de Aghion and Morduch (2000) in the Grameen model, and also in many of it's followers the members decide about the size of the loans during the group formation, because that is the amount for which they will be jointly liable. All of this can limit the growing potential of the micro firms, it negatively holds them back, and prevents them from reaching a higher income level and also thwarts the possibility of the outburst from poverty. This critic however is weakened by the fact that Ross and Savanti (2005) reached different results, non of the interviewed borrowers of ASA and CASHPOOR said that anybody was made to modify his original project or the loan amount. Of course it is a question, whether the group members previously adopted their needs to a level what according to them the other members of the group would also accept.

Although Hartraska, Caudill and Gropper (2006) by examining the micro loan programs running in Central-Asia and East-Europe have found that the institutes offering group loans are working with lower expense level, however more authors list the high expenses of the loans to the disadvantages, which has to be paid by the donors or those clients who live in poverty. (For instance: de Aghion and Morduch (2000)). The traditional counterarguments are that for the quick and relatively safe loans it worth's to pay high expenses, because the alternative of the group loan programs are not usually the cheaper individual loans, but the more expensive usury loans, or the functioning

without loans. But regardless of this counterargument, let's see the results of the researches, which concern our topic!

Bhatt and Tang (1998) in their study analyze in detail the transaction costs of the lender and the clients. The advantages of the MFI's is according to them that they are offering loans adopted to the unique local attributes, with low transaction costs. The screening and the selection of the clients, the monitoring and the pressure done to enforce repayment is replaced from the lender - who would probably fail with these activities - to the clients. Because the typical clients of the group loans usually live in communities, where the social ties are tight, therefore relying on Karlan (2007) it can be supposed, that the expenses of monitoring are much lower there, than those of the MFI. Next to their new tasks the clients have the advantage that they can receive a loan without the examination of their creditworthiness, excluding complex documentation, and they don't even have to provide physical collateral to support their loans. Relying on these arguments the group programs should run at a much lower cost level, than they have in reality.

According to Bhatt and Thang (1998) this phenomenon has more explanation. Many MFI's do not reach financial sustainability, they always need external donors, or they are financed by loans, and the interest of course increases the expense level. Secondly they claim, that the labor expenses vary from region to region. While in Asia one worker costs 5.000 dollar, in the U.S.A. 25.000-30.000 dollars has to be spent on each employee. These factors can appear both at the individual and the group loans, thus the two arguments of the author duo cannot be wholly accepted.

It varies from institute to institute, how much an MFI can spend on client recruiting, on the access of the poorest segments, on trainings before and during the duration and on consulting possibilities. We have seen, that in some of the constructions even the providing of the location of the trainings is the task of the clients, however the other extreme example is, when the employees of the bank are consulting with each of the clients separated to assure the client's success. The different studies, which are supporting the opinion of the higher or lower expenses of the group loans compared to the individual ones, are not mentioning these important constituents of the constructions, when they are presenting their results. Bhat and Thang are referring to these aspects, when they are explaining the success or the failure of the American group loan programs, which were not understood by others.

After presenting the real and the hidden extra expenses of the clients and the transaction costs, let's see some thoughts on the sustainability of the loans. Since more and more MFI's are working in different countries of the world, and the financial resources, especially the financial resources cheaper than the market based financing are replaced by loans or other kind of liability every institute has to work besides a dual goal: both financial sustainability and the access of the largest possible layer of the poor are necessary. Relying on Hermes and Lensink (2007a-b) the exemplary Grameen Bank was not always self-sustaining; from 1985 to 1986 it would have had to lay out loans at an interest rate of 75% in order to reach a profit margin of 0%. By today the MFI's are forced to produce profit, that is the reason why it is an important question whether group or individual loans are serving profitability better.

According to Cull, Demirguc-Kunt and Morduch (2007) amongst those institutes which are offering individual loans there are many self-sustaining institutes who do not need donors. But their circle of clients has also changed compared to the other actor's of the market. The ratio of those who live in deep poverty and women are lower within the individual loan portfolios, than it is in case of group constructions. The so called mission drift (Ghosh and van Tassel, 2008b) is especially emphatic, if the MFI offering individual loans is moving on a quick growing track, which is not frequent at the level of group constructions.

Although the individual loans, if the loan interest rates exceed the level, which would be acceptable for the clients, it will lead to an increase of the expected loss of the bank. This phenomenon cannot be noticed at the group loan level, which is explained by the authors with efficiency of monitoring and group pressure. Relying on these Cull, Demirguc-Kunt and Morduch (2007) claim that it is especially important, that at the level of a particular MFI and the level of the whole micro financial market group and individual loans should be balanced.

The trade off between the access to the poor and sustainability, the connected critiques, the weaknesses of the group loans and the controversies of the models could be listed in a more detailed way. In the chapter, which was introducing the empirical results I have presented these results too, which fully or partially contradict to the predictions of the theoretical models, and could be rightfully listed amongst the critiques of group loans. Such questionable point was the homogeneity of groups or the execution of the sanctions. Those cases of ex post moral hazard appeared as a disadvantage, when the individual was able to pay, but he/she could not cover his/her partner's loan too that is

why even the individually solvent client reported default besides the model of group financing. (Besley and Coate, 1995; Paxton, 1996; Ahlin and Townsend, 2003). This latter, additional moral hazard has to be treated as a serious risk factor. However I won't go into detail in these topics, as possible critical points repeatedly, I have already introduced them.

The critics listed so far are all connected to the realization of group loans. However in the professional literature the most serious critical topic was not the possible obstacles of the realization, but the space loss of the group loans. Earlier chapters introducing the theoretical works, amongst them the multi-period models are justifying, the decline of joint liability, and explaining why individual programs proved to be more sustainable. Thus I won't cover these often critical, theoretical works once more.

1.5.7.1 Thinking on the margin of microfinance – the blaze and fall of Muhammad Yunus?

As I have noted in the previous chapter, the literature of microfinance and group lending grows dynamically, and the judgment of these programs changes rapidly. The scandal around Yunus, which burst out after I wrote the previous chapters did not help in the objective investigation of the topic. Because there were no scientific reactions to the news at the end of 2010 - that Yunus used Norwegian donation for other purposes than intended - I believe that these do not decrease the advantages, disadvantages and previous results of the group loans from a professional aspect, they „only" decrease the fame of the Grameen Bank, which is an emblematic symbol of group lending.

However, I wouldn't think that my thesis is complete, if I did not say a word about the events of the spring of 2011 – when I was finishing this thesis – of the scandal around Yunus. As I have mentioned scientific reactions cannot yet be reached in this topic, that's the reason why I have to use the international media as a source.

On December 1st, the NRK, Norwegian National TV Channel broadcasted a document movie, according to which Yunus had used the donation the NORAD donating organization unduly. The donation was of a worth equaling 100 million dollars. According to the original donor contract, the capital should have been used for the processing of micro loans by the Grameen Bank, however Yunus has transferred the amount to the sister company of the bank, to Grameen Kalyan, what does not offer lending services at all. Three days after the broadcast the Norwegian minister for

Development and Environs, Erik Solheim quickly confuted, that embezzlement or corruption occurred, however the fact that the capital was not used according to the contract is not praiseworthy according to him. After his speech the attacks against Yunus became stronger. (Chowdhury, 2010; Fülöp, 2010; Polgreen, 2011)

On the 4th of December, 2010 the Asia Times Online published the correspondence of the Norwegian and the Bangladeshi governments and Yunus about the events of 1996 in detail. According to the article - and other news published in those days - Yunus could not give any acceptable explanation during one year about the fact that he transferred the donation to the Kalyon company, and why would that serve the struggle against poverty better, than the originally signed usage. This correspondence was ended by a meeting in April, 1998. Yunus, who was about to travel to Norway asked for an appointment with the president of the NORAD in a private letter, who according to the Asia Times Online stopped the further questions. (Chowdhury, 2010)

Concerning Yunus, the description of the events is more advantageous in the further articles, which were mainly based on the New York Times from January, 2011. According to them Yunus's human immaculacy is not questionable, but the transparency of the Grameen Bank and the connected enterprise groups has to be solved in the long run, since Yunus, who is over 70 cannot be in a leading position for a longer time. Than the creditability of the institute will be indispensable, after Yunus's fame will not be able to replace it. (Fülöp, 2011; Polgreen, 2011).

The New York Times also interprets the resuscitation of the story from 1996 as a part of a systematic political attack. Since all of this coincides with libel trial, which happened in the January of 2011, what was started by a local politician against Yunus back in 2007, because the Nobel Prize winner banker called to Bangladeshi political elite corrupt.

Also recently (spring of 2011) the yoghurt-falsification scandal is actual. The goal of the common program of the Grameen and the Danone was to force back malnutrition in ten years. The environmentally friendly package and the selling of the yoghurts will also provide income for the Bangladeshi women. The consumption of one yoghurt each they, can cover the most important daily vitamin and nutrient need of the children. According to the charges from the February of 2011, the yoghurt is falsified and could be harmful for the health, for what Yunus has to go to court. The judgment can be born only in years.

Parallel with the yoghurt-case the Bangladeshi government – as the owner of 25% of Grameen Bank - began an investigation against the Grameen Bank at the end of 2010. In February, 2011 the minister for finance warned Yunus to resign. By returning to the state of the 1980s', the government plans to have 60% ownership in the bank (Polgreen, 2011).

According to the international media Seikh Haszina Wazed, current prime minister is in the background of the attacks. The personal antipathy of her was trotted out in 2007 when Yunus seemed to start a political career; he has even founded a party. Later on Yunus gave up these plans, but since then Haszina Wazed sees him as a political opponent, who has to be defeated with every possible device (Fülöp, 2011; Polgreen, 2011).

The supporters of Yunus believe that this situation is regrettable, because the Grameen Bank was not only the pioneer of the micro-loans, but its more dedicated to the help of the poor than many other MFI's, amongst them I have already mentioned the extreme example of Compartamos Bank MFI. The interest rates of the Grameen are not too high compared to the interest rates of the other MFI's and the 75% of the Grameen Bank is owned by the clients themselves, thus the major part of the produced profit is in the hand of the target-group. (Polgreen, 2011) The future of Yunus's and the institutes created by him is questionable now. In addition the interpretation of the events, which I have presented on the previous pages, can change, since there are more investigations in process. Thus I look at chapter 1.5.6.1. of the thesis only as a snapshot, which contains the information available in April, 2011, however it won't change to claims of the earlier chapter essentially, it is only an interesting addition to them.

2 A Model of Bank Financing for Companies in the Case of Customer Non-payment

In the first part of present paper, I provided an overview of existing microfinance – and more specifically: group lending – models and previous empirical findings. Supporters of these financial instruments hail group loans as the means of opening up the banking services market to layers of the society which have previously been considered unbankable. It was the first part, as well, where we reviewed the works concerned with the feasibility of group lending in more developed countries. Hence the topic of the second part: to what extent can the entire model or some specific elements of it be adopted in and adapted to the Hungarian economy. As at the time of writing the draft of present paper (summer of 2009), experience about lending activities targeting those living in deep poverty (and successful projects, especially) was far from abundant, I had to focus on other topics. (Even though the government's „Kiút" (meaning: „the way out") project was already in place when finalizing the manuscript of this thesis in April 2011, any conclusions would have been definitely premature.)

Accordingly, I started to look for a target group not or at least (in their own view) not sufficiently served by the domestic banking system. I do not intend to suggest that the Hungarian SME sector as a clientele is perfectly similar to the unbankable microentrepreneurs of the Third World living on 1-2 dollars a day, yet they undoubtedly have to face credit rationing. Thus, in the second part of the paper, I will first build a model based on this empirical experience by further elaborating on Jean Tirole's model for external financing under conditions of information asymmetry and moral hazard. Two factors rather typical in Hungary, namely late payer customers and defaulted customers, will be introduced to the framework of the model.

Given the theoretical evidence for the obvious expectation that any customer-related credit risk will also increase the level of credit risk represented by the supplier which then again reduces the maximum external financing available to the supplier, I am going to employ group lending models to examine a number of instruments in order to determine whether they might help reduce credit rationing. The motivation for doing so is that a chain of overdue payables induces a heavy interdependence of businesses in terms of their ability and willingness to pay. If this involuntary dependence indeed exists, we should examine whether its „institutionalization", namely its introduction into

the terms and conditions of lending, might help obtain external financing. Let us find out whether the requirement of additional collateral if an explicit form of supply chain credit risk was included in credit contracts would be more difficult for entrepreneurs to meet than the terms and conditions of customized credit facilities.

Accordingly, I will develop model variants specifically adapted to our domestic conditions. I will also explore whether joint liability lending indeed facilitates external financing or, as the critiques cited earlier suggest, it rather puts an unjustifiable amount of additional burden on the borrowers. Model results will be evaluated in terms of general and customer-related credit rationing, total welfare effect, the owners' cash flow and the bank's expected profit.

Statistics about the payment morale definitely confirm the relevance of the topic and that it is worth building a model. According to the SME overview of the Institute for Economic and Enterprise Research (GVI) published in early 2008, nearly one third of the customers of Hungarian SMEs had been late payers during 2007, which also meant the delayed collection of one third of their sales revenue. It has become commonplace knowledge that it is the construction sector which is most severely afflicted by circular debts. The picture is, however, somewhat altered by the fact that some 49 percent of total revenue in the economic services sector was collected late, exceeding the 46 percent figure of the construction industry. For larger enterprises, the proportion of customers with overdue bills is lower, though not significantly. The same holds true for exporters. Thus, according to the data, it is the construction companies, or at least those producing for the domestic market, which are most affected by the delayed collection of revenues. Which then again turns into a circular debt whenever the customer's delay prevents the supplier from meeting its own liabilities as they fall due. In 2007 such an event was reported by 42 percent of responding enterprises, in contrast to previous years' 30 percent figure (Papp, 2008).

Consequences might take the form of deteriorating efficiency indices (average collection period, average turnover of payables), difficulties in liquidity planning (if delays come unexpected) or weak liquidity (if it is „only" the delays common to the industry). Even though trade credits are a widely used source of SME financing in other countries, as well, that does not usually disqualify SMEs from bank financing. Delayed payments and circular debt, however, adversely affect enterprises' chances when applying for bank loans. In addition to the applicant's own payment history, commercial banks' credit scoring systems also assess the payment discipline of their major partners.

This problem is anything but unknown in our region. The 2001 study of Will Bartlett and Vladimir Bukvic, for example, strived to identify the barriers to SME growth in Slovenia. Even though 49.12 percent of all responding Slovenian SMEs considered delayed receivables a serious problem, the effect of delayed payments was found not to be significant in the study's model of competitive disadvantages. The authors attributed the factor's weak explanatory power to the phenomenon affecting the entire SME sector, competitive and uncompetitive entrepreneurs alike.

Supplier payables and other short term liabilities are not only important in Hungary, but also in the US, for instance, where their aggregated balance makes up as much as 16 percent of SMEs' all external sources (Udell, 2004). Hungary, however, seems to be home to a distorted type of this so-called „trade" credit[3]. Earlier data, namely from 2006, indicated a significant improvement over the year before, receivables amounting to 42 percent of entrepreneurs' total sales revenue (s.n., 2007). Such interpretation of this index, however, might be misleading, as a part of the receivables recorded in suppliers' and contractors' balance sheet might never be settled; the amount belonging to businesses having been liquidated in the meantime will most probably have to be written down.

Jean Tirole's model, set forth in Chapter 2.1, is the cornerstone of the second part of present paper. Chapter 2.2 introduces the defaulted customer[4] into the model, who decreases the expected revenue of the supplier's projects. The collection of receivables brings about additional information asymmetry and moral hazard, as well. Given an initial wealth *A*, a defaulted customer will reduce the maximum available amount of external financing as a result of these two factors. My deductions will follow the line of thought of Tirole (2005), extending the framework to incorporate a problem that has not been dealt with originally. In Chapter 2.3 I am going to present my own model that introduces to the credit contract between buyer and supplier a conditional joint liability only coming into force if the buyer defaults. This model is one step ahead of Tirole's concept: applying a group lending approach, buyer and supplier – a slice of the supply chain – are considered as a joint entity. Circular debts in Hungary being at least as much a result of entrepreneurs' unwillingness to pay as of their inability to do so, I decided

[3] A trade credit is any arrangement to buy goods or services on account, that is, without making immediate (cash or wire transfer) payment but by setting a due date by which the buyer has to settle their debt. This date will determine the credit period, while the credit amount equals the invoiced amount. The cost of trade credits is usually expressed in cash / early payment discounts or non-cash payment surcharges.

[4] The model might be adapted for a late payer customer instead of a defaulted one.

not to include in the credit terms a joint liability clause for the entire credit amount, as it would even have increased entrepreneurs' exposure to each other. It is only the amount of the customer's receivable balance (or, from the customer's perspective the balance of its relevant accounts payable balance) that is covered by the joint liability clause in case the bank had to grant a second loan to remedy the liquidity problems of the defaulted customer. The second part of present thesis will be rounded off in Chapter 2.3 with the robustness testing and the quantitative illustrations of the models developed beforehand.

2.1 Lending According to Tirole's (2005) Model under Conditions of Information Asymmetry and Moral Hazard

In Jean Tirole's (2005) contract theory approach, there is an asymmetry of information about the debtor's willingness and ability to pay between the two parties, the borrower and the lender, participating in the external financing of enterprises. The lack of information leads to *moral hazard* and it is this information asymmetry that induces the phenomenon of *credit rationing*, as well.

I am going to prove the assertion about credit rationing strictly adhering to Tirole's (2005) line of thought. Even though in my own, upgraded models I work with continuous-investment projects, in this chapter I am going to derive the model assuming the simplest scenario: a fixed investment size project. Using this assumption, our presentation of credit rationing becomes much more telling. Decreases in the credit amount caused by various factors can, nevertheless, be examined presuming a continuous-investment project, and that is exactly how I will proceed in forthcoming chapters, too.

Let the entrepreneur in the model have a project requiring a fixed investment I that yields income R in the case of success (the probability of which is p), and zero otherwise (with a probability of $1-p$). Beyond normal business risk, the project is also exposed to moral hazard. If the borrower behaves, that is, he exerts efforts to make the project successful; the probability of success is p_H. If he decides to misbehave or „shirk", that is, he does not make proper use of the enterprise's resources and his own labor to facilitate success that results in a probability p_L of success, where $p_L<p_H$. „Shirking" yields private benefit B for the entrepreneur, which might be interpreted either as efforts saved or as profits earned through the private use of the enterprise's assets.

The entrepreneur initially only has an initial wealth *A*, thus he applies to the bank for a credit of *(I-A)*. The lender issues the loan at an interest rate which makes zero profit for them, as they operate in a perfectly competitive market. Accordingly, instead of including an expected profit in our ex ante calculation, we will assume the lender to set an interest rate at which their expected loss is zero. The parties are risk neutral, they make their decisions based on the expected value of cash flows. The expected net present value (NPV) of the project, the entire amount of which the entrepreneur is exclusively entitled to receive after having paid off the loan, is only positive if the entrepreneur behaves.

The lender only being able to collect their outlay if the entrepreneur behaves, they will define their own income R_ℓ such that they preserve enough of an income for the borrower $R_b = R - R_\ell$ to motivate for the appropriate effort.

The bank's individual rationality constraint (IR constraint), of which only the equality can hold true in our case because of the perfectly competitive loan market, is:

$$p_H (R - R_b) \geq I - A \tag{2.1}$$

The incentive compatibility constraint (IC constraint) ensures that the expected (thus uncertain) income attainable through increased efforts is more attractive to the entrepreneur than „shirking", even though the private benefits would not be uncertain.

$$p_H R_b \geq p_L R_b + B \tag{2.2}$$

By rearranging inequality (2.2) for the incentive compatible income R_b of the entrepreneur and substituting the result into constraint (2.1), we arrive at the minimum amount of cash on hand $\overline{A}$ required to achieve investment size *I*, where $\Delta p = p_H - p_L$:

$$\overline{A} \geq I - p_H \left(R - \frac{B}{\Delta p}\right) \tag{2.3}$$

Financing, and thus the project itself, is only viable if the entrepreneur's initial wealth is not less than $\overline{A}$. Otherwise, even projects with a positive NPV will remain unrealized – which is Tirole's (2005) proof for the existence of credit rationing.

Hereinafter, the value given by equation (2.4) will be referred to as expected pledgeable income, which is that part of the project's income that can be pledged to the lender without jeopardizing the borrower's incentives.

$$\mathrm{P} = p_H \left(R - \frac{B}{\Delta p}\right) \tag{2.4}$$

Whereas $p_H \frac{B}{\Delta p}$ is the present value of the minimum cash flow the prospect of which is enough to make the entrepreneur behave. Tirole (2005) termed this expression agency cost.

Tirole's model predicts two types of entrepreneurs to be credit-constrained: those with a low initial wealth and those with a high agency cost. The latter one might be explained by the project outcome not being sufficiently informative about the entrepreneur's efforts (whether they behaved or misbehaved), that is, by the low value of Δp as a result of the two probabilities being too close to each other. A high profitability and a high probability of success make access to outside financing easier.

Given that in case of a successful project the entire expected NPV goes to the entrepreneur, Tirole measured the entrepreneur's utility and the welfare effect with the exact same expression:

$$U_b = p_H R - I \tag{2.5}$$

Of course it is not the whole amount of *(R-I)* that goes to the entrepreneur in case the project succeeds, as a portion of it covering the lender's ex-ante expected loss on the transaction had to be pledged to the bank at the time of entering the credit contract. That is why Tirole's wording that the NPV goes to the entrepreneur is inaccurate, as it is only the expected NPV that they receive.

2.2 Lending under Conditions of Moral Hazard, Information Asymmetry and Customer Default

As compared to Tirole's basic scenario, the model presented in this chapter has been modified in several aspects. The bank enters two individual contracts to issue two independent loans to two different entrepreneurs: the buyer and the supplier. Tirole's original model incorporates the normal business risk and the moral hazard associated with the project to be financed. Now, the customer's default risk, the credit risk of the borrower and the additional moral hazard of non-payment will also be introduced to the model.

The average turnover of the credit applicant supplier's receivables is high – supposed that the buyer pays. One period later it will turn out whether the buyer has paid or not. If the buyer's default and thus the revenue lost is significant enough to jeopardize the profitability and the success of the supplier's project, then the supplier will adjust their

strategy accordingly and decide whether they would like to, instead of striving to succeed in the externally financed project, work for their own private benefit (by concealing and „rescuing" the company's assets, to mention a strikingly typical practice in Hungary). The reason for the bank to issue in such a case a loan smaller than what Tirole's model would suggest is twofold. First, because of the expected loss from the buyer and, second, because of the additional moral hazard associated with non-payment. The extent of credit rationing, however, is also influenced by the buyer also being a client of the bank. There are two possible scenarios, both of which will be dealt with in detail in a subchapter. The lender might either opt for the liquidation of the financially distressed buyer in period t=1, or they might as well extend a liquidity credit equal in amount to the supplier's claim.

The basic purpose of the models listed here and derived in Subchapter 2.2 is to serve as a point of reference for our own models elaborated in Subchapter 2.3. With that in mind, I will give a detailed summary of results so far at the end of the subchapter.

2.2.1 The Supplier's Project – Liquidating the Financially Distressed Customer

First, I am going to look at the economic situation emerging in my three-party model from the point of view of the supplier; the customer's project will follow afterwards. The supplier wishes to start a continuous-investment project of size $I \in [0, \infty)$, with constant economies of scale. The project brings income *IR*, corresponding to yield *(R-1)* in the second period if successful, and zero otherwise. Thus the supplier's liability is limited to their initial investment – they can not make a loss higher than that.

The entrepreneur is free to decide how much effort they invest in the project. Higher efforts will ensure a probability of success p_H. While lower efforts yield a probability of only p_L, where $p_L<p_H$, but this behavior also secures a private benefit of extent *BI*. The term *BI* might be considered as the utility of the effort saved by „shirking", proportionate to the size of the project. Yet we might as well hypothesize that the reason for the efforts in favor of the project being lower is that the entrepreneur devotes their remaining capacities to using the company's assets in a way that only brings private benefits but creates no value for the lender. Private benefits being more or less dependent on project size – the use of a private helicopter at a corporate giant and the

use of a microentrepreneur's company phone for private purposes both increase private benefits –, the model treats them as being proportionate to project size *I*.

Initially, the supplier only has assets *A<I*, thus *(I-A)* must be externally financed. The development of a theoretical model for SMEs' bank financing being my goal, external financing always means a bank loan and a lender (financer) always means a bank as far as this model is concerned. In return for the credit, the lender (the bank) expects a portion R_ℓ of the project's total income *RI*, leaving an income R_b to the entrepreneur. Credit duration is two periods. The market for bank loans is perfectly competitive, that is, the expected profit of the bank on the credit is zero. For the sake of simplicity, let us adopt Tirole's assumption that the actors have no time preference concerning the cash flows.[5] They are considered risk neutral, as well, making their decisions exclusively based on expected NPV.

In case the project succeeds, its entire expected NPV goes to the entrepreneur. If the entrepreneur misbehaves, the expected NPV of the entire project becomes negative and thus the lender's income is zero. The assumption about the project's expected NPV can be formulated as

$$E(NPV) = (p_H R - 1)I > 0 \qquad (2.6a)$$

and

$$E(NPV) = (p_L R + B - 1)I < 0 \qquad (2.6b)$$

Assets *I* of the project also include some receivables, now assumed to be identical to the accounts receivable balance. Evidently, accounts receivable represents a *0<c<1* proportion of the balance sheet total. Thus, having been issued the bank loan, the supplier's accounts receivable balance equals *cI*, while all other assets add up to *I-cI*. These accounts receivable are due at the end of the first period, hence earlier than the loan payoff. The supplier reinvests the collected sales revenue to the project in the second period.

Let *q* denote the probability that the entrepreneur can collect their accounts receivable on time. However, *q* is influenced by the effort the customer devotes to their own project. In case the customer misbehaves, the original probability *q* changes to λq, where $0 \le \lambda \le 1$. Probabilities *q* and λq are known ex ante to both the entrepreneur and the bank, yet the bank has no credible information about the actual collection of the

[5] The incorporation of an arbitrary rate of interest into the model does not fundamentally affect the results.

debts. If the customer pays, the supplier receives the entire debt *cI*, changing the structure of its assets: instead of the accounts receivable balance, *cI* will now be listed under cash and cash equivalents, leaving the project's total value *I* (the balance sheet total) unchanged. There is a *(1-q)* or (1- λq) chance, however, that the receivables will remain uncollectible. In that case the bank, also having the customer among its clients, will initiate the liquidation of the customer. Let us suppose that the customer's debt is lost in this case, thus the project size shrinks to *(I-cI)*. The entrepreneur makes their decision about the extent of their efforts only after the due date of their receivables has passed.

It is possible to develop a model where customers' defaults also influence the supplier's probability of success. Being part of the same supply chain, both enterprises are affected by the same macro and industry factors, which make it a reasonable assumption that the unfavorable conditions responsible for the customer's default will have an adverse impact on the supplier, as well. This model variant is discussed in detail in Szűcs-Havran-Csóka (2010). As it does not have a remarkable effect on the results and because such a factor would make the equations of our subsequent models far more complicated, I decided to exclude from my analyses any potential relationship between the customer's default and the supplier's probability of success.

Figure 2.1. provides an overview of the project in its extensive form. The customer's payment or default is treated as an external factor; external factors (the project's success, as well) are incorporated into the model by introducing „nature" as a decision maker. Nature making its decision first in this form of the model, the supplier already knows whether their customer has paid when they decide about the extent of effort to be exerted. The bank, on the other hand, has to approve (or decline) the credit application before it is known whether the customer has paid.

The lowermost part of the figure shows the cash flows of the project, the supplier and the bank (in this respective order) corresponding to the different outcomes. The vector highlighted in blue, for example, denotes the scenario when after the approval of the credit application the customer – previously having decided to behave – turns out to be solvent and the supplier, taking into consideration all the above, decides to misbehave. The project succeeds, in spite of its lower probability of success p_L, and generates income *IR*. The portion $R_b + BI$, already including the private benefit of „shirking",

remains with the entrepreneur and the bank receives the entire payoff $R_\ell = \frac{1}{p_h}(I\text{-}A)$. In the scenario highlighted in green, both the customer and the supplier opt for „shirking". Notwithstanding the above, the customer still settled their obligation on time and the supplier's project brought success, as well. The cash flow vector is the same as in the previous example.

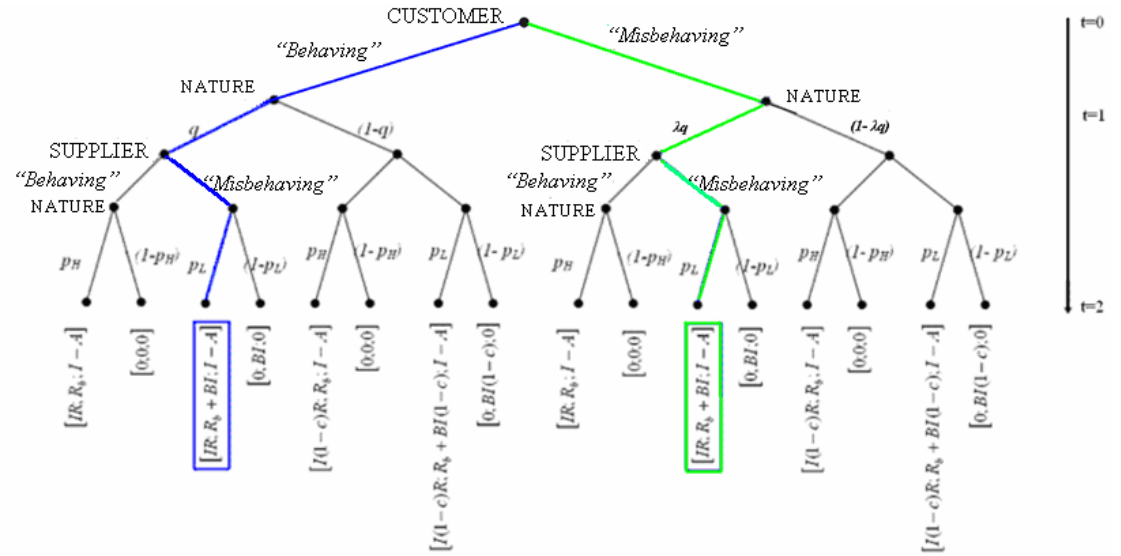


Figure 2.1.: The extensive form of the project in case the supplier has a relative information advantage

2.2.1.1 The supplier's credit contract

In order for external financing to be arranged, the expectations of both the supplier and the bank have to be met. The ex ante expected income of the project is (2.7a), where *p* is the probability as determined by the entrepreneur's behavior. In case the customer misbehaves, the expression changes into (2.7b):

$$E(R) = p\left[q + (1-q)(1-c)\right]IR = p_H I_H^* R \qquad (2.7a)$$

$$E(R) = p\left[\lambda q + (1-\lambda q)(1-c)\right]IR = p_L I_L^* R \qquad (2.7b)$$

Let us first see the lender's participation constraint. The bank wants its expected income at the end of the second period not to be less than the original loan *(I-A)*. Given that the lender only earns an income if the entrepreneur behaves, the credit contract must ensure sufficient motivation by preserving a portion R_b of the income for the borrower. This incentive must be effective in any one of the subgames shown in Figure 2.1. The lender obviously wishes to ensure that the project's cash flow takes a path characterized by

probability p_H, irrespective of whether the receivables can be collected or not. Consequently, the banks two participation constraints are given by expressions (2.8a-b) below.

$$p_H(IR - R_b) \geq I - A \tag{2.8a}$$

$$p_H[(1-c)IR - R_b] \geq I - A \tag{2.8b}$$

The entrepreneur being the one to receive the entire expected NPV of the project, their expected profit by the end of the project equals:

$$E[NPV_b] = (p_H R - 1)I \tag{2.9a}$$

$$E[NPV_b] = p_H R \cdot I(1-c) - I \tag{2.9b}$$

Therefore, still treating the two possible subgames separately, the following must hold true (2.10a-b):

$$p_H R_b \geq p_L R_b + BI \tag{2.10a}$$

$$p_H R_b \geq p_L R_b + BI(1-c) \tag{2.10b}$$

By rearranging expressions (2.8a-b) of the lender and (2.10a-b) of the entrepreneur for the entrepreneur's income R_b and introducing the notation $\Delta p = p_H - p_L$ we arrive at the below conditions (2.11a-b-c-d), respectively, used to draw up a sufficiently motivating contract:

$$R_b \leq \frac{p_H IR + A - I}{p_H} \tag{2.11a}$$

$$R_b \leq \frac{p_H IR(1-c) + A - I}{p_H} \tag{2.11b}$$

$$R_b \geq \frac{BI}{\Delta p} \tag{2.11c}$$

$$R_b \geq \frac{BI}{\Delta p}(1-c) \tag{2.11d}$$

From amongst the above inequalities, (2.11b) and (2.11c) are the stricter ones, the use of which lead to the following solution:

$$A \geq I\left\{1 - p_H\left[R(1-c) - \frac{B}{\Delta p}\right]\right\} \tag{2.12}$$

This is the point where the assumption comes into play that the project's total expected NPV is only positive if the entrepreneur behaves, whereas in case they „shirk", it will turn negative even in spite of the private benefits. This presumption leads to the

conclusion that the parenthesized expression on the right hand side of inequality (2.12) can only take a value between 0 and 1. Consequently, by dividing both sides by this expression, we arrive at the following relationship between the entrepreneur's initial wealth (A) and the project's original investment size (I):

$$A \frac{1}{\left\{1 - p_H \left[R(1-c) - \frac{B}{\Delta p} \right]\right\}} \geq I \qquad (2.13)$$

By introducing the notation $Ak \geq I$ for the sake of simplification, the equity multiplier k can be written as:

$$k = \frac{1}{\left\{1 - p_H \left[R(1-c) - \frac{B}{\Delta p} \right]\right\}} > 1 \qquad (2.14)$$

2.2.1.2 The effect of the equity multiplier

According to equation (2.9), it is in the vested interest of the entrepreneur to realize the largest possible project. Given the initial wealth A, inequalities (2.13) determine the maximum project size, that is, the upper bound on investment I. As $k>1$, the optimum strategy for the entrepreneur is to invest k times their cash at hand, implying that they should borrow $dA=(k-1)A$. (In terms of traditional financial metrics, k corresponds to the leverage ratio calculated as total assets over equity.)

The higher the value of k, the larger the attainable project size I. Irrespective of whether the customer defaults, borrowing capacity is positively affected by a high probability of success being associated with the proper level of effort (p_H), by a high potential income R from the project and by the lowest possible private benefit (B) of shirking. It is also favorable if it makes a big difference in terms of probability of success whether the entrepreneur behaves or misbehaves. Which, nevertheless, might also imply that efforts are well reflected in the income realized from the project; and thus „shirking" would probably result in undesirable consequences for the entrepreneur.

Is the customer's ability or willingness to pay questionable, the maximum amount of external financing available to the supplier is bound to decrease. Accordingly, the higher the proportion of credit sales (that is, the accounts receivable balance) within the balance sheet (c), the lower the amount of external financing available to the supplier.

The equity multiplier does not incorporate the probability of the customer's default: neither q, nor λ. This originates in the model's basic assumptions: the contract discussed earlier is the only chance for the bank to keep the supplier from misbehaving. However, in real life the payoff of the customer's debt equally depends on their ability and on their willingness to pay. Though using the credit applicant's accounts receivable balances, the lender might draw some conclusions concerning the average collection period, those only provide information about the probability q, but not about its ever-changeable influencing factor: the debtor's willingness to pay, substituted by λ in the model.

Under such conditions, it is the severity *(c)* of the damage which is decisive, while the hard-to-estimate probability of damage gets pushed into the background. The reason is that it is parameter c through which the bank, having a vested interest in drawing up an optimal contract, is affected by the customer's default. This is the parameter based on which the borrower adjusts their effort strategy, thereby creating additional moral hazard. The result, consequently, is in line with the data available at the time of credit approval. The data available can provide information about how hard a potential delay would hit the borrower.

According to the results, the model suggests that entrepreneurs who have a poorly diversified customer portfolio, being dependent on a handful of strategic partners and at the same time having a long accounts receivable collection period and managing overdue receivables inefficiently will be issued a credit smaller in amount than similar businesses with a more balanced customer portfolio. The loan will also be smaller for any entrepreneurs who are heavily dependent on the timing of revenue collection, irrespective of the accounts receivable to total assets ratio.

If the customers' probability of payment is $q=1$ and $\lambda=1$, then we simply arrive back at the original Tirole model, as only equations (2.11a) and (2.11c) prevail. Because of the amended participation constraints, the optimal contract is altered, as well. Let k^* denote the maximum attainable leverage as derived from (2.11a) and (2.11c):

$$k^* = \frac{1}{1 - p_H\left(R - \frac{B}{\Delta p}\right)} \tag{2.15}$$

The customer's default, also jeopardizing the supplier's project, reduces the maximum available amount of bank financing in the following way:

$$k = \frac{k^*}{1 + k^* p_H Rc} \qquad (2.16)$$

From equation (2.16), the finding that the customer's default reduces the borrowing capacity of the supplier becomes evident. Thus credit rationing, originally a result of the information asymmetry about the supplier's project in Tirole's model, is further increased by the customer's default. (A more detailed analysis of the supplier's project presented above, covering banking risks, the welfare effect and supplier utility, can be found in Szűcs-Havran-Csóka (2010)

2.2.2 The Customer's Project – Liquidation in Case of Financial Distress

The customer, also being a client of the bank, has a project similar to that of their supplier. One unit of capital invested in this project of size *i* yields, in case of success, a gross return of *r* at the end of the second period. The probability of success is either s_H or s_L, depending on the level of effort. Failure brings no income at all, yet if the entrepreneur decides to misbehave, they still get a „guaranteed" private benefit *b* for each unit of invested capital.

The customer, just like (but independently of) the supplier, also borrows from a bank, as they only have an initial wealth *a*. Thus the bank issues loans in an amount of *(I-A)* plus *(i-a)* to their two clients. The lending market being perfectly competitive, the expected value indicates no profit to be made by the bank on their loans. The lender can only collect their debt if the borrower behaves, thus the bank draws up contracts that motivate debtors to „work". The contract also includes a so-called cross-default covenant, that is, if the client defaults on any of their debts to third parties, the lender will initiate the collection of the loan, too.

Let us assume that the customer buys raw materials on account during the project. That means their total assets will grow to *(i+cI)*. Both their inventory and their accounts payable will increase by the same amount. Is the entrepreneur unable to settle their debt to the supplier due at the end of the first period, the bank will initiate its liquidation, thus they will be unable to go on with the project. If the customer settles the raw material bill, their total assets will return to its original value *i*. In the case of liquidation, the owner will not realize any income, but they still enjoy the entire amount of private benefit *bi*. And the supplier, as experience suggests, will probably never be

able to collect their outstanding debt cI [6], for which entrepreneurs usually blame lengthy court proceedings.

The time value of money and the time preferences of the actors are, once again, excluded from the model. This factor would not, however, have substantial influence on our findings anyway. Actors are risk neutral, making their decisions exclusively based on the expected NPV of future cash flows. The project of both the supplier and the customer has a positive expected NPV, but only if the entrepreneurs choose to behave. „Shirking" (misbehavior) does still not mean that the entrepreneur does not work at all, but rather that they work in a way that reduces the probability of the loan's repayment, thereby harming the interests of the lender. They might, for instance, use the company's assets for private purposes or conceal them, or work on projects which maximize shareholder value by enterprise value.

In this simple model, let the projects of the customer and the supplier be independent from each other, that is, let the correlation between the projects' success be zero. In that case, the customer's credit contract will be defined by two constraints, derived in a similar way as for the supplier. Because of its participation constraint, the bank only issues a loan to the customer if, given probability q of paying on time at the end of period one and probability of success s_H, their expected income is not less than the original outlay:

$$qs_H(ri - r_b) \geq i - a \tag{2.17}$$

In order for the entrepreneur to choose the higher level of effort, an income r_b of sufficient amount must be preserved for them:

$$qs_H r_b \geq q\lambda s_L r_b + bi \tag{2.18}$$

By introducing the notation $\Delta s = s_H - s_L$ and by substituting expression (2.18) into (2.17), we arrive at equation (2.19) representing the borrowing constraint of the buyer:

$$a \geq i\left[1 - qs_H\left(r - \frac{b}{q(s_H - \lambda s_L)}\right)\right] \tag{2.19}$$

[6] If we were to amend this assumption such that the customer does not realize any private benefit in the case of liquidation, the optimal contract would also be different, of course. The requirements to be met by the customer will be less strict. However, it can be proven even for these weakened contractual terms that our own model (to be introduced later) ensures even more favorable credit conditions.

2.2.3 The Customer's Project – Additional Lending in Case of Financial Distress

The above, simplest form of the base model does not properly correspond with Hungarian practice. A risk management expert at one of the Hungarian banks, primarily focusing on the larger businesses of the SME sector, reported that if one of their clients encountered temporary liquidity problems, the bank would often reschedule their debt or, occasionally, even grant an additional liquidity loan to the enterprise. This is especially the case if the entrepreneur's default would, due to existing supplier-customer relationships; also affect any other clients in the bank's credit portfolio.

Let us call the customer's default in the first period, for the sake of simplicity, a liquidity shock on the customer side. Now, according to the practice mentioned above, I will present a variant to the base model we use as a point of reference, where the bank grants an additional loan to the customer in case of a liquidity shock. This additional, liquidity loan will be used to settle their accounts payable – as their debt to the supplier would be the very cause of bankruptcy in the model. If this option and any additional costs are accounted for by the bank in the original credit contract then the contract needs to be amended for both clients.

Considering the customer, the bank will not only expect them to repay the original outlay *(i-a)*, but they will also need to cover the payback of the liquidity loan *cI*, the probability that it will be required being *(1-q)*. Assuming that the customer might change their effort strategy after having been issued the second loan and that the bank has no information about and no control over that decision, the bank's participation constraints are as follows, (2.20b) being the stricter one:

$$s_H(ri - r_b) \geq i - a \qquad (2.20a)$$

$$s_H(ri - r_b) \geq i - a + cI \qquad (2.20b)$$

Here, the IC constraints of the customer also take into consideration that the entrepreneur's income r_b might, in case of a liquidity shock, be further reduced by the amount *cI* of the new loan (due at the end of the second period, as well).

$$s_H r_b \geq s_L r_b + bi \qquad (2.21a)$$

$$s_H(r_b - cI) \geq s_L(r_b - cI) + bi \qquad (2.21b)$$

Accordingly, the entrepreneur needs an initial wealth *a* as given by inequality (2.22) in order to achieve project size *i*:

$$a \geq i\left[1 - s_H\left(r - \frac{b}{\Delta s}\right)\right] + (1 + s_H)cI \qquad (2.22)$$

In this scenario, the supplier will always be able to collect their accounts receivable. Using their own cash or the new bank loan, the customer is going to pay, with a probability of 1. That is why the impact of the customer's default does not even need to be included in the credit contract, thereby arriving back at Tirole's (2005) continuous-investment model.

2.2.4 Comparing the Base Models

Obviously, the question arises as to which one of the two base models, the liquidation (Chapter 2.2.2) or the additional financing (Chapter 2.2.3) of the customer, is optimal in which scenario. From amongst the supplier projects, the variant introduced in Subchapter 2.2.1 belongs to the former one, while Tirole's (2005) original (Subchapter 2.1) version for variable investment size belongs to the latter model. There is a difference in how the optimal decision rule is determined for the entrepreneurs and for the bank.

Entrepreneurs' optimal continuation strategy can be derived from the expected NPV of equity holders, which then again correspond to the utilities of the risk neutral actors making their decision based on present values. Expected values of equity holders' NPV (in this case equal to the projects' expected NPV) are listed in Table 2.1.

According to the table, continuation is always the optimal path for the supplier, as it eliminates the credit risk represented by the customer, whose solvency then becomes guaranteed: either by their own income or by the second bank loan. Considering the customer, continuation is the optimal choice as long as, with the project size *i* already given, their expected income is still higher than the expected value of the liquidity shock. This latter condition (2.24) follows from the comparison of the continuation vs. the liquidation scenario in terms of the project's expected NPV, which then again is the same as the entrepreneur's utility (2.24). Ex post, following the credit approval, when *i* is already given, continuation is determined by inequality (2.24).

$$U_{project}^{liquidation} = qs_H ri - i < U_{project}^{continuation} = s_H ri - i - (1-q)s_H cI \qquad (2.23)$$

$$cI < ri \qquad (2.24)$$

Expected NPV of Equity holders'	Supplier	Customer
Customer liquidated	$p_H RI\left[1-c(1-q)\right]-I$	$qs_H ri-i$
Continuation	$p_H RI-I$	$s_H ri-i-(1-q)cI$

Table 2.1.: Expected present values of the owners' and the projects' cash flows
Source: author's calculation

However, in order for the entrepreneur to achieve the highest possible equity multiplier, they will have to accept, ex ante, a continuation strategy that is definitely less favorable if the project as a whole is considered. In Tirole's (2005) approach, when the lender decides about continuation, they actually try to maximize the expected value of the net pledgeable income. There is an optimal threshold for the bank, just like for the entrepreneur, which if exceeded in amount by the liquidity shock (that is, by the accounts payable balance) will prevent the bank from continuing. In order to find this threshold, I make an assumption similar to Tirole's that ρ^* is the liquidity shock threshold value we are looking for and that $F(\rho)$ is the distribution function of the shock. The present value of the net pledgeable income is given by equation (2.25). The expression has its maximum where the partial derivative with respect to ρ is zero, as seen in equation (2.26):

$$\mathrm{P} = F(\rho)s_H(ri-\frac{bi}{\Delta s}) - s_H\int_0^{\rho^*}\rho f(\rho)d\rho - \left[i-a+\int_0^{\rho^*}\rho f(\rho)d\rho\right] \qquad (2.25)$$

$$\frac{\partial \mathrm{P}}{\partial \rho} = f(\rho)s_H(ri-\frac{bi}{\Delta s}) - s_H f(\rho)\rho - f(\rho)\rho = 0 \qquad (2.26)$$

By rearranging condition (2.26), we arrive at the continuation rule acceptable for the bank given as (2.27). This condition ensures the maximization of that part of the debtors' income which can be pledged to the lender without violating the relevant IC constraints. Thus, in the contract about the additional loan, the bank employs (2.27) to define that maximum value of *cI* which does not yet prevent them from issuing the liquidity loan:

$$cI < \rho^* = \frac{s_H(ri-\frac{bi}{\Delta s})}{(1+s_H)} \qquad (2.27)$$

Consequently, comparing expressions (2.27) and (2.24), it is apparent that the bank's continuation strategy is suboptimal both for the entrepreneurs[7] and for the entire project. Both the line of thought to be followed and the conclusion correspond with those in Tirole's (2005) models.

Thus what I am going to examine next is whether the introduction of joint liability yields an increase in the maximum financing available with a given amount of initial wealth, without reducing the pledgeable income, and, also whether this new contractual term can improve the utilities of the two entrepreneurs as compared to the base models. In the next subchapter, my model will provide evidence that joint liability, being very costly for both entrepreneurs, is not always a feasible solution to credit rationing.

2.3 The Model of Conditional Joint Liability with a Defaulted Customer

Having outlined the conditions of the credit contracts used as points of reference, I will now show that even the partial implementation of joint liability incurs additional costs to the entrepreneurs. This is true even in the case when the entrepreneurs are connected by an implicit, quasi joint liability as neighboring members of a supply chain, having an influence on each other through their ability to pay. The result might be a special variant of the statement cited in the first part (more specifically in Chapters 1.4 and 1.5.4) that joint liability incurs excessive costs to exactly the poorest borrowers. While elaborating on the model, the short presentations of the different variants are used to complete the model's robustness testing. When comparing the different constructions, I will also demonstrate why, at the same time, factoring has become an existing solution in the market, indeed capable of improving entrepreneurs' borrowing capacity. Finally, Chapter 2.3 concludes with some quantitative examples.

2.3.1 Base Model – Conditional Joint Liability with a Defaulted Customer

First, I am going to introduce some assumptions for the sake of simplicity. Apart from these, the project of both the customer and the supplier will remain unchanged. First, the

[7] As $s_H(ri - \frac{bi}{\Delta s}) < 1$, constraint (2.27) is evidently stricter than inequality (2.24)

projects of the two entrepreneurs and their outcomes shall be independent, the default of the customer shall have no influence on the supplier's probability of success.[8]

A further assumption to assist in the derivation without weakening the primary conclusions is that, because of the similar industry environment, the potentially identical geographical location and other factors, the probabilities of success of the two entrepreneurs are taken to be equal:

$$p_H = s_H \tag{2.28}$$

$$p_L = s_L \tag{2.29}$$

The supplier's project looks the same as before: they can make an income *RI* with a probability of success p_H on a project of investment size *I*. The probability of success p_L associated with „shirking" is, once again, coupled with a private benefit *BI*. The probability that the customer pays is *q* if they behave and λq otherwise. If collection is successful, the supplier receives the customer's entire debt *cI* at the end of the first period. To start the project, the supplier's initial wealth *A* is complemented by a bank loan of amount *(I-A)*.

The customer's project of size *i* also makes an income *ri*, with a probability of success p_H. „Shirking" brings private benefit *bi* to the customer, yet the probability of success is bound to fall to p_L. The customer is also granted a loan, its amount being *(i-a)*. If they behave, the probability that they can settle their accounts payable is *q*, in which case the entire debt *cI* is repaid. In case they „shirk", probability *q* is amended downwards by a factor $0 \leq \lambda \leq 1$.

The assumption still prevails that the actors are risk neutral, making their decisions based on their expected income. The bank's loss is zero, which also determines the appropriate interest rate. Even though it would be possible, the time value of money is still not incorporated into the model, thus cash flows from different periods are directly comparable.

A point where the model has changed is how the customer's default is treated. Should the actors opt for the liquidation of the defaulted customer, the bank is certain to lose a portion *(i-a)* of its original outlay *(I-A+i-a)* already at the end of the first period. The customer can not complete their project, even though continuation would be optimal for

[8] In real life, the correlation between the returns of companies in the same industry, between the incomes realized by members of the same supply chain might actually be different from zero. It is possible to incorporate a positive correlation into the model. That, however, obviously reduces the value of joint liability as special collateral.

them as long as the liquidity shock is smaller than the gross income *ri*. The supplier's original project size *I* shrinks to *I(1-c)*, inducing an increase in the entrepreneur's leverage ratio. The amount of capital on which they can realize an income is reduced, and at the same time they will need to sacrifice a larger proportion of their income to service their debt. If this motivates the supplier to misbehave, the probability of success is also bound to deteriorate, which then again causes the potential loss the bank expects to make on the supplier to increase. All in all, the survival of the customer serves the interest of all three parties.

Having considered the above, the bank decides to continue, hence issuing another credit of amount *cI* to the customer. Besides the already financially distressed customer, however, the supplier will also be liable for the loan – they are jointly liable for the obligation *cI*. If the customer recovers, they will pay off a debt of *(i-a)+cI* to the bank at the end of period two. Thanks to the additional loan, the bank also managed to rescue its original outlay of *(i-a)*, though it already seemed to be defaulted at the end of period one. Is the customer still unable to meet their obligation at the end of the second period, it is only the already defaulted loan *(i-a)* that the bank is certain to lose. Amount *cI* can, because of the joint liability condition, also be collected from the supplier.

In this scenario, the supplier will always collect their receivables, either from the income produced by the customer (with probability *q* or λq) or from the bank's liquidity loan to the customer (with probability *(1-q)* or (1- λq)). Thus the customer's liquidity problems at the end of period one, appearing in the original model, can be eliminated. But if the customer suffers a liquidity shock (with probability (1-q) or (1- λq)*)* then the supplier will be forced to, in order to solve their own liquidity problems, assume joint liability for the loan which the customer will use to pay off their debt to the supplier. Is the customer still unable to pay at the end of the second period, the supplier is obliged to pay back credit *cI* to the bank, the exact same amount they would have lost anyway if it had been for the liquidation of the customer. Their benefit from this kind of arrangement is that the customer's financial distress only hits them at the very end of the project, which might leave them with enough time to prepare. Moreover, the amount *cI*, being a part of their current assets, can serve the supplier's project, can generate income right until the end, yielding an income of *RcI* in case the project is successful, and it is only afterwards that it needs to be paid back to the bank. Because of these latter considerations, „shirking" results in the supplier receiving the entire private benefit *BI*,

without losing a share proportionate to *c*, as project size *I* is certain to remain available at least until the end of period two.

If it is appropriate for the parties, joint liability can be extended to the portion *cI* of the supplier's credit *(I-A)*. In this case, if the customer is solvent at the end of the second period while its supplier has defaulted on their credit, the customer is going to pay, in addition to their own two loans, the amount of *cI* to the bank, who thereby improves their recovery rate on the supplier's defaulted loan, as well. Hereafter, the model will always include this extension. Without this extension, the construction would simply represent a combination of lending and factoring, which model variant is presented in Subchapter 2.3.3.1. The project is summarized in Figure 2.2., while the related probabilities and cash flows are contained in Tables 2.2. and 2.3.

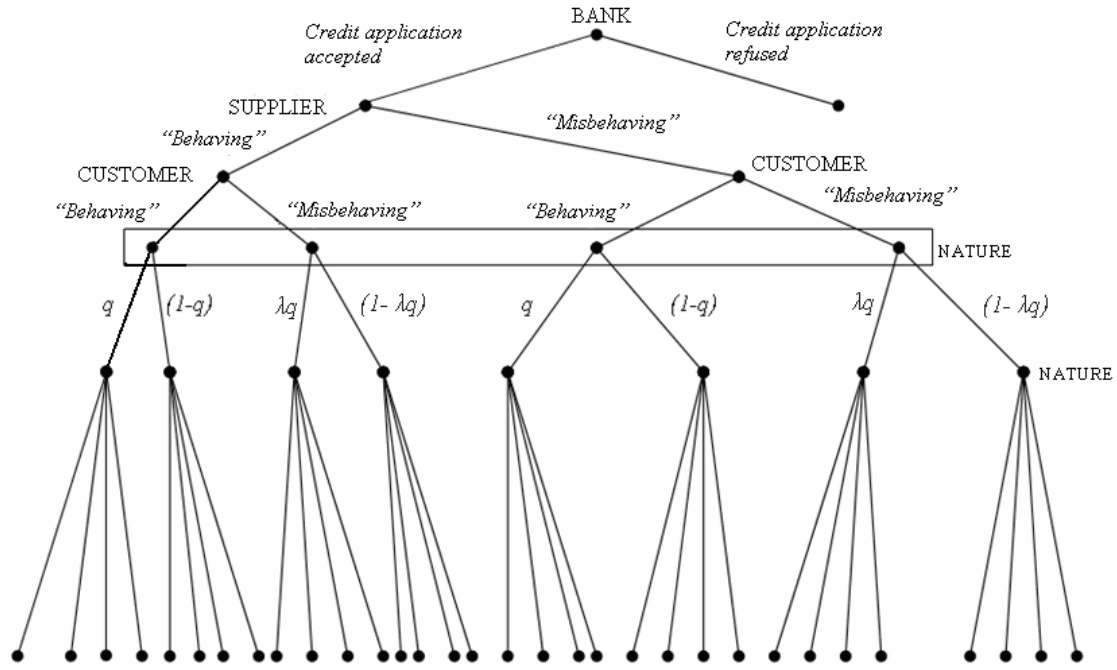


Figure 2.2.: The supplier's project in its extensive form with conditional joint liability
Source: author's figure

Table 2.2.: Probabilities of the various project outcomes

			Supplier			
			Behaves		Misbehaves	
			Successful	Unsuccessful	Successful	Unsuccessful
Customer	No shock	Behaves / Successful	$qp_H\,p_H$	$q(1-p_H)\,p_H$	$qp_L\,p_H$	$q(1-p_L)\,p_H$
		Behaves / Unsuccessful	$qp_H\,(1-p_H)$	$q(1-p_H)(1-p_H)$	$qp_L\,(1-p_H)$	$q(1-p_L)(1-p_H)$
		Misbehaves / Successful	$\lambda qp_H\,p_L$	$\lambda\,q(1-p_H)\,p_L$	$\lambda\,qp_L\,p_L$	$\lambda\,q(1-p_L)\,p_L$
		Misbehaves / Unsuccessful	$\lambda\,qp_H\,(1-p_L)$	$\lambda\,q(1-p_H)(1-p_L)$	$\lambda\,qp_L\,(1-p_L)$	$\lambda\,q(1-p_L)(1-p_L)$
	Shock	Behaves / Successful	$(1-q)\,p_H\,p_H$	$(1-q)(1-p_H)\,p_H$	$(1-q)\,p_L\,p_H$	$(1-q)(1-p_L)\,p_H$
		Behaves / Unsuccessful	$(1-q)\,p_H\,(1-p_H)$	$(1-q)(1-p_H)(1-p_H)$	$(1-q)\,p_L\,(1-p_H)$	$(1-q)(1-p_L)(1-p_H)$
		Misbehaves / Successful	$(1-\lambda q)\,p_H\,p_L$	$(1-\lambda q)(1-p_H)\,p_L$	$(1-\lambda q)\,p_L\,p_L$	$(1-\lambda q)(1-p_L)\,p_L$
		Misbehaves / Unsuccessful	$(1-\lambda q)\,p_H\,(1-p_L)$	$(1-\lambda q)(1-p_H)(1-p_L)$	$(1-\lambda q)\,p_L\,(1-p_L)$	$(1-\lambda q)(1-p_L)(1-p_L)$

Source: author's calculation

Table 2.3.: Cash flows of the various project outcomes

				Supplier			
				Behaves		Misbehaves	
				Successful	Unsuccessful	Successful	Unsuccessful
Customer		Behaves	Successful	$[IR; R_b; R_\ell]$ $[ir; r_b; r_\ell]$	$[0;0;0]$ $[ir; r_b; r_\ell]$	$[IR; R_b + BI; R_\ell]$ $[ir; r_b; r_\ell]$	$[0; BI; 0]$ $[ir; r_b; r_\ell]$
	No Shock		Unsuccessful	$[IR; R_b; R_\ell]$ $[0;0;0]$	$[0;0;0]$ $[0;0;0]$	$[IR; R_b + BI; R_\ell]$ $[0;0;0]$	$[0; BI; 0]$ $[0;0;0]$
		Misbehaves	Successful	$[IR; R_b; R_\ell]$ $[ir; r_b + bi; r_\ell]$	$[0;0;0]$ $[ir; r_b + bi; r_\ell]$	$[IR; R_b + BI; R_\ell]$ $[ir; r_b - cI + bi; r_\ell]$	$[0; BI; 0]$ $[ir; r_b - cI + bi; r_\ell]$
			Unsuccessful	$[IR; R_b; R_\ell]$ $[0; bi; 0]$	$[0;0;0]$ $[0; bi; 0]$	$[IR; R_b + BI; R_\ell]$ $[0; bi; 0]$	$[0; BI; 0]$ $[0; bi; 0]$
		Behaves	Successful	$[IR; R_b; R_\ell]$ $[ir; r_b - cI; r_\ell^*]$	$[0;0;0]$ $[ir; r_b - 2cI; r_\ell^* + cI]$	$[IR; R_b + BI; R_\ell]$ $[ir; r_b - cI; r_\ell^* + cI]$	$[0; BI; 0]$ $[ir; r_b - 2cI; r_\ell^* + cI]$
	Shock		Unsuccessful	$[IR; R_b - cI; R_\ell^*]$ $[0;0;0]$	$[0;0;0]$ $[0;0;0]$	$[IR; R_b - cI + BI; R_\ell^*]$ $[0;0;0]$	$[0; BI; 0]$ $[0;0;0]$

	Misbehaves	Successful	$[IR; R_b; R_\ell]$ $[ir; r_b - cI + bi; r_\ell^*]$	$[0;0;0]$ $[ir; r_b - 2cI + bi; r_\ell^* + cI]$	$[IR; R_b + BI; R_\ell]$ $[ir; r_b - cI + bi; r_\ell^* + cI]$	$[0; BI; 0]$ $[ir; r_b - 2cI + bi; r_\ell^* + cI]$
		Unsuccessful	$[IR; R_b - cI; R_\ell^*]$ $[0; bi; 0]$	$[0;0;0]$ $[0; bi; 0]$	$[IR; R_b - cI + BI; R_\ell^*]$ $[0; bi; 0]$	$[0; BI; 0]$ $[0; bi; 0]$

Source: author's calculation

A fundamental question regarding the terms of the credit contract is whether the two entrepreneurs can adjust their level of efforts after the potential liquidity shock of the customer. If yes, then it is more reasonable for the bank to optimize in two subgames separately. The first subgame here is when the customer is solvent and they pay off their supplier, the probability of which is either q or λq, depending on whether the customer behaves. The other subgame comprises those scenarios when the customer is hit by a liquidity shock and they need a liquidity loan cI, the probability of which is either $(1-q)$ or $(1-\lambda q)$, again depending on whether the customer behaves. According to the literature reviewed in the chapters concerned with theoretical aspects, joint liability motivates debtors to monitor each other (even if some authors consider the level of monitoring to be suboptimal for the lender) – however, my model will make no use of this finding. Especially because there is nothing that could keep the entrepreneurs from adjusting their strategies after the liquidity loan has been issued. Consequently, I am going to proceed by treating the subgames separately when elaborating on the optimal contract structure.[9]

Just like for any previous variant, the NPV of either project can only be positive if the project's owner behaves, therefore that is what the bank tries to achieve through the incentives in the credit contract. Accordingly, the bank's participation constraint will be given by inequalities (2.30a-b):

$$p_H(IR - R_b) + p_H(ir - r_b) \geq I - A + i - a \qquad (2.30a)$$

$$p_H(IR - R_b) + p_H(ir - r_b) \geq I - A + i - a + cI \qquad (2.30b)$$

The customer's IC constraint can be given by the four inequalities (2.31a-b-c-d). The first one prevails if the accounts payable balance is settled on time. The second ensures that it is more favorable if both clients behave as compared to if they both „shirked". The third and the fourth make sure the customer is better off if he behaves, no matter whether the supplier behaves or „shirks".

$$p_H r_b \geq p_L r_b + bi \qquad (2.31a)$$

$$p_H r_b - p_H[p_H cI + (1-p_H)2cI] \geq p_L r_b - p_L[p_L cI + (1-p_L)2cI] + bi \qquad (2.31b)$$

$$p_H r_b - p_H[p_L cI + (1-p_L)2cI] \geq p_L r_b - p_L[p_L cI + (1-p_L)2cI] + bi \qquad (2.31c)$$

$$p_H r_b - p_H[p_H cI + (1-p_H)2cI] \geq p_L r_b - p_L[p_H cI + (1-p_H)2cI] + bi \qquad (2.31d)$$

[9] It is possible to derive a model variant where we accept the assumption that the customer and the supplier monitor each other. In that case, neither one of the debtors adjusts their strategy after a possible liquidity shock, thus cases q and $(1-q)$ can be expressed in the same expected value formula. As a result, some parts of the inequalities will need to be amended, yet our conclusions will remain the same.

From amongst these constraints, the third one (2.31c) implies a stricter condition for the incentive compatible income that remains with the customer, which can be given by inequality (2.32):

$$r_b \geq \frac{bi}{\Delta p} + (2 - p_L)cI \qquad (2.32)$$

There are four different conditions concerning the IC constraints of the supplier, as well. The first applies if the customer pays on time. By the second, the bank ensures that both actors are better off behaving than „shirking" together. Using the third, the contract motivates the supplier to behave even if the customer misbehaves, while the fourth makes sure that it is not worth for the supplier to „shirk" when the customer behaves.

$$p_H R_b \geq p_L R_b + BI \qquad (2.33a)$$

$$p_H R_b - p_H(1 - p_H)cI \geq p_L R_b - p_L(1 - p_L)cI + BI \qquad (2.33b)$$

$$p_H R_b - p_H(1 - p_L)cI \geq p_L R_b - p_L(1 - p_L)cI + BI \qquad (2.33c)$$

$$p_H R_b - p_H(1 - p_H)cI \geq p_L R_b - p_L(1 - p_H)cI + BI \qquad (2.33d)$$

By rearranging the inequalities for the income remaining with the supplier R_b and by applying the stricter constraint (2.33c), we arrive at:

$$R_b \geq \frac{BI}{\Delta p} + (1 - p_L)cI \qquad (2.34)$$

By substituting expressions (2.32) and (2.34) from the customer's and the supplier's IC constraints into the bank's participation constraint (2.30), we get:

$$p_H\left[RI - \frac{BI}{\Delta p} - (1 - p_L)cI\right] + p_H\left[ri - \frac{bi}{\Delta p} - (2 - p_L)cI\right] \geq I - A + i - a + cI \qquad (2.35)$$

By rearranging inequality (2.35), we are presented with an expression defining the minimum initial wealth *A* and *a* required by the two clients to achieve project sizes *I* and *i*, respectively:

$$A + a \geq I\left[1 - p_H\left(R - \frac{B}{\Delta p}\right)\right] + i\left[1 - p_H\left(r - \frac{b}{\Delta p}\right)\right] + \left[1 + p_H(3 - 2p_L)\right]cI \qquad (2.36)$$

2.3.2 Comparing the Three Constructions

The presented model will be evaluated with respect to a number of different aspects. The primary question is whether the level of credit rationing is reduced, or whether the additional costs associated with a joint liability arrangement represent too much of an

additional collateral, that is, whether they necessitate an extra amount of pledgeable income in our model. Thus, beyond credit rationing, the entrepreneurs' expected NPV needs to be examined, as well. These two will be further complemented by the project's expected NPV and the expected value of the maximum amount of income that can be pledged to the bank.

We can describe the models two different ways. First one can illustrate that initial cash at hand (*A* and *a*) enables a project of a given size (*I* and *i*). Or the second point of view, the models also defines the minimum level initial wealth (*A* and *a*) which is needed to start a project of size *I* and *i*. The comparison of the different versions is correct only if we adopt the second point of view. Only in this case is the project size over the different model versions equal, enabling the comparison of formulae where from the *I* and *i* project sizes all other figures of the project can be derived. In case of the bank's continuation rule also the size of the loans ((*I*-*A*) and (*i*-*a*)) is incorporated to the comparison, thus at that point the results of comparison are limited.

2.3.2.1 Credit Rationing

As a first step in evaluating the model of conditional joint liability, I am going to look at how the borrowing capacities of the two actors have changed. Table 2.4. shows the results for the two base model variants and my own model.

	Aggregated borrowing capacity
Customer liquidated	$A+a \geq I\left[1-p_H(R(1-c)-\frac{B}{\Delta p})\right]+i\left[1-qp_H(r-\frac{b}{q(p_H-\lambda p_L)})\right]$
Continuation	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+(1+p_H)cI$
Conditional joint liability	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+\left[1+p_H(3-2p_L)\right]cI$

Table 2.4.: Aggregated borrowing capacity in the three constructions

Source: author's calculation

Apparently, my model does not necessarily warrant more favorable credit terms. Conditions (2.37-2.38) must be met in order for the joint liability to improve borrowing capacity as compared to both the liquidation and the continuation scenario.

$$p_H RcI + (1-q)\,p_H ri + \frac{p_L - \lambda p_L}{p_H - \lambda p_L}\, p_H \frac{bi}{\Delta p} > \left[1 + p_H (3 - 2p_L)\right] cI \qquad (2.37)$$

$$(1 + p_H) > \left[1 + p_H (3 - 2p_L)\right] \qquad (2.38)$$

Let us assume that $q>0.5$ and $p_H>0.5$! This is not at all unreasonable considering that the bank decided to issue a loan to both clients.

The coefficient of *cI* in expression (2.37) – knowing that the project's expected NPV is positive, given that the entrepreneur behaves – is bigger than one on the left side, while it is within the interval (0; 2) on the right side. At the same time, it seems reasonable to expect the customer's expected income ($p_H ri$) to significantly exceed the accounts payable balance (*cI*). The coefficient of this expected income is within the interval (0; 0.25). Given the above, it seems feasible to meet condition (2.37). If either one of the probabilities of success is high or if either the customer's or the supplier's project generates a high income, the model of conditional joint liability might well be more favorable than the customer's liquidation. Similarly, if the difference between the two probabilities of success is small or if the customer's private benefit from „shirking" is high, it is worth opting for the conditional joint liability model.

The interpretation of the condition is even more straightforward when comparing the two continuation (individual vs. joint liability) scenarios. The coefficient of probability p_H on the left hand side of condition (2.38) is 1, while it is always bigger than that on the right hand side, thus it is more favorable to continue with an individual liability arrangement from a credit rationing point-of-view.

Comparing the two individual constructions, neither one of the models guarantees a lower/higher level of credit rationing. Income coefficient *R* is probably a number larger than but close to one, as *(R-1)* is the entrepreneur's profit margin. Accordingly, we expect the continuation strategy to be associated with a higher level of credit rationing than the liquidation of the customer. It is the price of the certainty of continuation which gets reflected in the higher level of credit rationing. The explanation is that the customer's potential liquidity shock (with a probability of *(1-q)*) is not that threatening for either one of the entrepreneurs as it was before. Consequently, the bank is compelled to devote a larger portion of the income to the motivation of the entrepreneurs, which then again reduces the amount of credit available.

2.3.2.2 Entrepreneurs' Expected NPVs

Irrespective of the construction, the entrepreneurs start up their projects with initial wealth *a* and *A*. The basic criterion of project evaluation is the NPV rule, yet because we ignore time preferences, the expected free cash flow to equity (FCFE) values will yield an equivalent order, from the point-of-view of the owners. The expected value of the project's cash flow is not equal to that of the owners' cash flow, it is important to make a distinction here. The reason is that the owner's payout function is convex: their losses are limited but their profits are free to increase, as a function of *I*.

Based on the results about credit rationing, the proportion of the project's income that has to be pledged in order to cover the joint liability is too high for the portion remaining with the entrepreneur to be sufficiently motivating. Thus, considering the owners' cash flow, I expected the joint liability to result, if the customer defaults, in a loan payoff higher than for any one of the individual contracts. The expected equity NPV (expected FCFE) values for the various constructions are summarized in Table 2.5.

Looking at the two entrepreneurs one-by-one, we find that continuation under individual liability is always more favorable than the joint liability construction. Second comes in the order of preference of the supplier the continuation under joint liability. The customer prefers continuation under joint liability to continuation under individual liability, except when $p_H=1$. Considering the customer, the parameters provide no clear indication as to whether liquidation is more favorable than continuation, because that is only the case if $p_H ri > cI$. The relationship $ri > (2 - p_H)cI$ leads to the continuation under joint liability being more favorable than liquidation.

The following explanations exist for entrepreneurs' preferences. Considering the supplier, continuation under individual liability means that the bank takes over the credit risk of the accounts receivable. Continuation under joint liability leaves a part of this credit risk with the supplier, therefore the expected PV will decrease but, at the same time, the income to be realized on the accounts receivable will not be lost. The real advantage of this contract, that is, the „smoothing" of the liquidity risk is, however, not reflected in the expected cash flow. The reasoning is even simpler for the customer's case. In the joint liability scenario, the liability for their project's continuation is partly born by others, that is, the liability they have to assume, functioning as quasi-collateral, is smaller.

Expected NPV of Entrepreneurs	Supplier	Customer
Customer liquidated in case of a liquidity shock	$p_H RI[1-c(1-q)]-I$	$qp_H ri-i$
Continuation with the customer's individual liability	$p_H RI-I$	$p_H ri-i-(1-q)cI$
Continuation with joint liability	$p_H[RI-(1-q)(1-p_H)cI]-I$	$p_H[ri-(1-q)(2-p_H)cI]-i$

Table 2.5.: Entrepreneurs' expected NPV in the three constructions
Source: author's calculation

The sum of the two actors' equity NPVs is, however, also worth examining, as *cI* is too heavily represented in the individual NPVs of the joint liability scenario. By rearranging Table 2.5., we arrive to Table 2.6., our point of focus still being equity NPV. The figures in the new table can be interpreted as the aggregated NPVs remaining with the entrepreneurs, which could actually be redistributed between the two actors. This could be possible in a transferable-utility model where, even though the individual preferences about the three constructions differ, the switch to another construction enables one of the entrepreneurs to make an expected additional income sufficient to also compensate their partner for the change of models. According to the totals of the FCFE-based NPVs, continuation clearly has an advantage over both liquidation and joint liability (except if p_H=1 or p_H=0.5). Given some not-so-strict conditions, liquidation will become less favorable than continuation with joint liability.

Sum total of expected NPVs of Entrepreneurs	Supplier + Customer
Customer liquidated in case of a liquidity shock	$p_H(RI+ri)-I-i-p_H(1-q)(cIR+ri)$
Continuation with the customer's individual liability	$p_H(RI+ri)-I-i-(1-q)cI$
Continuation with joint liability	$p_H(RI+ri)-I-i-p_H(1-q)(3-2p_H)cI$

Table 2.6.: Totals of the entrepreneurs' expected NPVs for the three constructions
Source: author's calculation

Thus, summarizing the above: the supplier will always prefer continuation, which might be the more favorable solution to the customer, as well, if some rather weak conditions are met. It is nevertheless doubtful that, whenever it seems favorable to the entrepreneurs, the bank would always be willing to enter the continuation contract. This is discussed in the next subchapter, which will demonstrate that the bank's optimal strategy does not necessarily coincide with the entrepreneurs' preferences, who might therefore be ready to enter suboptimal contracts.

2.3.2.3 Continuation Rule of the Profit Maximizing Bank

The bank's ex ante objective is to maximize its profits, which will ex post be zero because of the perfectly competitive loan market. In the comparison of the two base models, I used equation (2.25) to define the expected value of the net pledgeable income, which is the concept I am going to use now, as well. After all, it is the maximization of the expected net pledgeable income that is equivalent to a profit maximizing behavior. Let ρ^* once again be the threshold value which, if exceeded in amount by the liquidity shock, will prevent the bank from continuing. The distribution function of the liquidity shock is $F(\rho)$. For the bank, it is desirable to opt for the joint liability contract whenever the increase in their expected income exceeds their additional outlay. Obviously, in a model where the customer gets liquidated irrespective of the size *cI* of the liquidity shock, there is no sense in looking for a ρ^* that could determine the continuation strategy. Thus Table 2.7. shows the expected value of the sum of pledgeable incomes only for the two continuation scenarios.

	Expected profit of the bank – Expected net pledgeable income
Continuation	$P_{bank}^{continuation} = p_H(R-\frac{B}{\Delta p})I + F(\rho)p_H(r-\frac{b}{\Delta p})i - (I-A) - (i-a) - \int_0^{\rho} \rho f(\rho)d\rho(1+p_H+p_H R)$
Conditional joint liability	$P_{bank}^{joint} = p_H(R-\frac{B}{\Delta p})I + F(\rho)p_H(r-\frac{b}{\Delta p})i - (I-A) - (i-a) - \int_0^{\rho} \rho f(\rho)d\rho[1+p_H(3-2p_L)+p_H R]$

Table 2.7.: Expected profit of the bank and the threshold value of the liquidity shock

Source: author's compilation

For the expressions in Table 2.7., we can find the places where the first partial derivative with respect to ρ is zero, which, according to Tirole (2005), will be points of maximum. Thus the cut-off values for the two continuation strategies calculated using the derivatives can be expressed as (2.39) and (2.40) below:

$$\rho^*_{continuation} = \frac{p_H(r - \frac{b}{\Delta p})i}{(1 + p_H + p_H R)} \tag{2.39}$$

$$\rho^*_{joint} = \frac{p_H(r - \frac{b}{\Delta p})i}{1 + p_H(3 - 2p_L) + p_H R} \tag{2.40}$$

As we remember from earlier chapters, continuation rule (2.39) is suboptimal for the entrepreneurs, as the customer would go on with their project already if their accounts payable was below the expected income $p_h ri$. Apparently, the cut-off value given by expression (2.39) is always less strict than that given by (2.40). Thus even though joint liability means additional collateral for the bank, it does not actually make the first-period liquidity loan more easily available because of the decrease in pledgeable income. The presented model seems to confirm the conclusion drawn from experiences in microfinance, now considered for enterprises, that joint liability causes excessive additional costs for the clients as compared to individual loan arrangements.

The bank might find it useful to examine whether either one of the continuation constructions would represent an increase in expected net pledgeable income as compared to the liquidation scenario. Expressions defined in terms of ρ^* and $F(\rho^*)$ are, however, not suitable for this purpose, as, obviously enough, continuation is impossible in the liquidation scenario no matter what the threshold value is. Therefore I am going to simplify the expressions for net pledgeable income P by assuming a scenario where the different values of P are determined using a specific, given value of cI which is known to motivate the bank to decide for continuation, given the appropriate construction. Then, the contents of Table 2.7. are modified as follows (Table 2.8.):

	Expected profit of the bank – Expected net pledgeable income
Customer liquidated	$P_{bank}^{liq.} = p_H(R - \frac{B}{\Delta p})I + p_H(r - \frac{b}{\Delta p})i - (I - A) - (i - a) - (1-q)p_H cI - (1-q)p_H ri - p_H \frac{b}{\Delta p} \cdot \frac{p_L - \lambda p_L}{p_H - \lambda p_L}$
Continuation	$P_{bank}^{continuation} = p_H(R - \frac{B}{\Delta p})I + p_H(r - \frac{b}{\Delta p})i - (I - A) - (i - a) - cI[1 - q + p_H]$
Conditional joint liability	$P_{bank}^{joint} = p_H(R - \frac{B}{\Delta p})I + p_H(r - \frac{b}{\Delta p})i - (I - A) - (i - a) - cI[1 - q + p_H(3 - 2p_L)]$

Table 2.8.: Expected profit of the bank for the three constructions

Source: author's calculation

Table 2.8. also confirms that individual liability allows for a larger *P* than joint liability. Yet joint liability might still be better than the liquidation of the customer. It is a limitation of this comparison, however, that the bank issues loans of differing amounts in each construction even though project sizes *I* and *i* are unchanged. Thus the amounts of loans *(I-A)* and *(i-a)* in Table 2.8. are not constant throughout the three constructions. This contradiction is illustrated in the quantitative examples in Subchapter 2.3.4.

Summarizing the above: even though both the additional loan and a part of the supplier's zero-period loan is covered by double collateral, this arrangement also acts to weaken the motivation of the two entrepreneurs. But then again, that needs to be compensated, which is the reason why the absolute value of the income pledged to the bank can not exceed the pledgeable income of the individual liability construction.

2.3.2.4 Welfare Effect

The last aspect to be examined is the welfare effect of the joint liability arrangement. Just like Tirole, I am also going to measure social utility through the expected value of the NPVs realized by the two projects. Even though the joint liability construction is the only one where the project-level expected NPV differs from the expected NPV of entrepreneurs (as defined in Chapter 2.3.2.2), all three aggregated NPVs are included in Table 2.9. The calculations showed that the two continuation arrangements (under individual or joint liability) are characterized by the same level of social utility, exceeding that of the liquidation scenario. This finding corresponds to our expectations, as in both cases, the three actors can realize the same expected aggregated cash flow on the same aggregated investment. The sharing of the liability only affects expected cash flows on the project owners' level.

Project NPV	Supplier + Customer
Customer liquidated in case of a liquidity shock	$p_H(RI+ri)-I-i-(1-q)p_H(cIR+ri)$
Continuation with the customer's individual liability	$p_H(RI+ri)-I-i-(1-q)cI$
Continuation with joint liability	$p_H(RI+ri)-I-i-(1-q)cI$

Table 2.9.: Totals of the projects' expected NPVs for the three constructions
Source: author's calculation

2.3.2.5 Comparing the Three Constructions - Findings

The comparison of the three constructions is summarized in detail in Table 2.10. It can be concluded that in the model described in Chapter 2.3.1, a part of the loans being covered by a joint liability arrangement does not reduce credit rationing. The reason is that both entrepreneurs have to pledge an additional part of their income because of the liquidity loan, even though it will be only one of them who will pay back the credit. Continuation under individual liability is usually favorable to the two entrepreneurs with respect to credit rationing, yet they might not be able to enter the optimal contract in this scenario.

Entrepreneurs' NPV values have shown that the additional costs of joint liability reduce the entrepreneurs' utilities. Given that the issuance of a first-period liquidity loan is more frequently favorable for the bank under individual liability than it is under joint liability, the profit maximization of the bank does not, either, force the entrepreneurs to opt for the continuation strategy suboptimal for them.

Aspect	Const.	Expression for measuring the aspect in question	Result	Condition
Borrowing capacity	Liquidation (L)	$A+a \geq I\left[1-p_H(R(1-c)-\frac{B}{\Delta p})\right]+i\left[1-qp_H(r-\frac{b}{q(p_H-\lambda p_L)})\right]$	$J \succ L$	$p_H RcI+(1-q)p_H ri+\frac{p_L-\lambda p_L}{p_H-\lambda p_L}p_H\frac{bi}{\Delta p}>$ $>[1+p_H(3-2p_L)]cI$
	Continuation (C)	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+(1+p_H)cI$		
	Joint liability (J)	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+[1+p_H(3-2p_L)]cI$	$C \succ J$ $C \succ L$	In any case $p_H RcI+(1-q)p_H ri+\frac{p_L-\lambda p_L}{p_H-\lambda p_L}p_H\frac{bi}{\Delta p}>$ $>(1+p_H)cI$
Supplier's utility	L	$p_H RI[1-c(1-q)]-I$	$C \succ J \succ L$	In any case
	C	$p_H RI-I$		
	J	$p_H[RI-(1-q)(1-p_H)cI]-I$		
Customer's utility	L	$qp_H ri-i$	$C \succ L$	$p_H ri > cI$
	C	$p_H ri-i-(1-q)cI$	$J \succ C$	$p_H < 1$
	J	$p_H[ri-(1-q)(2-p_H)cI]-i$	$J \succ L$	$ri > (2-p_H)cI$

Table 2.10.: Comparison of the three constructions

Source: author's compilation

Expected value of the net pledgeable income to the bank	L*	$P_{bank}^{liq.} = p_H(R-\frac{B}{\Delta p})I + p_H(r-\frac{b}{\Delta p})i - (I-A) - (i-a) - $ $ - (1-q)p_H cI - (1-q)p_H ri - p_H \frac{b}{\Delta p} \cdot \frac{p_L - \lambda p_L}{p_H - \lambda p_L}$	$J \succ L$	$(1-q)p_H cI + (1-q)p_H ri + p_H \frac{b}{\Delta p} \cdot \frac{p_L - \lambda p_L}{p_H - \lambda p_L} >$ $> cI[1-q+p_H(3-2p_L)]$
	C	$P_{bank}^{continuation} = p_H(R-\frac{B}{\Delta p})I + F(\rho)p_H(r-\frac{b}{\Delta p})i - (I-A) - (i-a) - $ $ - \int_0^{\rho} \rho f(\rho) d\rho (1+p_H + p_H R)$	$C \succ J$	In any case
	J	$P_{bank}^{joint} = p_H(R-\frac{B}{\Delta p})I + F(\rho)p_H(r-\frac{b}{\Delta p})i - (I-A) - (i-a) - $ $ - \int_0^{\rho} \rho f(\rho) d\rho [1+p_H(3-2p_L) + p_H R]$		
Welfare effect	L	$p_H(RI+ri) - I - i - (1-q)p_H(cIR+ri)$	$J \approx C \succ L$	In any case
	C	$p_H(RI+ri) - I - i - (1-q)cI$		
	J	$p_H(RI+ri) - I - i - (1-q)cI$		

Table 2.10. (continued): Comparison of the three constructions

Source: author's compilation

*: The expression holds true for an accounts receivable balance of a given amount *cI*. Can be compared with the other elements of Table 2.9., leading to the conclusion $J \succ L$.

2.3.3 Model Variations for Joint Liability

After having compared the individual and the joint liability constructions, and having concluded that the doubled collateral provided by joint liability is making the loan more expensive for every party, I will examine the robustness of the results. First I define the model variations, then the evaluation follows according to the aspects already applied in the previous chapters.

2.3.3.1 Factoring

If the extent of joint liability is decreased, then we arrive to an already existing market solution, to recourse factoring. More precisely, factoring can be reformulated in the framework of the joint liability model. The bank evaluates the credit application of the two contractors jointly. The positive decision means that the bank provides not only financing but also factoring services to the supplier.

According to the local practice most of the factor companies are trying to buy all the invoices issued by a given customer, and to cover the whole customer portfolios of a given client. When buying the invoice usually the clients receive 80% of the demanded amount. The remaining 20% usually meant the factoring fee, and partially is paid to the client after the customer had accomplished. In case of the recourse factoring, which is the local practice, the factor does not bear the credit risk of the issuer, i.e. the bank is making the client to buy back the invoice of the non-paying client. (Martinkó, 2009) Thus the contract with pecuniary interest is converting its own customers' credit risk to the credit risk of the supplier. The contractor who is using the factoring can only benefit from the increase of the turnover of the receivables; he/she cannot hedge the credit risk of the trade credit.

In the model of the factoring everything shall be unchanged if the customer pays at the due date. Let change the model as follows in the case of a liquidity shock, which has a probability of *(1-q)* or *(1-λq)* depending on the effort of the customer. The supplier still owes joint liability for the new *cI* sized credit of the customer. On the other hand the customer won't be responsible for his/her part in the original loan of the supplier. Then the following terms will define the constraints of the optimal contract:

$$p_H\left(IR - R_b\right) + p_H\left(ir - r_b\right) \geq I - A + i - a + cI \qquad (2.43)$$

$$R_b \geq \frac{BI}{\Delta p} + (1 - p_L)cI \tag{2.44}$$

$$r_b \geq \frac{bi}{\Delta p} + cI \tag{2.45}$$

By restating the inequality (2.43-2.45) we will get how much initial capital we need to reach the size of the projects *I* and *i*.

$$A + a \geq I\left[1 - p_H(R - \frac{B}{\Delta p})\right] + i\left[1 - p_H(r - \frac{b}{\Delta p})\right] + \left[p_H(2 - p_L) + 1\right]cI \tag{2.46}$$

2.3.3.2 The Cessation of Private Benefit in case of Liquidation

In this sub-chapter I describe a model variation, which will only influence the constructions with individual liability, when the bank and the supplier are liquidating the customer in case of the customer's insolvency. Contrarily to the original assumptions, in case of liquidation the customer is not realizing the *bi* private benefit, he/she is losing the whole amount. Compared to the original version, this modification decreases the customer's incentive compatible income and credit rationing also.

The optimal contract then will only be modified in the case of the customer. The individual rationality constraint of the bank (2.47), the incentive compatibility constraint of the contractor (2.48) and the maximum level of external financing (2.49) is given with the following expressions:

$$qp_H(ri - r_b) \geq i - a \tag{2.47}$$

$$qp_H r_b \geq \lambda qp_L r_b + \lambda qbi \tag{2.48}$$

$$a \geq i\left[1 - qp_H(r - \frac{\lambda b}{p_H - \lambda p_L})\right] \tag{2.49}$$

2.3.3.3 The Liquidation Value of the Project is Positive

In the previous parts of modeling the bank always loses all of it's claims, if the client defaults. I.e. from the measuring numbers of the credit risk the recovery rate (RR) was

taken to be 0, and thus the loss given default (LGD) was assumed to be 100%. Similarly the supplier lost the whole value of receivables of size *cI*.

In this alternative variation a higher RR is supposed in all of the three constructions than zero. Because the LGD is influenced by the seniority and the contracted collaterals, it should be decided whether the bank requires collateral from it's clients or not. Taking into account the national practice, I have built in the collateral to the model. Although for the bank the collateral is going to be less valuable, than for the contractor, who in case of non-payment is forced to resign from his/her producing asset.

The required collateral shall be an asset with the value of *l* for the customer! The collateral required from the supplier shall represent L value for the particular contractor.

In case of non-payment the bank will only realize β portion of the original value of the collateral, where $0<\beta<1$. If the bank decides to provide a liquidity loan to the customer in the first period, there is not any additional collateral needed. Similarly the supplier will be able to partially collect his receivables from the customer. In case of the liquidity difficulties of the customer or beside the unsuccessful project of the customer the supplier only collects γcI of his/her *cI* sized claims. The γ parameter can take a value from the (0;1) interval. All of the other parameters of the project are the same, compared to the previous chapters.

The assumption of an LGD<1 is modifying not only the model of joint liability, but also the individual contracts, that's why it is necessary to reformulate all the three constructions. If the bank and the supplier are liquidating the customer in case of a liquidity shock, then the bank's individual rationality constraint – besides individual liability- is (2.50.a-b), in addition the incentive constraint of the supplier (2.51.a-b) can be given with the following inequalities:

$$p_H\left(IR - R_b\right) + (1 - p_H)\beta L \geq I - A \qquad (2.50a)$$

$$p_H\left[(1 - c(1 - \gamma))\, IR - R_b\right] + (1 - p_H)\beta L \geq I - A \qquad (2.50b)$$

$$p_H(R_b + L) \geq p_L(R_b + L) + BI \qquad (2.51a)$$

$$p_H(R_b + L) \geq p_L(R_b + L) + BI(1 - (1 - \gamma)c) \qquad (2.51b)$$

By restating the expressions (2.50.a-b) and (2.51.a-b) and by using the $\Delta p = p_H - p_L$ nomination we will have a limit (2.52) for the borrowing capacity of the borrower.

$$A \geq I\left\{1-p_H\left[R(1-(1-\gamma)c)-\frac{B}{\Delta p}\right]\right\}-L\left[p_H+(1-p_H)\beta\right] \qquad (2.52)$$

Because this thread is identical to the previous ones, therefore instead of the further derivations I just concentrate on the description of optimal contracts. The optimal contract of the costumer, if it can be liquidated in the first period by the partners (2.53) is given by the following inequality:

$$a \geq i\left[1-qp_H\left(r-\frac{b}{q(p_H-\lambda p_L)}\right)\right]-\ell\left[qp_H+(1-qp_H)\beta\right] \qquad (2.53)$$

If the bank gives an additional liquidity loan for the customer to be able to continue to project then (2.54) determines the supplier's and (2.55) the customer's optimal contract.

$$A \geq I\left\{1-p_H\left[R-\frac{B}{\Delta p}\right]\right\}-L\left[p_H+(1-p_H)\beta\right] \qquad (2.54)$$

$$a \geq i\left[1-p_H\left(r-\frac{b}{\Delta p}\right)\right]+(1+p_H)cI-\ell\left[p_H+(1-p_H)\beta\right] \qquad (2.55)$$

In case of conditional joint liability the common borrowing capacity (2.56) can be counted as follows:

$$A+a \geq I\left[1-p_H\left(R-\frac{B}{\Delta p}\right)\right]+i\left[1-p_H\left(r-\frac{b}{\Delta p}\right)\right]+\left[1+p_H(3-2p_L)\right]cI-(L+\ell)\left[p_H+(1-p_H)\beta\right] \qquad (2.56)$$

2.3.3.4 The Evaluation of Alternative Models

After having presented the main alternatives, I will examine how the original model of conditional joint liability can be improved.

The results regarding factoring can be found in Table 2.11. It proves that factoring dominates the model of conditional joint liability from the aspects of credit rationing and the continuation strategy of the bank. The explanation is the same in both cases. In case of factoring the conditional joint liability does not destroy the motivation of the borrowers, and by this a higher pledgeable income can be reached, what is increasing the lending willingness of the bank. According to the same aspects the customer would like to avoid his/her responsibility in the supplier‘s loan, thus he/she always prefers factoring to joint liability. Then he/she receives a liquidity loan „cheaper" with lower additional responsibility in the factoring version of the model, than in case of joint

liability. For the supplier and from the aspect of welfare effect the two constructions are equivalent.

By comparing the factoring to continuation with individual liability, we find that even though factoring does not decrease credit rationing, but it provides the bank a higher expected profit, thus the bank determines a less strict continuation rule, than in the simple continuation model. It can happen that the two borrowers accept a smaller sized project in order to assure a less stricter continuation rule for themselves ex ante. This latter solution results in a higher utility for the customer while the supplier's utility won't change, because he/she still has to bear the counterparty risk related to the customer. From the aspect of social welfare, there is no change either, the distribution of the responsibility between the two contractors will only influence the income distribution amongst them, but will not influence the whole produced income.

The decreasing private benefit of the customer is examined by Table 2.12. The changes in the conditions of the model will modify the optimal contract and the borrowing capacity. The conclusion is that joint liability would result in such a high level of pledged income, that it would not decrease credit rationing.

In the third alternative model not only the construction of joint liability will be modified,

but also the individual contracts, which were used as a reference point. Therefore Table 2.13. compares the three loan contracts according to the aspects of the bank, the two borrowers and the welfare effect.

The effect of the collateral is influencing the three constructions in a nearly identical way. The connected modifications will only differ in case of the welfare effect; however the former conclusion is just gaining more strength here too. Thus it can be concluded, that the collateral required by the bank does not change the results of the previous sub-chapters.

The partial collection of receivables can influence the expected net present value of the supplier in merit. In the original model, there was an evident preference order for the supplier amongst the three constructions ($F \succ E \succ L$), which next to the positive liquidation value of the receivables will not be completed in any cases. It is still true from the point of view of the supplier that the continuation with individual liability dominates the liquidation of the customer and joint liability. However for he/she will only prefer joint liability to the liquidation of the customer if the $(1-\gamma)R > (1-p_H)$ expression is true. I.e. if the supplier loses less in case of the non-

payment of the customer, he/she will be less motivated to participate in joint liability. At the other criteria of evaluation the conditions providing the advantage of joint liability partially changed, but the preference order, was not modified in a way like the NPV of the suppliers.

Table 2.11.: The evaluation of factoring

Aspect	Construction	Expression for measuring the aspect in question	Result	Condition
Borrowing capacity	Factoring (F)	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+\left[1+p_H(2-p_L)\right]cI$	F $\succ$ J	In any case
	J	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+\left[1+p_H(3-2p_L)\right]cI$		
The supplier's utility	F	$p_H\left[RI-(1-q)(1-p_H)cI\right]-I$	J $\approx$ F	In any case
	J	$p_H\left[RI-(1-q)(1-p_H)cI\right]-I$		
The customer's utility	F	$p_H\left[ri-(1-q)cI\right]-i$	F $\succ$ J	In any case
	J	$p_H\left[ri-(1-q)(2-p_H)cI\right]-i$		
Expected value of the net pledgeable income to the bank	F	$P_{bank}^{joint}=p_H(R-\frac{B}{\Delta p})I+F(\rho)p_H(r-\frac{b}{\Delta p})i-(I-A)-(i-a)-$ $-\int_0^{\rho}\rho f(\rho)d\rho\left[1+p_H(1-p_L)+p_H R\right]$	F $\succ$ J	In any case
	J	$P_{bank}^{joint}=p_H(R-\frac{B}{\Delta p})I+F(\rho)p_H(r-\frac{b}{\Delta p})i-(I-A)-(i-a)-$ $-\int_0^{\rho}\rho f(\rho)d\rho\left[1+p_H(3-2p_L)+p_H R\right]$		

Welfare effect	F	$p_H(RI+ri)-I-i-(1-q)cI$	J ≈ F	In any case
	J	$p_H(RI+ri)-I-i-(1-q)cI$		

Source: author's compilation

Aspect	Construction	Expression for measuring the aspect in question	Result	Condition
Borrowing capacity	L	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-qp_H(r-\frac{\lambda b}{p_H-\lambda p_L})\right]+p_H RcI$	J ≻ L	$p_H RcI+(1-q)p_H ri-$ $-\left[\frac{p_H(1-q\lambda p_H)-\lambda p_L(1-qp_H)}{p_H-\lambda p_L}\right]p_H\frac{bi}{\Delta p}>$ $>[1+p_H(3-2p_L)]cI$
	C	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+(1+p_H)cI$	C ≻ J	In any case
	J	$A+a \geq I\left[1-p_H(R-\frac{B}{\Delta p})\right]+i\left[1-p_H(r-\frac{b}{\Delta p})\right]+[1+p_H(3-2p_L)]cI$	C ≻ L	$p_H RcI+(1-q)p_H ri-$ $-\left[\frac{p_H(1-q\lambda p_H)-\lambda p_L(1-qp_H)}{p_H-\lambda p_L}\right]p_H\frac{bi}{\Delta p}>$ $>(1+p_H)cI$

Table 2.12.: The comparison of the models in case of the decreased private benefit of the customer

Source: author's compilation

Aspect	Const-ruction	Expression for measuring the aspect in question	Result	Condition
Bor-rowing capacity	L	$A + a \geq I\left[1 - p_H(R(1 - c(1-\gamma)) - \frac{B}{\Delta p})\right] + i\left[1 - qp_H(r - \frac{b}{q(p_H - \lambda p_L)})\right] - (L + \ell)[p_H + (1-p_H)\beta]$	J ≻ L	$p_H R(1-\gamma)cI + (1-q)p_H ri + \frac{p_L - \lambda p_L}{p_H - \lambda p_L} p_H \frac{b}{\Delta p} > 1 + p_H(3 - 2p_L)cI$
	C	$A + a \geq I\left[1 - p_H(R - \frac{B}{\Delta p})\right] + i\left[1 - p_H(r - \frac{b}{\Delta p})\right] + (1 + p_H)cI - (L + \ell)[p_H + (1-p_H)\beta]$		
	J	$A + a \geq I\left[1 - p_H(R - \frac{B}{\Delta p})\right] + i\left[1 - p_H(r - \frac{b}{\Delta p})\right] + [1 + p_H(3 - 2p_L)]cI - (L + \ell)[p_H + (1-p_H)\beta]$	C ≻ J	In any case
Supp-lier's utility	L	$p_H[RI - (1-q)(1-\gamma)RcI] - I - (1-p_H)L$	C ≻ J C ≻ L J ≻ L	In any case In any case $(1-\gamma)R > (1-p_H)$
	C	$p_H RI - I - (1-p_H)L$		
	J	$p_H[RI - (1-q)(1-p_H)cI] - I - (1-p_H)L$		
Custo-mer's utility	L	$qp_H ri - i - (1-qp_H)\ell$	C ≻ L	$p_H(ri + \ell) > cI$
	C	$p_H ri - i - (1-q)cI - (1-p_H)\ell$	J ≻ C	In any case
	J	$p_H[ri - (1-q)(2-p_H)cI] - i - (1-p_H)\ell$	J ≻ L	$ri + \ell > (2-p_H)cI$

Table 2.13. : The comparison of the three constructions in case of LGD<1

Source: author's compilation

Expected value of the net pledgeable income to the bank	L*	$P_{bank}^{likv.} = p_H(R-\frac{B}{\Delta p})I + p_H(r-\frac{b}{\Delta p})i-(I-A)-(i-a)-$ $-(1-q)p_H cI+[p_H+(1-p_H)\beta]L-(1-q)p_H ri-p_H\frac{b}{\Delta p}\cdot\frac{p_L-\lambda p_L}{p_H-\lambda p_L}$	C ≻ J	In any case
	C	$P_{bank}^{continuaation} = p_H(R-\frac{B}{\Delta p})I+F(\rho)p_H(r-\frac{b}{\Delta p})i-(I-A)-(i-a)-$ $-\int_0^{\rho}\rho f(\rho)d\rho(1+p_H+p_H R)+[p_H+(1-p_H)\beta]L+[F(\rho)p_H+(1-F(\rho)p_H)\beta]\ell$		
	J	$P_{bank}^{joint} = p_H(R-\frac{B}{\Delta p})I+F(\rho)p_H(r-\frac{b}{\Delta p})i-(I-A)-(i-a)-$ $-\int_0^{\rho}\rho f(\rho)d\rho[1+p_H(3-2p_L)+p_H R]+[p_H+(1-p_H)\beta]L+[F(\rho)p_H+(1-F(\rho)p_H)\beta]\ell$		
Welfare effect	L	$p_H(RI+ri)-I-i-(1-q)p_H(cIR+ri)-(1-qp_H)(1-\beta)\ell-(1-p_H)(1-\beta)L$	J ≈ C ≻ L	In any case
	C	$p_H(RI+ri)-I-i-(1-q)cI-(1-p_H)(1-\beta)(L+\ell)$		
	J	$p_H(RI+ri)-I-i-(1-q)cI-(1-p_H)(1-\beta)(L+\ell)$		

Table 2.13. (continued): The comparison of the three constructions in case of LGD<1

**: In case of a cI sized receivables the expression is true, it can hardly be compared to the other constituents with the table*

Source: author's compilation

To sum up the results of the examined constructions, the changes of the conditions will not influence the former conclusion. The model proved to be robust. However the conditional joint liability would be able to decrease credit rationing, but it puts such extra expenses to the contractors that individual liability is proved to be more advantageous. But in case of factoring – which is not by accident an existing market solution – the contractors may accept the extra costs related to factoring, even if it is suboptimal for them, in order to assure the continuation ex ante. Because they know that the financing bank prefers continuation with factoring to continuation with individual liability.

2.3.4 The Numerical Illustration of the Models

To close the modeling I illustrate the models already presented with some numerical illustrations. This illustration helps to understand the criteria according to which I am comparing the different constructions in Table 2.10.

Table 2.14. contains the input data of the supplier and the customer, where the figures are identical to the assumptions used during the model building. Relying on Table 2.14. the size of the projects of the borrowers (*I* and *i*) is given and we are looking for the minimal own investment (*A* and *a*) in Table 2.15.

The project of the supplier		The project of the customer	
I	100	i	80
R	1.15	r	1.20
p_H	0.95	p_H	0.95
p_L	0.70	p_L	0.70
B	0.2	b	0.18
c	0.05	λ	0.97
q	0.88		

Table 2.14.: The input parameters of the projects of the contractors

Source: own calculation

Based on the input parameters the constraints of the participants and the main the figures of the projects can be calculated. Table 2.15. contains the related findings.

The minimal owner's equity and the size of the loan is not given separated for the two borrowers in case of joint liability. (See cells highlighted in blue). To define the separated value of the loans, I divided the value of total external financing (*I-A+i-a*) into two parts proportional to the size of the financed projects. The needed initial

wealth of borrowers (*A* and *a*) is the difference of the projects total size (*I* and *i*) and of the separated amounts of the loan (*(I-A)* and *(i-a)*).

	Supplier			Customer			Together		
	L	C	J	L	C	J	L	C	J
Minimal owner's equity (A, a)	72.21	66.75	*65.48*	50.22	53.27	*57.39*	122.44	120.02	122.87
The amount of the loan	27.79	33.25	*34.52*	29.78	31.73	27.61	57.56	64.98	62.13
Maximal size of the project	100.00	100.00	100.00	80.00	85.00	85.00	180.00	185.00	185.00
Maximal level of leverage (D/V)	0.28	0.33	0.35	0.37	0.37	0.32	0.32	0.35	0.34
The borrower's incentive compatible revenue	80.00	80.00	81.50	60.38	62.60	64.10	140.38	142.60	145.60
The project's expected revenue	108.59	109.25	109.25	80.26	91.20	91.20	188.85	200.45	200.45
Expected project NPV	8.59	9.25	9.25	0.26	10.60	10.60	8.85	19.85	19.85

Table 2.15.: The main indicators of the projects

Source: own calculation

It also has to be explained, how the maximal project size can grow from the initial 80 to 85 unit in the continuation and the joint liability construction, what is given by Table 2.14. (Accordingly the two contractor' combined project size differs from 180, it is 185. See the cells highlighted in grey!) The explanation is, that the liquidity loan is already included in Table 2.15., however it is only needed in *(1-q)* part of the cases. The amount of the liquidity loan equals the supplier's claim of size cI which has a value of 5 in the numerical example.

In the case of the supplier joint liability provides the highest leverage possible. It is the customer who has to counterweight the increase of the leverage with his/her equity. The combined leverage of the two contractors already illustrates this finding; continuation with joint liability is dominated by the individual construction. The incentive-compatible income of the supplier is growing in accordance with the additional liability in the joint model. From the aspect of the expected income and the expected NPV, individual and joint liability are identical for the supplier.

In case of the customer's project the construction with possible liquidation enables financing with the lowest owner's equity and incentive compatible revenue for the

borrower. The explanation is given by equitation (2.19). Only in this construction are the parameters λ and q part of the optimal loan contract. In every other case only the possibility of the liquidity shock appears and there is not the exact value of the connected probabilities incorporated to the contract. If the liquidation is possible, the customer's motivation to behave is high enough to allow a lower level of equity and borrower's incentive compatible revenue. In the construction of liquidation the effect of „misbehaving" appears in the model not only through p_L but also trough the λ parameter, while regardless of the chosen strategy q is basically decreasing the probability of success. In the continuation constructions the danger of liquidation does not incite the customer, thus the bank has to force the customers with the other elements (higher a and r_b) to a proper effort.

In the construction with liquidation, however the high leverage of the customer will not compensate the high equity requirements of the supplier, thus for the two projects together joint liability requires less initial wealth.

The three constructions were not only evaluated by leverage and the borrowing capacity, Table 2.16. sums up the other relevant markers for the three contractors and for the society.

	L	C	J
Continuation rule	-	11.99	10.10
Welfare effect	8.85	19.85	19.85
Supplier's utility	8.59	9.25	9.22
Customer 's utility	0.26	10.63	10.60
Owners' utility	8.85	19.88	19.82

Table 2.16.: The banks continuation role and the utility of stakeholders
Source: own calculation

The bank determines less strict continuation rules with individual liability. The maximal size of the customer's payable *cI*, which can be covered by the bank's liquidity loan is 11.99. This threshold in case of joint liability will decrease to 10.10.

The expected net present value regarding the utility of the stakeholders fits with the earlier results. The welfare effect is measured by the expected NPV values of Table 2.15. The expected NPV is always higher in case of any kind of continuation than in case of the liquidation of the customer. Even the possibility of the joint liability is

decreasing the expected NPV of the two contractors; however the continuation even with joint liability dominates the scenario of liquidation.

The reality of the parameters of Table 2.14. should be judged empirically, but the empirical analysis is not part of this theoretical, modeling chapter.

2.3.5 The Possibilities and the Limits of the Model – Joint Liability amongst the Firms[10]

So far in the second part of my thesis I did not exceed the logic of modeling, but to close these chapters I have to analyze the limits of the models.

The simplified idea used for modeling is, that I am applying joint liability in a situation which is not typical to microfinance; I assume joint liability among two neighbor members of a supply chain.

There are many essential differences between the target group of microfinance and the market segment of SME financing. The MFIs' target-group consists of individuals living in a village-society connected to a tightly woven social network. There are mainly self-employed natural persons, individual contractors in a microloan portfolio. On the contrary the national SMEs have a legal personality; they are originally connected to a looser social network, which differs from the natural person's connections.

Usually SMEs prefer legal forms with limited liability. Then the firms' bankruptcy fully differs from the situation where a private person defaults. Namely the owner's pay-off function is convex: the loss is limited, but on the other hand the profit is only limited by the efficiency of the company. The essential difference between the pay-off functions results that the profit maximalization of natural persons can differ from a company's profit orientation.

This problem can be solved at different levels, or at least we can decrease the limitedness of the results of the model. Firstly still staying within the framework of the model I can refer to the works of Jean Tirole. In his works usually and in his book "Theory of Corporate Finance", he is modeling the financing of the companies with limited economic liability. As I build my own model using Tirole's framework, the conclusions of the above chapters explicitly contain the fact of limited liability. Namely

[10] This sub-chapter mainly reflects to the critiques I received from the reviewers and my colleagues for the draft version of this dissertation.

the contractors only participate in the financing of the project with a capital of size *A* and *a*, and their loss never exceed the value of their invested equity. Tirole supposes the maximalaziation of utility measured by the expected NPV and the participants are risk neutral. (Namely the standard deviation of the maximized expected value is neutral.) My own model follows his framework in this aspect.

In the literature of microfinance there is a large number of models, and usually the authors define the actors' incentive limits in a contract theoretical framework, relying on the expected revenue and on the expected utility. Therefore I reckon, that the combination of the results of Tirole's models and microfinance can be accepted at the level of modeling.

However as a next step I look for examples in the literature whether joint liability can be applied amongst the companies. The first impression is that the literature of group lending does not provide too many base in this question. The authors are usually using the following terms to describe the target groups (clients), the participants of the programs: „poor", „poor individuals", „borrowers", „microentrepreneurs". Even if the term, „firm" appears, it soon turns out, that the authors are writing about self-employed borrowers or about a family business. Other authors do not provide any details about the clients of the particular MFI examined by him/her. According to the testimony of the webpage of BRAC, FINCA, CASHPOR and the Grameen Bank, the mentioned institutes are lending to private persons and declaredly to women. (according to the viewpoint from April, 2011). Therefore the construction of joint liability can not be automatically applied to the financing of firms without further explanation.

However after reviewing the literature from this aspect, even if it is not a typical practice however, I have found constructions, which are using joint liability amongst the firms. For instance in the model of Gangopadhyay and Lensink (2005) a firm with high risk level is the guarantor in the loan contract of a safe firm. In their article they are modeling the contract with the methodology presented above.

Earlier I have reasoned why I have specifically taken joint liability from the elements of group constructions. The customer and the supplier are naturally in a dependent relationship with each other even without bank financing. They are often connected to each other by two ties: the product-flow from the supplier towards the customer is followed by the cash flow in the opposite direction. If the supplier sells on credit, the second tie among the participants is the trade credit instead of the immediate cash payment. Therefore the supplier is exposed to its partner's credit risk anyway. A

possible non-payment of the customer can result in contagion, namely the supplier may have a delay on his/her own payables, for instance on his bank-loan. This existing implicit dependence is converted to the contracted joint liability to increase borrowing-capacity in my model. Such an extension or reformulation of joint liability is not unique in the literature; we can describe the idea, as the generalization of joint liability.

Philip Bond (2004) in his article extends the concept of joint liability, when he examines the joint liability of the clients of a given financial institute. The individual borrowers only get future financing, if the financial institute survives, what depends on the repayment of all the individual borrowers. These borrowers only have access to future financing if there are enough other borrowers who repaid their loans. Thus the situation can be interpreted that there is a kind of joint liability between the participants.

An even more spill example is broached by the author, when he claims, that there is a similar dependence amongst the employees of a firm. If they are not working according to their best knowledge, the performance of the firm can decrease, and finally it may default. Then every employee has to find a new workplace, and can count with temporary unemployment.

If we use this kind of extended joint liability, than its application amongst the firms becomes acceptable. However a real limit of combining of microfinance and the SME lending can be, that SME's revenue is higher than the income of the poorest members in the society. The higher income level can contribute to a higher risk taking level than that of target-group of microfinance, where according to particular authors borrowers are risk averse above the optimal level. That is why it is questionable, whether the incentive structure is encouraging enough or not for SME clients.

Similarly, the assumption of contingent loan renewal is violated in case of SME sector, where there are many competitive financial institutes. But on the first hand this problem already exists in the case of the MFI clients, and on the other hand I have modeled the financing of firms facing credit rationing, and I assumed that they are lack of external financing.

It can be also questionable, whether there may be an easier way to form joint liability in case of firms, than in the worked out model. Even an acquisition can happen, what cannot even be mentioned amongst natural persons. However the goal of the firms presented in the model is not joint liability, it is only a necessity originated from the business relationships between them, and its extent is identical with the size of the provided trade credit. The possibility of acquisition is particularly questionable, because

the thesis is modeling credit rationed firms, where the income available for debt-service can be influenced by the non-payment of even one customer. There can be model variations imagined – which are not contained in my thesis – that the non-payment of the customer influences even the supplier's probability of success (Szűcs-Havran-Csóka, 2010).

Finally let me shortly conclude the results of the second part of the thesis. Starting from the works of Jean Tirole [2005] I have presented in a contract theoretical framework how the non-paying customer affects the borrowing capacity of the supplier. The phenomenon of credit rationing was not a surprising result, since the informational asymmetry increased between the bank and its client. A possible suggestion for solving this problem is the model of conditional joint liability, which is using the existing dependence structure between the neighbor members of the supply chain as a special form of collateral.

The credit risk – related to the trade credit provided the customer by the supplier – is made explicit by the worked out contract structure. Compared to the individual contracts for the customer and for the supplier, the construction of conditional joint liability will not decrease credit rationing, because according to the frequent critiques in the literature, the increase of the level of liability results in high extra expenses for the borrowers compared to individual contracts. For the two contractors the separate, individual contracts can be more advantageous, however the continuation can worth them even with joint liability. These results can be held, even if some of the model's assumptions are changed. Finally, to close the second part of the thesis, I have presented my main findings with a short numerical illustration, where the received results are identical with the former deductions.

3 Analysis of the Aged Receivable Balance of a Customer Portfolio

The last, the third section of my thesis deals with the empirical research. The analysis is connected to one of the starting points of the second section: the non-paying customer. The preceding chapters and the author's publication cited earlier (Szűcs, Havran, Csóka, 2010) present the extent to which a non-paying customer adversely affects the supplier's access to external financing. The question examined in this third chapter is, due to the nature of available data, more general, only focusing on the characterization of the phenomenon 'late-payer customer' instead of the consequences of non-paying customers. The question is closely related to chain debt, a phenomenon well-known in professional circles. In the chapters describing the models, I have only mentioned how badly Hungarian companies are struck by late payments and non-paying customers. Insolvency then spills over to others, thus leading to a chain of debts. Media reports estimate such debts to be in the hundred billion HUF range.

The dissertation aims to use the data available to explore, as far as the given customer portfolio is concerned, the volume of outstanding trade credits and any related risks. The methodology employed does not allow for any generalizations and the sample can not be considered representative, either, thus my findings will only be valid for the businesses examined. Notwithstanding the above, the study is still unique in its kind, as there is no data source publicly accessible to academics on the changes in the volume of outstanding and late receivables except for quarterly macro-level accounts receivable statistics. This apparent lack of interest is primarily caused by the lack of data, which is the very reason why I am exceptionally grateful to the anonymous **receivables management company who provided me with the data.** Even if it was not the entire debt chain, I could at least examine the trade credit portfolio of one given company, thereby contributing to Hungarian literature in the topic.

The most interesting, 'ultimate' question of my research is perhaps whether there are any financial indicators or other non-economic, payment morale-related variables by which late-paying customers are homogenous? Which factors can late-payments be explained by best? Our findings might provide a basis for customer relationship management practices.

In order to be able to answer this question, the following logical steps are important. The third chapter starts with a methodological introduction, reviewing the literature of chain debts (earlier: “queuing”) and the models of customer-specific credit risk and default risk. Then a short description of the database and the available variables follows. As the first step of the actual analysis, I will perform a cluster analysis in order to find the major payment patterns in the customer portfolio. Second, I am going to explore the relationship between late payments and other customer-specific pieces of information, employing methodologies appropriate for the level of measurement of each variable. Third, for those elements of the database where the relevant financial statements were also available, I am going to use logistic regression (in analogy to bankruptcy prediction models, based on the recommendation in the chapter on methodology) to point out the ratios that might predict future late-payments.

3.1 Methodology

The problem of non-paying customers is logically connected to a topic of great history in Hungarian literature: chain debts (or queuing as it was termed earlier). Thus I am going to devote some thoughts to the authors of this topic first. These works not having offered a methodology suitable for the database in question, I will turn to bankruptcy prediction and credit risk models in my search for such a methodology. After all, from amongst the various multivariate data analysis techniques, I am going to employ cluster analysis and logistic regression in the actual analysis of the data.

3.1.1 Queuing, Chain Debts

Preceding the quantitative analysis, I am first going to review Hungarian literature on queuing (or chain debts, circular debts). Based on my readings so far, there are two eras of literature to be distinguished: the studies conducted before the regime change and those written afterwards, under the conditions of a developing market economy.

The very rich literature of the pre-transition era dealt with late payments between large state-owned enterprises. From time to time, exposed to changes in the government’s economic policies, these companies were faced with the ’hardening’ of their soft budget constraint. In such times, they used trade credits (having even been legally non-existent

for quite a long time) as a source of financing, that is, they did not settle their accounts payables.

Enterprises having had only one single current banking account, their partners' claims had to be queued for some time, depending on the current balance of that one account. That is where the terms 'queuing' and 'financial lines' frequently used in literature from that era come from. The authors of this period mainly focused on the elimination of queuing (e.g.: Háda, 1990).

At the very beginning of the 1990's the second question, dealt with by many authors during the time of the evolving, was already present. Professionals suggested that businesses' trade credits, as a form of money substitute, were reducing the efficiency of monetary policy and loosening the strictness. At the same time, the macroeconomic situation of the country and the economic transition required a restrictive monetary policy, thus companies' efforts to compensate for the restrictions by a sort of „quasi money" creation was undesirable. A good example for the above is given by Éva Várhegyi (1989a): corporate data – more specifically the structure of assets and liabilities – from 1988 show that the demand restraints the government had tried to enforce through working capital loan operations were circumvented by the actors of the economy by not paying their suppliers' invoices. Várhegyi (1989a) also reports the opportunities of monetary restriction having been highly questionable because of both the expansion in the public sector and the „quasi money" creation in the corporate sector. In her opinion, the large corporations, protected in both a political and an economic sense, were not forced to react to monetary measures according to the rules of the market. Monetary policy, thus, contributed to the spreading of queuing, which then again acted to lessen the effectiveness of monetary restriction. Related calculations were also published by Éva Várhegyi and László Sándor (1992). They examined the velocity of circulation of the M2 money supply as a function of monetary policy. They also drew a conclusion pointing well beyond the topic of monetary policies, but highly relevant to my thesis: the delayed payment of suppliers' bills is regarded as a corporate business decision, which, even though often a result of external pressure, reflects inappropriate behavioral norms.

Besides Éva Várhegyi (e.g. in 1989a), the relationship between queuing and monetary policy was also discussed by István Ábel and László Sándor in 1991, while it was the thesis and the publications of Géza László which, as a kind of summary, closed the discussion of this topic in the mid-nineties. From the beginning of the era, the paper of

István Szalkai (1990) is worth reading, while the 1994 thesis of Mária Ivanics provides a detailed summary of the history of queuing; Göllner (1992) already uses the term ‘circular debt’.

In addition to the monetary/financial effects, Géza László examined the macro-level problem of queuing on the micro level, too. His work is based on the observation of Éva Várhegyi and László Sándor (1992) that non-payment is a business decision, and what is more, it is a behavioral norm. He developed a multivariate model of game theory for companies’ payment norms, proving that the proportion of on-time payments has to be remarkably high in order for the payment norms to further prevail. A relatively low proportion of late-payers in the economy is already enough for the norm of on-time payment to erode and give way to the norm of late payment, which turned out to be a stable equilibrium point in his dynamic game (László, 1992, 1996a-b).

By the mid-nineties, queuing and chain debts (or circular debts) had lost in popularity amongst academics, that is, the second – post-transition – era of relevant literature had practically come to an end. Papers on factoring and SME financing, however, still mention the phenomenon of chain debts. Though both the daily press and economic magazines keep publishing higher and higher figures concerning debt chains, academic works on the topic are rather scarce these days. It is mainly dealt with in industrial papers – the 2006 study of Róbert Klujber, for instance, focuses on the construction industry.

Recent years’ available analyses either originate from economic actors or were commissioned by the government. Chain debt is a recurring topic in the periodical SME survey of the Institute for Economic and Enterprise Research (GVI), and the impact studies of the ministerial departments are usually available on the appropriate website.

As it is apparent from the above summary, Hungarian literature does not offer a suitable methodology, while international literature available in English is anything but abundant. Macro-level analyses and theoretical modeling approaches are both common, yet neither one suits our micro-level data. Recent studies (mainly by GVI) are, on the other hand, primarily based on aggregate financial statement figures. Data from earlier periods also being available to them, they mainly focus on basic trends and the simple description of changes in structure (inter-industry) and volume, Thus on my quest for the appropriate methodology I had to expand my view beyond non-paying customers and chain debts, and review the literature of some related topics.

1.1.2. Bankruptcy Prediction and Credit Risk Models

Just like any other type of credit, trade credits also have a certain credit risk associated with them. And companies where decisions are made on a daily basis concerning whether a customer should only be allowed to pay by cash or should be extended a line of credit, and if so, then what should be their limit know that very well. Obviously, corporate credit scoring is rather similar to the credit scoring of banks. The study of Hago (2001) uses expressions like corporate credit policy and corporate credit analysis, as a component of the former concept. Interestingly, some papers in the literature of financial services analyze the very question whether it is the bank or the supplier that has a comparative advantage in assessing the creditworthiness of a company (Diamond, 1984; Emery, 1984; Peterson – Rajan, 1997; Udell, 2004).

Any decent corporate finance textbook discusses working capital management and the role of customer relationship management (CRM) within. Their choice of methodologies is, however, far from abundant. The most straightforward way is to review the customer's previous orders and payment history. Authors tend to agree that suppliers should primarily rely on external sources in the case of new customers.

The customer's ratings by international rating agencies (if any) and the data in Dun & Bradstreet database could be leading aspects. Another recommendation of the textbooks is that the supplier should commission its bank to rate some of its large customers, maybe even calling in their bank, as well. Publicly available and for-pay blacklists, bad debtor registers might also reveal important information about new customers (Allen, Myers and Brealey, 2008). Another possibility is to use the method of relationship banking, i.e. the 5C principle (to be discussed in detail in the section about SME lending related methods). Some authors even suggest that the supplier should regard the extension of a trade credit as an investment decision and determine the level of expected loss and expected profit so as to earn on the credit an expected return corresponding to the level of risk taken (Atrill, 2003). This latter idea is, unfortunately, hardly ever accompanied by any specific methodological recommendations.

Following the advice of the textbooks to possibly ask one's bank about one's potential customers, my dissertation will also focus on the credit risk methodology used by banks. Lajos Horváth and Attila Mészáros (1996) used Piszkei Papír Ltd. as an example when discussing that banks' credit scoring experience might also facilitate businesses'

customer rating efforts. According to them, they key aspects to developing a customer rating system are:

- It should express the customer's importance
- Changes in customer behavior should be quantifiable
- It should express the customer's willingness to pay
- Loan impairment losses should be recorded by customer
- It should characterize the general economic situation of customers
- It should indicate customers' bankruptcy risk (this item was considered particularly important by Horváth and Mészáros)
- The credit risk associated with each customer should be described
- It should determine the credit limit for each customer
- It should facilitate the management of credit limits, collaterals and exposure

As also mentioned by the authors, the above aspects correspond to the aspects of a bank's credit rating system. Therefore, the work of Lajos Horváth and Mészáros (1996) provides the foundations for the topic of present chapter, that is, the review of credit risk related models – knowing that these models were developed primarily to support banks' and other financial institutions' lending and risk management decisions.

Before introducing the models, I will briefly define the concept of credit risk. From a practical point of view, according to the HFSA (Hungarian Financial Supervisory Authority) directive based on the recommendations of the Basel Committee on Banking Supervision:

„Credit risk: in the narrow sense it is the risk that the other contractual party will not be able to meet its obligations (arising from a loan, a deferred payment arrangement or any other credit-like legal relation) in accordance with agreed terms, potentially causing the financial institution to incur a loss. In the broad sense, any risk arising from non-fulfillment is considered credit risk, including risks arising from the non-fulfillment of sales contracts (settlement risk, open account trade risk) and from the future fulfillment of sales contracts (replacement risk)." (Source: HFSA, 2001)

Theoretical studies agree with the above definition, yet delve into a more detailed account of it, also employing the concept of default risk. Default risk is the risk of any losses incurred due to the debtor's full or partial default. Thus in the case of banks, defaulting on the interest, defaulting on the principal or defaulting on both all belong to

this category. In practice, there is one more element to be included in the definition: time. Most financial institutions, in accordance with Basel II, consider a client to be defaulted if they are more than 90 days past due. Credit risk, though it obviously includes default risk, is a broader concept. Beyond the default itself, an increase in the probability of the borrower's default is a credit-risk event, as well. This latter part of credit risk is referred to in literature as *migration / transition risk*. (For a more detailed credit risk definition see Jorion, 1999; McNeil, Frey and Embrechts, 2005; Crouhy, Galai and Mark, 2005.)

3.1.1.1 Types of Credit Risk Models

The literature of credit and default risk modeling is rather abundant, and what is more, these keywords often lead to writings with surprisingly differing contents. I read overviews from a number of authors, yet neither of them managed to classify all of the models. Thus, first of all, I will try to systematize the literature I read, without going into details about the specific models. The authors used the following aspects to classify the models:

- Historical / chronological order (e.g. Carling, Jacobson, Linde and Roszbach, 2007)
- Individual vs. portfolio models
- The size of the company to be examined (e.g. Falkenstein, Boral, Carty, 2000). This is equivalent to a classification by lending techniques (*transaction banking*, *relationship banking*). (E.g. Allen, DeLong and Saunders, 2004.)
- Classification by content, where models might be used for analytical, measurement / risk management or pricing purposes (e.g. Altman, Saunders, 1997 or partly McNeil, Frey and Embrechts, 2005)
- The methodology used
- The type of the data used (market vs. accounting; exogenous vs. endogenous).

These individual classification criteria can be combined and matched with or complemented by each other. In the below description, each model is going to be categorized by each above-mentioned aspect.

From a historical approach, it is the accounting-based, so-called credit risk scoring models we will first encounter in literature, the name of which is quite telling about the

type of data they use. These individual models serve the prediction of individual defaults by estimating the probability of default, or at least by forming groups that are homogenous by the level of default risk associated with the applicants. Accordingly, they might be considered risk measurement / management models by content. As a result, financial institutions generally calculate internal ratings for their clients. This earliest approach includes the following methodological groups (see Table 3.1. – the fourth column denotes the first user of each methodology):

Accounting-based models	**One variable**		*Beaver (1966)*
	Multiple variables	Multiple discriminant analysis (MDA)	*Altman (1968)*
		Linear regression	
		Logistic regression	*Ohlson (1980), Zavgren (1985)*
		Probit model	*Zmijewski (1984)*
		Recursive partitioning algorithm	*Frydman, Altman, Kao (1985)*
		Neural networks	*Odom, Sharda (1990)*

Table 3.1.: Classification of accounting-based bankruptcy prediction models
Source: author's compilation based on (Altman-Saunders, 1997), (Liao-Chen-Chou, 2005) and (Platt-Platt, 1990)

Similar classifications can be found in the works of a number of international and Hungarian authors, like Kiss (2003), Virág (2004) and Oravecz (2008).
Continuing along the chronological line of thought, Altman and Saunders (1997) coined the term 'market-based models' for the then new models in their own classification. According to Dietsch and Petey (2002), this was the point where the models became separable by company size. Those default-focused bankruptcy prediction models, namely, that makes use of accounting data, can be used to analyze non–traded corporate loans. For such non-traded loans, according to Dietsch and Petey, it is only a default that represents a real change, as compared to the state of solvency, from the point of view of the bank – a risk of downgrading can not be interpreted in this case. This is why

they assert that the market-based approach (also including migration risk) can be only applied for corporate clients traded on the stock market.

Table 3.2. shows the classification of market-based models. In structured models, a default occurs whenever the market value of the borrower's assets falls under the face value of the loan. As structural form models are used to model the processes concerning the asset value of one specific debtor, they are suitable for predicting individual credit risk events. Moreover, these analyses already make use of market data instead of accounting figures. In reduced form models, however, the process describing the occurrence of the default is an exogenous one, thus there is no debtor-specific explanation.

Market-based models	**Reduced form models**		*Jarrow-Turnbull (1995), Jarrow et al. (1997), Duffie-Singleton (1998, 1999)*
	Structural form models	Option based models	*Merton (1974), KMV model (1987), Kealhofer-model (1996)*
		Spread-based implicit PD	*Jonkhart(1979), Iben-Litterman (1991), Hull-White (1995)*
		"Mortality rate"	*Altman (1989)*

Table 3.2.: Classification of the market-based credit risk models

Source: author's compilation, primarily based on (Altman-Saunders, 1997), (Liao-Chen-Chou, 2005) and (Platt-Platt, 1990)

Table 3.2. might, however, be enriched by one additional dimension, which allows for the incorporation into the classification of some further aspects: content, methodology and the characteristics of variables. It is probably McNeil, Frey and Embrechts (2005) who provided the most comprehensive overview of reduced form and structural form models. Table 3.3., complementing Table 3.2., is based on their work. Static models, determining the probability distribution of the loan's value for one given point in time,

are suitable for risk management and measurement purposes. Dynamic models, on the other hand, facilitate pricing by focusing on the time function of the process instead of a single point in time. (As the topic of pricing extends well beyond the limits of this chapter, I will not go into any further detail. Several authors, for example Duffie and Singleton (2003) and Lando (2004) have devoted an entire book to the topic.)

The name "*threshold-models"* refers to the fact that the default occurs if and when the stochastic variable denoting the asset value drops below a certain threshold (e.g. the face value of the loans). The model cited as an example, CreditMetrics, is special insofar as it can characterize more than two states of the loan, that is, it can not only account for a default, but for migration risk, as well. Thus the group of migration models, treated by e.g. Altman and Saunders (1997) as an individual class of models, is actually a subgroup of structural form models.

Mixture models deal with the time of occurrence of defaults. Here, as I have already mentioned, defaults do not depend on debtor-specific data but on stochastically modeled macroeconomic variables. Besides individual loans, the listed models are also suitable for the analysis of complete loan portfolios, by simply using a multi-dimensional value process instead of individual asset values. Again, it is McNeil, Frey and Embrechts (2005) who elaborate in detail on the difference distinguishing financial and actuarial models. Thus this is the point where the actuarial models found in the work of e.g. Carling, Jacobson, Linde and Roszbach (2007) can be fit into the classification we described. McNeil, Frey and Embrechts (2005) also underlined a fact frequently derived or referred to by other authors (for example Crouhy, Galai and Mark (2000); Duffie and Lando (2001)), that is, that most „*threshold-models*" can be written in the form of a „*mixture-model*", too - thus there is no definite boundary between structural form and the reduced form models.

	Static	Dynamic
Structural form models	*"threshold models"* e.g. Creditmetrics, KMV	*Pricing*
Reduced form models	*"mixture models"* e.g. Credit Risk+	

Table 3.3.: Classification of credit risk models

Source: author's work based on (McNeil, Frey and Embrechts, 2005)

Falkenstein, Boral and Carty (2000) and Dietsch and Petey (2002) consider all the models we have mentioned so far to be applicable to the large corporate sector. And they are right about that, partly because of the assumptions of these models and partly because of the input data they require. Thus I will not go into any further detail about models focused on credit risk as a whole, including any models describing migration risk either on an individual or on a portfolio level.

The classification of Falkenstein, Boral and Carty (2000) is, however, particularly interesting. Their description suggests that the models presented so far only cover the upper right corner and the portfolio-level section (the circled part) of Table 3.4. It is not a coincidence that their contribution was rather limited to the very problem examined, that is, how I could describe and explain companies' defaults using an SME-dominated sample. Dietsch and Petey (2002) suggest that accounting-based models are the only ones suited for the purpose.

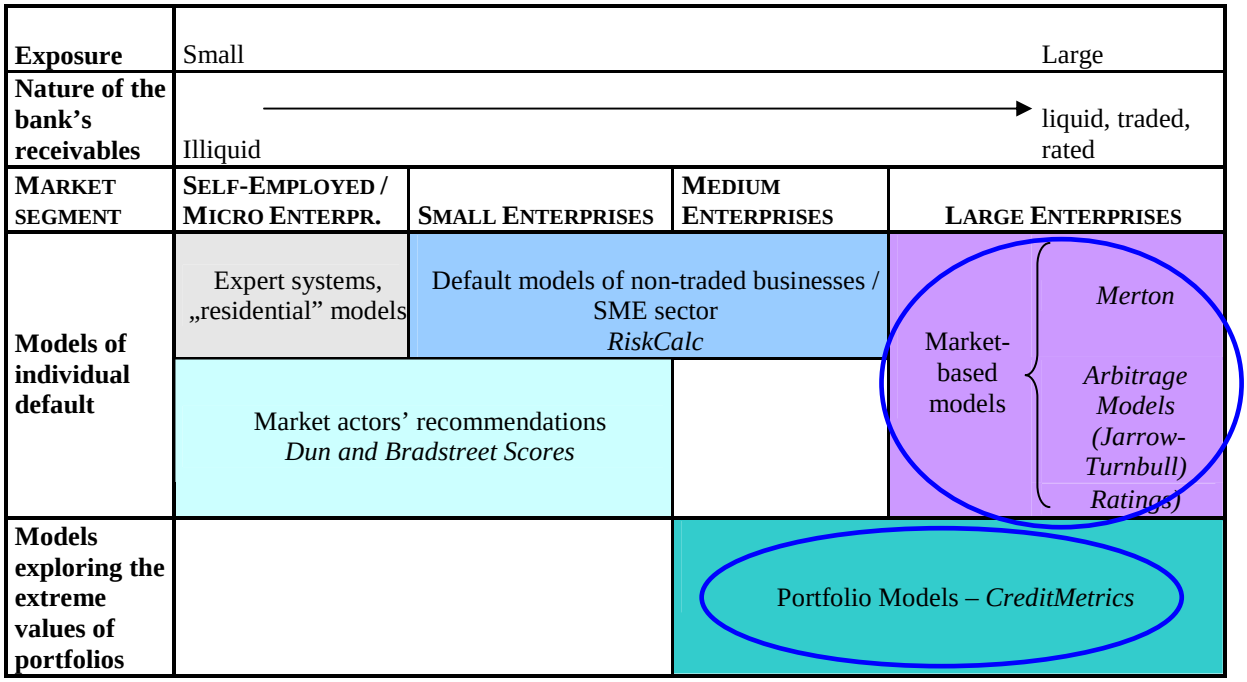


Table 3.4.: Credit risk modeling and characterization by the debtor's size
Source: Falkenstein, Boral and Carty (2000): p.12

Accordingly, my search for a suitable methodology was focused on the middle part of the table covering the SME sector. Relevant pieces of literature clearly distinguish between loans for SMEs and those for large corporations, thus the related risk

assessment methodologies are reasonably expected to be different, too. SME loans, due to the relatively small size of transactions, mean higher average costs for the bank. Though the financial statements of these businesses are less reliable than those of large corporations, this informational disadvantage might be made up for by the close long-term relationship between the bank and its client (Allen, DeLong and Saunders, 2004). If the bank's credit scoring process includes the analysis of financial ratios, it should be considered that SMEs often operate with lower leverage ratios, mainly financed internally, from retained earnings. The external financing are provided by the short term loans. The bank usually encounters higher liquidity ratios but lower inventory levels than in the case of publicly traded companies of a similar risk level. So it is not much of a surprise that the models and significant indicators performing well on the corporate level can not be directly applied to the SME sector (Falkenstein, Boral and Carty, 2000). First, I focused on methodological differences. As Allen, DeLong and Saunders (2004) established, very few publications have dealt with this question so far. Those few classified existing methods into three categories:

- Expert systems
- Rating systems
- Credit scoring systems.

Historically, it was the **expert** systems that were first applied by banks. The 5C method, already mentioned as part of corporate CRM, is one of these systems facilitating the credit scoring process. The character (good reputation, willingness to pay and personal characteristics), the capital (leverage), the capacity (ability to produce a stable income and cash-flow), the collateral and a cycle / conditions (general state of the economy, potentially unfavorable factors) all influence the credit decision. Here, as opposed to quantitative corporate models, qualitative factors do play an important role. By expert systems, however, we do not exclusively mean the totality of the subjective, individual judgments and experiences of bank employees, as neural networks, for instance, can be interpreted as artificial expert systems (Allen, DeLong and Saunders, 2004).

The application of **ratings** (or more specifically: internal ratings) is explained by Basel II. (Regulations of a similar nature are in place in the US, as well.) Basel II authorized the use of Internal Rating Based models to determine the capital requirements for credit risk. According to relevant BIS guidelines (2001), three types of internal rating system are allowed:

- Full expert-judgment reliant processes
- Statistical-based processes
- Constrained expert-judgment based processes.

Allen, DeLong and Saunders (2004) found that institutions mainly employ statistical methods for their corporate clients. However, the smaller the client, the more likely it is that the expert‘s judgment will prevail. According to what Krahnen and Weber (2001) experienced in Germany, internal ratings are primarily based on scoring models. Crouhy, Galai and Mark (2001), on the contrary, asserted that neither banks, nor external rating agencies necessarily use formal models in determining their ratings, even though quantitative information is included in their inputs. Rating agencies (Moody's and S&P), for example, when determining an issuer's rating do not only base their decision on an analysis of financial ratios, but also consider the quality and reliability of the company's statements, country risk, industry-specific factors, quality of management and other qualitative information. Beyond the issuer itself, the rating of any specific security is also influenced by any potential guarantees, its expiration, the collateral provided and any other contractual terms, for instance covenants.

Coming last in this overview, **credit scoring systems** represent the earliest type of credit risk and bankruptcy modeling: the accounting-based approach (see Table 3.1.). This one being the methodology to be applied in my empirical analysis, I am going to briefly review the main points of each model. In addition to the already cited work of Virág (2004), a detailed account of the topic in Hungarian can also be found in Kiss (2003), Oravecz (2007, 2008), Imre (2008) and Kristóf (2008b).

3.1.1.2 Accounting-based Bankruptcy Prediction Models and their Application in SME-lending

Accounting-based models are based on financial ratios derived from the financial / accounting statements of the companies; according to the values taken by these ratios, businesses are divided into two groups: bankrupt and solvent firms. These models focus on historical data and ignore the future – they classify the company's future without having estimated its future performance and ratios. What they deliver is actually not a probability figure, it can just be intuitively interpreted as such. The bottom line of these methods is to examine which group the company in question resembles more (Virág, 2004).

In his 1966 article, **Beaver** used **one single** variable to distinguish between bankrupt and solvent firms. Looking for the most suitable ratio, he examined 30 different financial ratios in his study. According to his findings, predictions derived from ratios based on asset categories other than current assets tend to be more accurate even a year before the actual default as if one would examine liquid assets. The most efficient predictors were: CF/Total Assets, CF/Total Debt and Net Sales Revenue/Total Debt. The inaccuracy of such predictions is, however, between 13-19 percent even as late as one year before the actual default (Beaver, 1966). A disadvantage of the model is that different ratios might yield different classifications.

Multivariate models eliminate this problem by making use of all relevant ratios in the evaluation process. There are several types of models in this category, as well, distinguished by the methodology they are based on: multiple discriminant analysis (Altman), regression models (Edmister), logit regression (Ohlson, Zavgren) or probit analysis (Zmijewski). The use of neural networks and bankruptcy prediction models based on recursive partitioning is a recent development (Platt-Platt, 1990).

Altman based both his 1968 model and the so-called ZETA-model on **multiple discriminant analysis** (MDA). An MDA basically classifies all observations into two or more predefined groups, the groups having been defined by qualitative variables. The objective of any discriminant analysis is to generate such linear combinations of the observed variables that can efficiently (with the least possible extent of overlapping) separate the groups observed within the sample. Figure 3.1. illustrates the bottom line of this method for two variables.

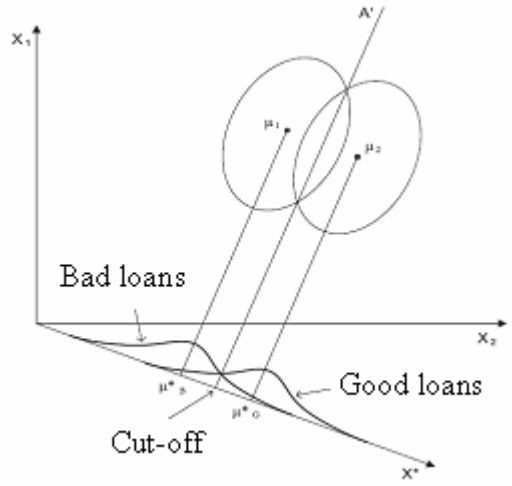


Figure 3.1.: Discriminant analysis
Source: Beatrix Oravecz (2007): p. 611

First, Altman constructed a linear bankruptcy function from his sample of medium enterprises, characterized by an accuracy of 95 percent one year before the default, 72 percent two years before and only 48 percent three years before. The model incorporated the following ratios:

- Working Capital/Total Assets
- Retained Earnings/Total Assets
- Earnings Before Interest and Taxes/Total Assets
- Market Capitalization/Book Value of Total Debt
- Net Sales Revenue/Total Assets

There is an evident correlation between these indices, which definitely requires the careful selection of ratios, yet at the same time, according to Altman, the predictive power of the model can be high with a relatively low number of variables (Altman, 1968).

In the **ZETA-model**, having noticed the tendency that more and more bankruptcy cases had been filed against large corporations and retailers, as well, he expanded the sample and examined 58 surviving and 53 bankrupt companies based on the following seven financial ratios:

- EBIT/Total Assets
- EBIT/Deviation of asset value from the 10-year trend
- Ln(EBIT/Total Interest Payable)
- Retained Earnings/Total Assets
- Current Assets/Current Liabilities
- Registered Capital/Owner's Equity
- Ln(Assets)

(Virág, 2004).

The strongest criticism against the model is that even though its ex-post classification confidence is appropriate within the original sample, it deteriorates by at least 10 percent whenever ex-ante predictions for a different sample are considered. The reason is the temporal instability of data and the inter-industry differences. The elements of the sample (bankrupt and surviving companies) come from various industries without the differences between the competitive situation, life cycle and other attributes of these industries having been taken into consideration. If we only focus on the absolute value of the ratios, as Altman did, that implies the following implicit assumptions: the relationship between dependent and independent variables is the same for the elements

to be predicted as it was in the test sample; the ratios have not shifted as compared to their historical values and neither did the correlation between them change. If these assumptions are not met, the application of **industry-relative ratios** might be more efficient, as suggested by Platt-Platt (Platt-Platt, 1990).

Another remark of Platt-Platt concerns model choice: in a linear model, the change in the dependent variable induced by a unit change in one of the independent variables is always the same, irrespective of the current level of the independent variable. Considering that the indicators of a company of good financial health are bound to suffer a far more dramatic decrease in the case of a default than those of an already unstable business, it is more appropriate to use the logistic regression (logit) model, where the function's estimated value can be interpreted as the probability of default (Platt-Platt, 1990).

Logistic regression, therefore, can handle the problems that MDA could not. It is suitable for analyses where several independent variables are used to predict a dichotomous dummy dependent variable – thus it also meets the recommendation of Platt-Platt concerning bankruptcy modeling. An advantage of the model is that it does not assume the normality and the continuity of the explanatory variables, but of course it does not prohibit such attributes, either. The dependent variable being dichotomous, it follows the Bernoulli distribution with a parameter p=P(Y=1), where p is the probability of default given the concrete values of explanatory variables. Within the sample examined, the number of non-paying businesses follows a binomial distribution. Using the above inputs, the logistic regression assigns a probability of bankruptcy to each company in the sample in the form (3.1), where X is the vector of independent variables and β indicates regression parameters:

$$p = \frac{e^{\beta^T X}}{1 + e^{\beta^T X}} \qquad (3.1)$$

Unlike discriminant analysis, normality and the identity of covariance matrices is not a requirement in this model, but multicollinearity might represent a problem (Hámori, 2001).

The studies expressly focusing on SME clients do not spend too much time pondering about which accounting-based model to choose. Logistic regression is mentioned as the most widely used procedure (Atiya, 2001; Laitinen and Laitinen, 2000) and authors

themselves mostly use logistic regression to perform their own estimations (e.g. Altman and Sabato, 2007; Falkenstein, Boral and Carty, 2000). Thus I am also going to use this method in the forthcoming chapters.

Another – far more abundant – part of SME lending literature is concerned with, instead of the methodology, the financial ratios to be used as explanatory variables in scoring models. It is not by chance that the set of indicators used and their regression coefficients are treated as strictly confidential information by commercial banks. Not even the front-office staff knows which pieces of information from amongst those provided in the credit application will actually be utilized by the back-office in making the decision. In spite of the theoretical and practical relevance of the topic, theoretical papers about variables possessing the required discriminative power are extremely rare. Laitinen and Laitinen (2000) cite some older papers on the topic (Aziz, Emanuel and Lawson, 1988; Scott, 1981; Keasey and Watson, 1987), yet they criticized those recommendations for being too general and oversimplified to actually facilitate any modeling efforts. Empirical studies tend to select the appropriate variables based on earlier publications or using factor analysis. Another possibility is to use the backward or the forward method. The backward method first incorporates all available variables into the model and proceeds by sorting out non-significant indicators one by one. The forward method, on the other hand, adds the variables one by one to the model, until the point where the addition of the last variable would not improve the model's explanatory power any more.

Should we opt for selecting our variables based on available literature, the number of potential variables to be considered would be quite large. Beyond the recommendations of Beaver (1966), Altman (1968) and Platt-Platt (1990) that we have just reviewed, the overview of Allen, DeLong and Saunders (2004), for example, also provides a comprehensive table listing the various authors, the indicators they used and the year and the country when and where they conducted their research (see: Allen, DeLong and Saunders (2004): p. 25) The list published by Kiss (Kiss, 2003: pp. 43-44) reflects Hungarian experience and the recommendations of banking practitioners. After all, we can conclude that it is the ratios concerning profitability, leverage, debt coverage and liquidity that are used most frequently, with size effect and efficiency ratios (like asset turnover) also being popular as proxy variables reflecting management performance.

Recommendations specifically for SME clients can be also found in literature. Falkenstein, Boral and Carty (2000) emphasize the performance of the Cash/Total

Assets ratio. Their experience suggests that a proxy variable for company size might also be useful, as risk was found to increase with company size in the SME sector. Allen, DeLong and Saunders (2004) used Total Asset Value for this purpose. Moreover, they also recommend the company's age to be accounted for in the analysis; and in the case of very small businesses (micro- and small enterprises), the information revealed by the owner's age, the number of dependants and the time for which the registered seat has been unchanged might be far more important than any financial ratios. Altman and Sabato also confirmed that the use of financial indicators alone is not sufficient in the case of SME clients. The non-financial data they underlined – namely the number of employees, the legal form of the enterprise, the geographical region and the industry – tend to improve models' predictive power. The database available to them lacking this kind of information, their analysis finally employed the following financial ratios to estimate probability of default values for SMEs:

- EBITDA/Total Assets
- Current Liabilities/Book Value of Owner's Equity
- Retained Earnings/Total Assets
- Cash/Total Assets
- EBITDA/Interest Payable

Apparently, the discriminative power of non-financial indicators tends to be rather high in models specifically designed for SME clients. (Authors often refer to these data as qualitative information, yet many of them (the number of the employees, for instance) can actually be measured on an interval scale or a ratio scale and thus only differ from the usual inputs by not being based on financial reports.) This is the very reason why I paid special attention to sources that took advantage of such (truly qualitative or non-financial but quantitative) variables in the modeling process.

Altman, Sabato and Wilson (2010) were probably the first to have been provided with a sample suitable for the application of non-financial indicators. They could work with some 5.8 million observations from the United Kingdom for the period between 2000-2007. First of all, they underlined that the termination of such businesses did not necessarily have to have been caused by weak performance, bankruptcy or liquidation. Concerning small enterprises, family reasons (retirement, divorce) can bring about the company's closure just as well as negative credit risk events can. The authors handled the definition of default accordingly. They divided their database into two subsamples

based on how detailed a statement the business in question had been required to file with the authorities. The model's discriminative power was found to improve by 8-10 percent in both subsamples whenever the limited range of financial indicators was complemented by non-financial information, as well. The types of non-financial data used (by arranging them into variables of different measurement levels) are listed below:

- Number of claims enforced in court and executions against the company
- Number of audited annual reports
- Auditor's Opinion (variable measured on a nominal scale, reflecting how favorable the auditor's evaluation of the company's statements was)
- Late fulfillment of statutory reporting requirements (number of days late)
- Availability of Cash Flow Statement (dummy)
- Whether the company in question is a subsidiary
- Age of the company
- Company size (Total Assets)
- Industry
- Industry-specific risk (previous year's default rate)

Lehman (2003) researched a sample of 20,000 German SMEs. From a bank's point of view, besides traditional financial indicators, the financial information used in behavioral scoring might also facilitate the distinction between 'good' and 'bad' debtors. Their current account balance, the variance and the minimum and maximum values thereof, the number of transactions and their drawing on or violation of their line of credit (if any) might all be important inputs. Non-financial data, as listed below, constituted the third group of the variables examined by Lehman (2003):

- Management: education of managers, number of years spent in the industry, corporate information systems used
- Financial status: unaudited, most recent financial data
- Market position: industry characteristics, company's position in the industry, customer-supplier relationships, dependence on a few strategic customers/suppliers
- Quality of bank-customer relationship: duration of the relationship, compliance with reporting requirements so far (delays).

Lehman's (2003) conclusion is similar to that of Altman et al. In spite of the above set of non-financial variables not being more significant than the elements of the first two groups of financial-type variables, their introduction into the models does indeed improve their discriminative power.

3.1.1.3 Bankruptcy Prediction in Hungary[11]

The history of Hungarian bankruptcy prediction models, in comparison to international literature, is rather short - the laws regulating bankruptcy and liquidation proceedings were passed in 1991, thus its history as a research topic dates back to the same year, as well. The first bankruptcy prediction model was developed by Miklós Virág and Ottó Hajdú (1996), who had analyzed companies' insolvency on a sample of 154 firms from the manufacturing industry, based on their annual reports from 1990-91. Only companies with a minimum of 300 employees were included in the sample, thus the relevance of their findings originates in the research having been performed in Hungary (and not in being related to the SME sector in any way). They applied the models of logistic regression and discriminant analysis, built on 5 and 4 independent variables, respectively. These were, in the case of logistic regression:

- Quick Ratio
- Return On Sales
- Cash Flow/Total Liabilities
- Current Assets/Total Assets
- Accounts receivable/Accounts payable

Another innovative work of Ottó Hajdú and Miklós Virág is a family of bankruptcy prediction models specifically designed for the industries (tabulation categories) and the divisions of the Hungarian economy (Virág, 1996). They opted for discriminant analysis and had a rather large (even in international comparison) sample of some 10,000 elements at their disposal. Their modeling efforts yielded one model for the national level, 10 models for the macroeconomic branches (tabulation categories) and 30 models for specific industries. For each industry, they also published the ratios that were found

[11] The chapter deals with academic publications exclusively; models developed by market actors and their methodology and experience are not included in the description.

to have facilitated most the differentiation between bankrupt and non-bankrupt businesses. (The respective weights of the ratios are also given, of course.)

As cited earlier, Platt-Platt (1990) suggested that it might be worth to use industry-relative financial ratios, especially if the sample is heterogeneous by industry. Virág and Kristóf (2006) also utilized this finding and developed their models by applying discriminant analysis, logistic regression, recursive partitioning and neural networks on a sample of 156 elements (based on their sample of 154 elements mentioned earlier).

As evinced by the work of Virág and Kristóf from 2006, Hungarian literature is not limited, either, to traditional models like discriminant analysis and logistic regression. Neural networks appeared both in the theoretical study of Benedek (2000) and later in the paper of Virág and Kristóf (2005). The two authors compared the predictive ability of logistic regression, discriminant analysis and neural networks using Virág's original database from 1990-91, and the new method definitely performed well. Citing the findings of, among others, Hámori (2001), Kristóf (2008) uses factors defined by principal component analysis as inputs in the comparison of the various models.

The empiric part of Kristóf's thesis (2008) is also centered around the estimation of the different models, and the literature overview provides a comprehensive description of the topic, as well. This was, nonetheless, the central topic of Imre's (2008) PhD thesis, too. Readers interested in further details are advised to consult the works of Virág and Kristóf. The range of the methods applied in practice is, naturally enough, wider than what has been discussed in the above paragraphs. For example, multidimensional scaling is a recent addition to Hungarian bankruptcy prediction methods, the most recent publication being that of Virág and Kristóf (2009).

As a conclusion to the subchapter and as an outlook beyond bankruptcy prediction, Hungarian PD models and related theoretical papers by Oravecz (2007) and László Madar (2008) should also be mentioned.

3.2 Data – Aged Balance of Trade Credits

The trade credit database consists of the May 2009 customer portfolio (1398 items) of a real-life company. This business is a member of a multinational group of corporations with several subsidiaries in Hungary, trading in construction materials. Table 3.5. provides some basic financial information (rounded figures) about the company.

	2008	2009
Net Domestic Sales	20 000	15 000
Acquisition Cost of Goods Sold	18 000	12 500
Total Assets	10 700	9 200
Current Assets	5 500	4 000
Merchandise Inventory	*2 800*	*2 000*
Accounts Receivable	2 400	1 800
Cash and Cash Equivalents	25	17
Accounts Payable	1 400	1 300

Table 3.5.: Key financial figures of the company examined (million HUF)
Source: company's website and its annual report of 2009

Besides the open receivables totals from all the 1400 customers of the company, a record of overdue amounts and an aged balance of accounts receivable was also provided. These being stock variables, the figures relate to one specific day in May 2009. The records, however, also show all open and overdue accounts from one week earlier, as well. In addition to the agreed credit limit, information (partly of a qualitative nature) on the customer, its manager and its payment history also appear in the database; these will be included in the quantitative analysis as dummy variables. Thus the variables that are given or can be defined for each and every customer are as follows:

- Aged balanced of open and overdue receivables for two dates;
- Detailed breakdown of open and overdue receivables by due date as of the date examined;
- The amount (if any) purchased/paid back between the two dates can be established;
- How many times the customer appeared on the so-called blacklist (record of non-paying customers) of the claims management company;
- Whether the owner/manager has held a similar position in a company that went bankrupt or had to be liquidated;
- Whether there is anything suspicious about the company:
    - Tax (and similar) arrears
    - Foreclosure initiated against the company
    - Frequent changes in place of residence and scope of activities.
- The credit line extended by the supplier, if any

- The amount (if any) by which the credit line was exceeded can be established.

Non-payment was defined through the following variables.

- BAD: may take the values 0, 1 or 2. Equals 0 if there is no debt more than 90 days past due. Equals 1 if the customer is 91-365 days past due and equals 2 whenever they fall more than one year behind. The variable also (partially) reflects the severity, the structure of non-payment.
- DEF90: dummy variable. Equals 1 if the customer is more than 90 days past due, 0 otherwise.
- DEF120: dummy variable. Equals 1 if the customer is more than 120 days past due, 0 otherwise.

An important remark to the above is that these definitions do not coincide with the criteria of bankruptcy and even less so with those of the company's liquidation – they intend to describe a less extreme situation when non-payment „only" affects the supplier. Variable DEF90 is primarily based on the New Basel Capital Accord (Basel II), which defines a defaulted borrower as anyone who is more than 90 days behind with their payments (BIS, 2006). The two other variables are basically stricter versions of DEF90. Even though my own definition of DEF90 and that of Basel II takes the exact same form, an important distinction is to be made depending on whom the client is indebted to. I made the assumption that it is companies' suppliers who first suffer from late payments, and it is only afterwards, if further financial difficulties arise, that they dare fall behind with or default on their obligations to banks. Accordingly, our non-payment variables describe a situation 'weaker' than either bankruptcy or a default on a bank loan, which must be taken into account when constructing our model and when interpreting the findings.

As a final step in data collection, I also looked up the company's key balance sheet and income statement figures in order to aid our later analyses.

3.2.1 Data Cleaning

An important step prior to performing any analyses is the cleaning of the data set, the main stages of which were:

1. For **96 clients** the database showed a **negative accounts receivable balance**. They made advance payments which were set off against any existing debts, or changed to zero if there were no outstanding liabilities. Accordingly, the

accounts receivable balances only show the amounts actually owed by the customers.

2. Further **174 customers did not have any open or overdue obligations** at that time. From amongst those, 89 had made their 2008 Annual Report available through public databases, while it is questionable whether the remaining 85 clients still existed at the time of our survey. Consequently, these latter ones were removed from the sample. It is a reasonable question, however, whether those 89 firms that presumably still existed at the time of sampling should be included in our analyses or not. The reason for this dilemma is the lack of information on how often the supplier updates its customer portfolio and on any recent orders. This makes it impossible to determine whether these are still active accounts or, alternatively, they have switched over to one of the competitors. The availability of balance sheet and income statement figures being critical – as evinced by the subsequent paragraphs – I decided to keep all apparently still existing (annual report available) zero-balance companies in the sample.
3. Next, I had to ensure that the data necessary for the construction of our model are available, thus my analyses had to be limited to that portion of the resulting set of customers the **annual report** of which was **available.** There were 405 customers – apart from those with a zero balance – without a publicly available annual report. Knowing that this is some 28 percent of the original sample, I also examined what type of customers they are, what the structure of their debts looks like. From 170 of them (8 privately/publicly held share companies, 27 limited partnerships and 116 limited liability companies) one would reasonably expect an annual report to be available. For 19 items, the form of incorporation was unknown. In 235 cases, the lack of report data was justified. This subsample contained 10 governmental institutions and one foundation, all of which were excluded from the sample. The remaining 224 customers were self-employed entrepreneurs.

The process yielded the following subsamples to be treated separately in our analyses:

1. self-employed entrepreneurs – 224 items → Subsample I
2. customers whose annual report was available – 905 items → Subsample II
3. customers whose annual report was not available – 164 items:
    a. can not be found – 2 items - excluded

b. newly founded (current year) – 11 items
c. existing and operating – 82 items
d. terminated business (liquidation, full and final settlement of claims) – 48 items
e. foreign business – 11 items – added to those existing and operating
f. newly founded but already terminated – 8 items
g. identification uncertain – 2 items - excluded

Above the receivable balances, being the most important variables pertaining to our units of observation and being available for each customer, we also have to explore the structure of the data that is missing. Subsample I contains self-employed entrepreneurs, for whom – apart from their liabilities – gender is the only variable and, based on their names, that could always be determined without any uncertainty.

In Subsample II the form of incorporation is also known for each unit, yet there are enormous differences in the extent to which report data are available. The analysis of related missing data follows in Chapter 3.3.3.

3.2.2 Characteristics of Open Receivables Balances

Prior to proceeding with the analyses themselves, I would like to present some descriptive statistics in order to demonstrate the size of the customer portfolio we were provided with. Statistics are presented by subsample.

Table 3.6. provides a preliminary overview of how the obligations of all 1313 customers are distributed by due date. The sum of all gray cells in any given column always equals 100 percent, as the sum of overdue balances, balances due in 15 days and those due in more than 15 days always adds up to the sum total of all accounts receivable. Below the gray section follow all the overdue balances, consequently, these cells exactly add up to the sum total of all overdue accounts receivable.

The table tells us that the company had a total open accounts receivable balance of HUF 2.6 billion – 1.4 billion of which were already overdue –, which corresponds to approximately 46 days' turnover (in 2008 terms). According to their 2009 Annual Report, they managed to reduce this rather high figure to HUF 1.8 billion by the end of 2009. Obviously, the totals of the subsamples are heavily influenced by the number of elements, thus one should also look at the average (per item) accounts receivable balances, as well (see Table 3.7.). Apparently, the average of all outstanding balances

was about HUF 2 million, with almost 1.1 million already overdue. The average for Subsample II (annual report available) was 18 percent higher, while, at about one fourth of the portfolio-wide average, it was expressly low among self-employed entrepreneurs (Subsample I). A sad fact was that the average of terminated businesses did not differ too much from that of the other customers; still, they only accounted for 3.67 percent of the total receivable balance thanks to their relatively low number. Trade credits granted (if any) to newly founded customers are on average HUF 1 million less than those of their older counterparts. However, even if the new company terminates its operation after a relatively short while, they still have the time to accrue a debt amounting to HUF 4.1 million, all overdue. (Of course, their share of the total receivable balance at 1.23 percent is relatively low, too.)

Consequently, those eight newly founded customers in the sample who terminated their operation rather soon do not contradict the suggestion of Altman, Sabato and Wilson (2010) that new companies represent a higher risk of non-payment. However, other authors asserted that they assumed a 2-year interim period; their experience implied that companies rarely go bankrupt in their first 2 years of operation, while years 3 to 9 were indeed found to be more risky. According to my definition, new companies were those founded after January 2008, and terminations were only considered if they happened in or before July 2010. Thus it seems as if those 8 companies in our sample did not experience the aforementioned less risky 2-year period. (Any assertions in this paragraph, however, should be treated very cautiously because of the extremely small size of the subsample.)

	Entire sample	Report data available	Self-employed entrepreneur	Terminated	Missing report	New	New and terminated
Sample count	**1289**	**905**	**224**	**48**	**93**	**11**	**8**
Total Open	**2 674 302**	2 205 038	110 845	98 163	215 747	11 612	32 896
Total Overdue:	**1 408 159**	1 110 400	71 605	95 201	95 919	2 138	32 896
< -15 days	**891 359**	789 542	26 653	1 697	69 305	4 161	-
-15-0 days	**374 784**	305 096	12 587	1 265	50 524	5 312	-
1-15 days	**267 846**	235 956	7 736	695	21 995	546	918
16-30 days	**96 002**	80 140	4 776	1 026	7 698	1 437	925
31-60 days	**149 026**	123 371	6 208	1 001	17 014	17	1 415
61-90 days	**182 206**	157 697	2 003	2 838	16 537	-	3 131
91-120 days	**165 478**	150 317	881	8 610	883	2	4 784
121-150 days	**62 168**	49 647	1 782	4 405	2 468	136	3 730
151-180 days	**58 679**	45 695	7 171	3 219	2 369	-	225
181-365 days	**210 388**	156 266	6 322	29 442	3 145	-	15 213
> 365 days	**216 366**	111 311	34 726	43 965	23 810	-	2 555

Table 3.6.: Accounts receivable balances by due date and by subsample

Source: author's calculation (in thousand HUF)

	Entire sample	Report data available	Self-employed entrepreneur	Terminated	Missing report	New	New and terminated
Sample count	**1289**	**905**	**224**	**48**	**93**	**11**	**8**
Total Open	**2 074 710**	2 436 506	494 845	2 045 062	2 319 859	1 055 626	4 112 026
Total Overdue:	**1 092 443**	1 226 962	319 664	1 983 349	1 031 383	194 382	4 112 026
< -15 days	**692 049**	872 422	118 989	36 112	745 210	378 308	-
-15-0 days	**290 756**	337 122	56 193	26 353	543 266	482 936	-
1-15 days	**207 794**	260 725	34 535	14 484	236 502	49 643	114 750
16-30 days	**74 478**	88 552	21 320	21 377	82 773	130 649	115 661
31-60 days	**115 614**	136 322	27 712	20 862	182 946	1 527	176 897
61-90 days	**141 355**	174 251	8 943	59 118	177 817	-	391 425
91-120 days	**128 377**	166 096	3 934	179 384	9 500	189	597 946
121-150 days	**48 229**	54 859	7 954	91 772	26 535	12 375	466 252
151-180 days	**45 523**	50 492	32 013	67 058	25 475	-	28 100
181-365 days	**163 218**	172 670	28 225	613 366	33 819	-	1 901 600
> 365 days	**167 856**	122 995	155 028	915 927	256 016	-	319 397

Table 3.7.: Average accounts receivable balances by due date and by subsample

Source: author's calculation (in HUF)

An average age statistic, being analogous – in terms of calculation – to the well-known financial concept of duration, might provide a useful overview of the age of one's accounts receivable balances. Traditionally, duration is the weighted average of the times until the relevant payments are received, with the ratios of the individual payments' present value to the total present value serving as weights:

$$D = \sum_{i=0}^{n} w_i t_i = \sum_{i=0}^{n} \frac{PV(CF_i)}{\sum_{j=0}^{n} PV(CF_j)} t_i$$

As we were only provided with the class interval frequency distribution of the receivable balances, I had to use the arithmetic mean of the class intervals in my calculations. Discounting has also been omitted for the sake of simplicity. Table 3.8. still reveals some clear-cut trends, which, nevertheless, were already implied by Tables 3.6. and 3.7., though in a less explicit form. Companies that are required by law to file and publish an annual report pay sooner than the average: 53 to 55 days past due. (At first sight, their payment morale is not affected by whether they have actually met their statutory reporting obligations.) Self-employed entrepreneurs (Subsample I), in spite of their liabilities not being limited, are some 5 months behind with paying their supplier. Customers who terminated their operation by the end of 2009 (primarily through liquidation) had begun accruing their debt much earlier; on average, they were 9 months behind with their payments to the company in question. Newly founded companies were the only ones not to be late on their bills: their debt was due in 4 days on average. Except for those, however, who had already terminated their business since then; though their life was short, they still managed to accumulate debts more than half a year past due.

	Entire sample	Report data available	Self-employed entrepreneur	Terminated	Missing report	New	New and terminated
Average age	68	55	145	269	53	- 4	197

Table 3.8.: Average age (duration) of accounts receivable (unit: rounded to days)
Source: author's calculation

The average age statistics already include a concise form of the conclusions to be drawn from the age structure of receivables. Table 3.9. confirms that, as suggested by their average age figure, those with a publicly available annual report have a more favorable (50 percent) ratio of overdue debts. Even the age structure of their overdue bills is better than that of the other customers – the share of obligations more than 5 months past due is lower in this subsample than in the entire sample. In this table, one can already distinguish those customers that have not met their statutory reporting obligations and have not made their annual report publicly available. The only reason why their average age figure looks very similar to that of Subsample II is that they have the lowest ratio (44.5 percent) of overdue obligations. But, if and when they do fall behind with their payments, they are characterized by extremities. They either pay within 90 days or it might take more than a year for the supplier to collect their money, if they ever get to that point. The age structure of the terminated companies' debts is not much of a surprise: they had typically been struggling with liquidity issues long before they terminated their operation, the majority of their liabilities is more than six months late. More than 80 percent of the obligations of newly founded companies, however, come from current (not yet due) bills. Nevertheless, receivables more than 90 days overdue represent a very similar, above 80 percent proportion in the rightmost column of Table 3.9., as well.

Obviously, the last two rows' figures are higher for each subsample, as those class intervals cover much longer periods than the preceding ones (representing 30 days). The differences found are nonetheless undoubtedly significant. The age structures of the subsamples indeed seem to differ, thus in the first phase of the analysis, I am going to use this information to identify relevant groups in the sample as a whole.

	Entire sample	Report data available	Self-employed entrepreneur	Termi-nated	Missing report	New	New & termi-nated
Sample count	**1289**	**905**	**224**	**48**	**93**	**11**	**8**
Total Open	**100,0%**	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Total Overdue:	**52,7%**	50,4%	64,6%	97,0%	44,5%	18,4%	100,0%
< -15 days	**33,3%**	35,8%	24,0%	1,7%	32,1%	35,8%	0,0%
-15-0 days	**14,0%**	13,8%	11,4%	1,3%	23,4%	45,7%	0,0%
1-15 days	**10,0%**	10,7%	7,0%	0,7%	10,2%	4,7%	2,8%
16-30 days	**3,6%**	3,6%	4,3%	1,0%	3,6%	12,4%	2,8%
31-60 days	**5,6%**	5,6%	5,6%	1,0%	7,9%	0,1%	4,3%
61-90 days	**6,8%**	7,2%	1,8%	2,9%	7,7%	0,0%	9,5%
91-120 days	**6,2%**	6,8%	0,8%	8,8%	0,4%	0,0%	14,5%
121-150 days	**2,3%**	2,3%	1,6%	4,5%	1,1%	1,2%	11,3%
151-180 days	**2,2%**	2,1%	6,5%	3,3%	1,1%	0,0%	0,7%
181-365 days	**7,9%**	7,1%	5,7%	30,0%	1,5%	0,0%	46,2%
> 365 days	**8,1%**	5,0%	31,3%	44,8%	11,0%	0,0%	7,8%

Table 3.9.: Percentage distribution of accounts receivable (volume)
Source: author's calculation

3.3 Analysis of the Aged Receivable Balance of a Customer Portfolio

Now, that data preprocessing is done, we can proceed with the actual analysis. First, I am going to use the entire sample to explore any well-separated payment patterns defined by the structure of open accounts as a classification criterion. Second comes the examination of Subsample I. Finally, using Subsample II (where the required financial ratios are available), I am going to estimate logistic models for the prediction of customer defaults based on the methodology of the bankruptcy prediction models in chapter 3.1.2.

The methodology I am going to use has been discussed in detail in several Hungarian sources. In addition to the theoretical approach, Füstös et al. (2004) also provides many practical examples to foster our understanding of the topic, while Sajtos and Mitev (2007) advise on practical aspects and on resolving any methodological dilemmas. The brief theoretical overview of Kovács (2006), at the same time, helps in understanding the basics of the methods and in the initial steps of practical application.

3.3.1 Patterns in Payment Habits

First, I am going to look for typical payment habits by solely focusing on payment patterns, and ignoring any other attributes of the customers. Afterwards, I will examine whether the customers characterized by the same payment pattern have any other characteristics in common. I am going to use cluster analysis, which will result in the number of observation units dropping dramatically. A remarkable advantage of the method is that one does not need to know in advance which group the individual customers belong to. A disadvantage of clustering is, however, that it creates such non-predefined groups even if they are not actually present in the sample. Results can not be generalized to the entire population, but, having observed each element of the sample (thus analyzing the entire population itself), this is not a problem in our case. Generalizability would imply that the customer portfolios of other suppliers behave in a similar way, yet such a conclusion would not be appropriate, irrespective of the methodology chosen.

There are two critical decisions to make when performing a cluster analysis. First of all, the result is highly sensitive to the input variables. This problem, given that we are exploring payment habits, becomes much simpler in our case. The aged balance of (open and overdue) receivables can be interpreted as a kind of time series, thus we only need to consider significant, order-of-magnitude differences. As a solution, instead of working with the receivables' values themselves, I examine their structure, that is, what percentage of the total open receivables balance has already been overdue or becomes due in the given due date interval (Sajtos and Mitev, 2007; Füstös et al., 2004).

There is no such straightforward solution, however, to the question about the number of clusters. Thus first, I turned to hierarchical agglomerative methods. The single linkage, nearest neighbor method is usually used to aid in the identification of outliers because it tends to create many small clusters accompanied by a couple of larger clusters. Sajtos and Mitev (2007) recommend Ward's method to determine the size of the clusters. The related SPSS outputs (the dendograms and the graphs of the coefficients) assisted in limiting the number of clusters to 8-12. Lacking an evident rule for the determination of the number of clusters, the decision was backed by an examination of the created clusters. Having examined the number of elements in each group and their actual homogeneity by payment habits, I decided to generate 12 clusters. It was comforting to see that the classification of the observation units was consistent irrespective of the

method, and an increase in the number of clusters did not result in a rearrangement of units, either, but rather in the splitting of one or the other group.

Final clusters were determined by K-mean clustering. Table 3.10.a lists the final cluster centers. (Variables are abbreviated according to the following logic: the names of open, but not yet due accounts and overdue accounts begin with 'NY' and the letter 'L', respectively. Next come the upper and the lower limit of the due-in date in decreasing order, considering not yet due amounts. For example, ny150a denotes the proportion of receivables due in 0 to 15 days. In the case of overdue amounts, the limits of the delay are written in increasing order. L3160a, for example, denotes the proportion of receivables that should have been paid 31 to 60 earlier, in other words: that are 31 to 60 days behind.) Table 3.10.b shows the number of elements in each cluster. Figure 3.2. illustrates the due date structure of the different clusters.

	Cluster											
	1	2	3	4	5	6	7	8	9	10	11	12
ny9915a	.02	.00	.00	.10	.04	.00	.09	.00	.00	.82	.03	.00
ny150a	.01	.00	.00	.83	.08	.00	.12	.00	.00	.11	.02	.00
L115a	.02	.00	.00	.05	.85	.00	.14	.00	.00	.04	.05	.00
L1630a	.01	.00	.00	.01	.02	.00	.63	.01	.00	.01	.03	.00
L3160a	.02	.00	.00	.00	.00	.00	.02	.03	.04	.00	.83	.00
L6190a	.01	.00	.01	.00	.00	.00	.00	.04	.94	.00	.03	.00
L91120a	.01	.00	.00	.00	.00	.04	.00	.86	.01	.00	.01	.01
L121150a	.01	.00	.04	.00	.00	.90	.00	.02	.00	.00	.00	.00
L151180a	.00	.00	.89	.00	.00	.06	.00	.04	.00	.00	.00	.01
L181365a	.01	.01	.07	.00	.00	.00	.00	.00	.00	.00	.01	.96
L366a	.00	.99	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

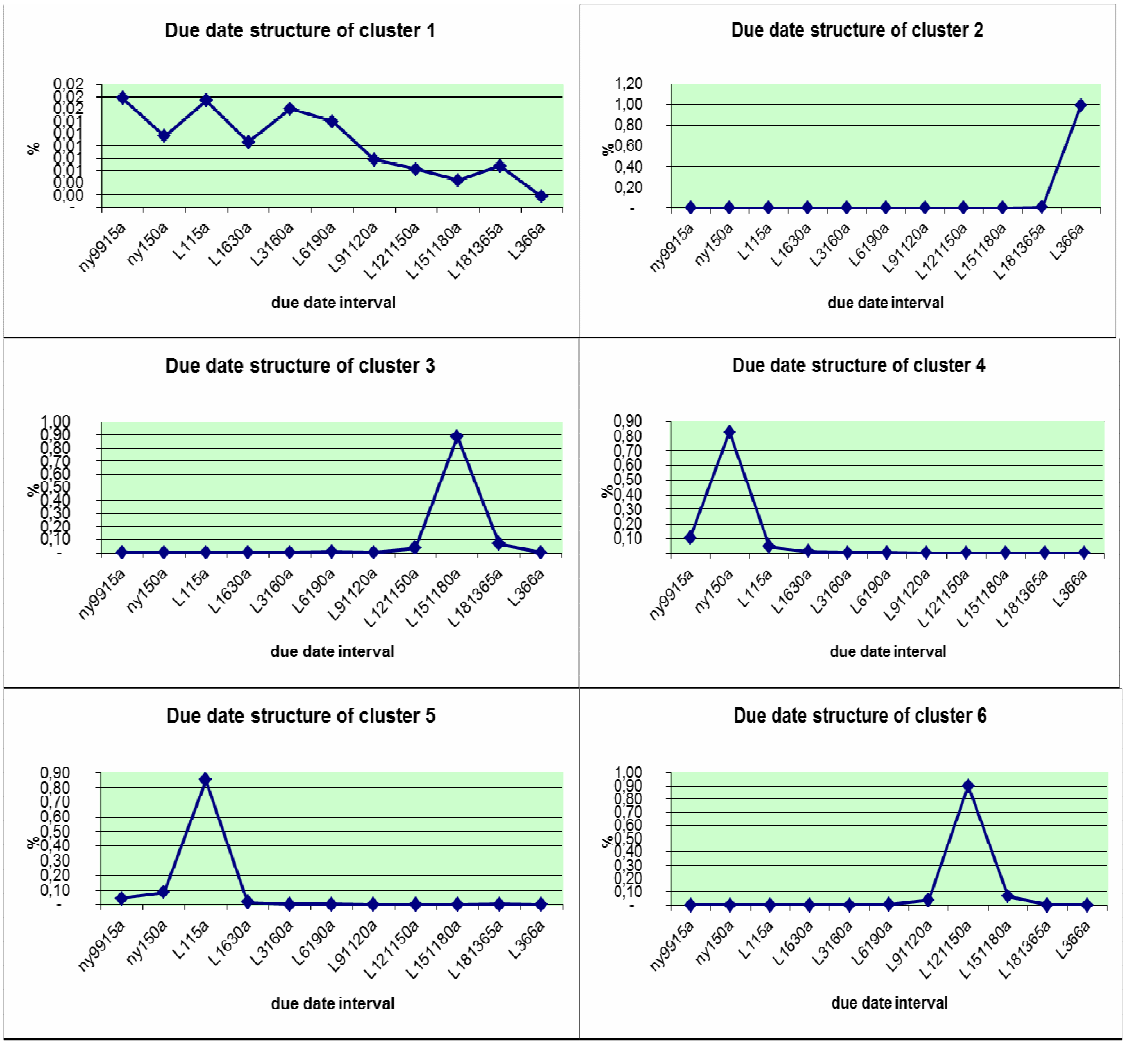
Table 3.10.a: Final cluster centers of the k-mean clustering

Source: SPSS

CLUSTER	1	263
	2	93
	3	32
	4	283
	5	135
	6	40
	7	47
	8	26
	9	32
	10	224
	11	41
	12	73
Valid		1289
Missing		0

Table 3.10.b: Number of elements in the k-mean clusters

Source: SPSS (unit: pieces)



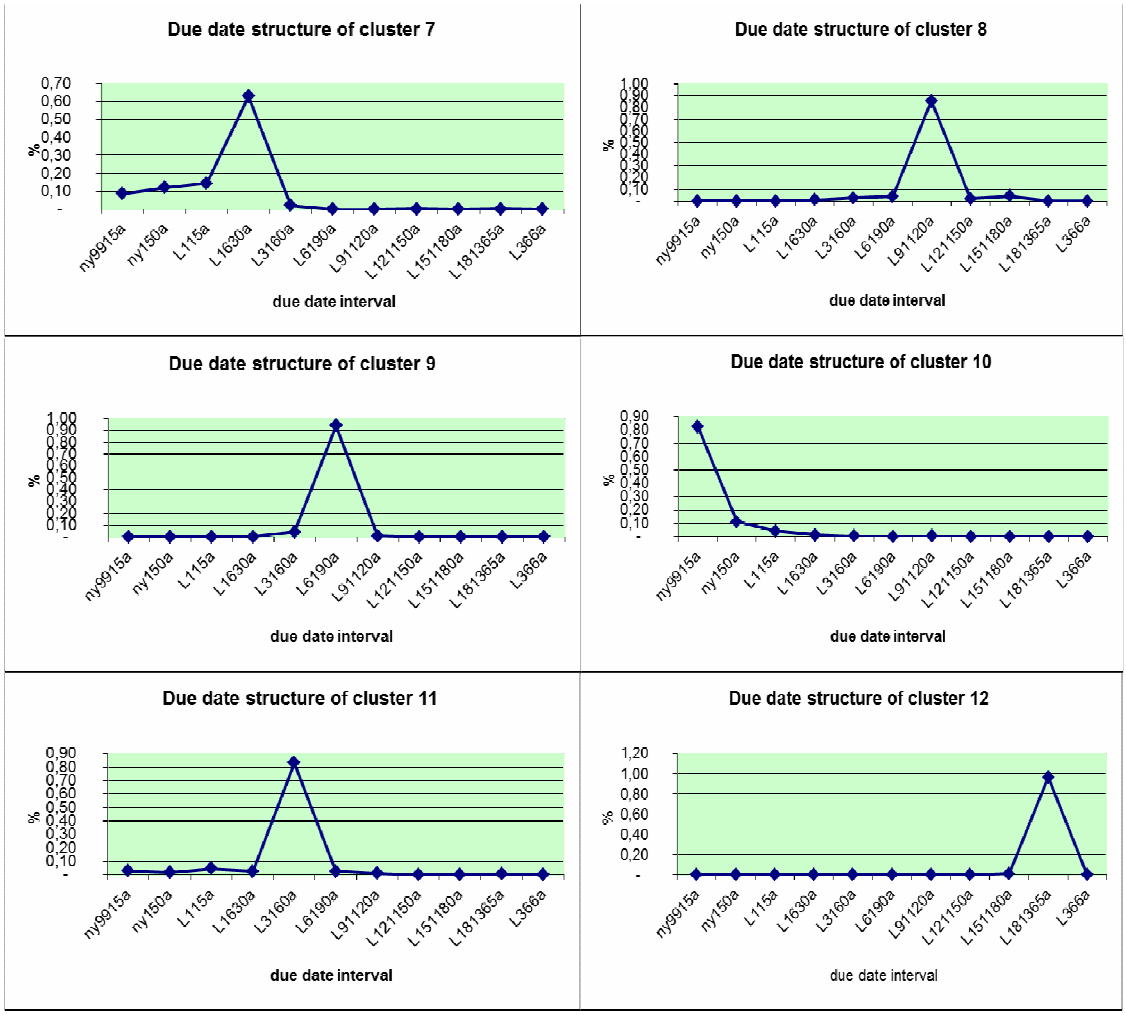


Figure 3.2.: Due date structure of the k-mean clusters (based on the final cluster centers)

Source: SPSS, Excel

At first sight, the result is not too surprising. The 11 due date intervals define 11 clusters, with the remaining one cluster being the first one, apparently including "the rest" of the customers, namely those who are not characterized by one typical due date. Nonetheless, the majority of the variables that have not been included in the cluster analysis also yield well-defined, well-separable groups. Table 3.11. compares the averages of non-clustering variables for each cluster.

Cluster		SumOpen	SumOverd	sumASSET08	sales08
1	Mean	1 877 352	1 505 881	449 413	737 337
	N	263	263	169	176
	St.Deviation	11 327 822	9 673 017	2 059 405	3 907 402
2	Mean	2 187 935	2 187 935	275 275	227 001
	N	93	93	41	41
	St.Deviation	3 321 612	3 321 612	754 219	473 182
3	Mean	1 069 184	1 069 184	817 674	1 041 836
	N	32	32	16	16
	St.Deviation	1 562 581	1 562 581	1 937 673	2 106 970
4	Mean	1 060 825	102 741	1 643 673	2 938 645
	N	283	283	225	225
	St.Deviation	2 852 556	305 045	4 712 460	10 114 675
5	Mean	1 146 483	894 843	1 598 899	2 401 444
	N	135	135	105	101
	St.Deviation	2 842 897	1 907 266	4 633 236	8 086 816
6	Mean	1 140 193	1 140 193	236 188	399 944
	N	40	40	24	23
	St.Deviation	2 028 743	2 028 743	434 018	682 508
7	Mean	1 358 014	980 072	681 126	803 760
	N	47	47	37	37
	St.Deviation	1 594 033	1 082 110	2 280 248	2 440 174
8	Mean	4 047 595	4 039 863	1 525 000	2 240 258
	N	26	26	20	21
	St.Deviation	12 815 393	12 784 162	5 010 308	6 319 917
9	Mean	1 419 048	1 419 048	143 547	206 337
	N	32	32	21	20
	St.Deviation	3 441 812	3 441 812	197 187	242 884
10	Mean	4 281 123	531 349	829 390	1 319 670
	N	224	224	179	178
	St.Deviation	14 019 261	2 653 300	2 832 709	4 690 280
11	Mean	2 063 140	1 957 411	1 467 888	2 110 262
	N	41	41	28	28
	St.Deviation	4 572 465	4 409 676	3 432 466	4 745 647
12	Mean	2 523 770	2 508 865	438 229	608 764
	N	73	73	40	40
	St.Deviation	4 317 896	4 284 926	1 117 371	1 484 960
Total	Mean	2 074 710	1 092 442	1 004 979	1 620 241
	N	1 289	1 289	905	906
	St.Deviation	8 385 875	5 240 556	3 445 168	6 536 064

Table 3.11.: Comparison of the clusters based on the most important variables' means

Source: SPSS

Cluster Number		BAD	DEF90	DEF120	REDEMP	Purch.	CRLINE_ DUMMY	OVER CRLINE_ DUMMY	Blacklist _No	Man_ dummy	Firm_ dummy	CEG_PERS _DUMMY
1	Mean	0,06	0,05	0,04	0,16	0,13	0,16	0,05	0,19	0,16	0,30	0,46
	N	263	263	263	105	105	263	263	263	263	263	263
	St.Deviation	0,26	0,22	0,20	0,48	0,34	0,37	0,21	1,01	0,36	0,46	0,62
2	Mean	2,00	1,00	1,00	0,05	-	-	1,00	0,19	0,32	0,59	0,91
	N	93	93	93	93	93	93	93	93	93	93	93
	St.Deviation	-	-	-	0,23	-	-	-	0,95	0,47	0,49	0,75
3	Mean	1,00	1,00	1,00	0,06	-	0,56	0,47	0,75	0,19	0,34	0,53
	N	32	32	32	32	32	32	32	32	32	32	32
	St.Deviation	-	-	-	0,25	-	0,50	0,51	1,87	0,40	0,48	0,72
4	Mean	0,00	0,00	0,00	0,58	0,38	0,71	0,34	0,12	0,11	0,13	0,23
	N	283	283	283	210	210	283	283	283	283	283	283
	St.Deviation	0,06	0,06	0,06	0,70	0,49	0,46	0,47	0,65	0,31	0,33	0,46
5	Mean	0,01	0,01	0,01	0,48	0,52	0,61	0,44	0,21	0,16	0,19	0,35
	N	135	135	135	97	97	135	135	135	135	135	135
	St.Deviation	0,12	0,12	0,12	0,72	0,50	0,49	0,50	0,86	0,36	0,40	0,52
6	Mean	1,00	1,00	1,00	0,13	-	0,65	0,43	0,30	0,28	0,25	0,53
	N	40	40	40	40	40	40	40	40	40	40	40
	St.Deviation	-	-	-	0,33	-	0,48	0,50	0,88	0,45	0,44	0,60
7	Mean	0,02	0,02	0,02	0,32	0,43	0,81	0,26	0,11	0,17	0,36	0,53
	N	47	47	47	47	47	47	47	47	47	47	47
	St.Deviation	0,15	0,15	0,15	0,56	0,50	0,40	0,44	0,52	0,38	0,49	0,65
8	Mean	1,00	1,00	0,27	0,04	0,04	0,58	0,50	0,46	0,15	0,27	0,42
	N	26	26	26	26	26	26	26	26	26	26	26
	St.Deviation	-	-	0,45	0,20	0,20	0,50	0,51	1,24	0,37	0,45	0,50
9	Mean	0,06	0,06	-	0,09	0,06	0,41	0,66	0,56	0,16	0,41	0,56
	N	32	32	32	32	32	32	32	32	32	32	32
	St.Deviation	0,25	0,25	-	0,39	0,25	0,50	0,48	1,97	0,37	0,50	0,67

10	Mean	0,03	0,03	0,02	0,54	0,42	0,93	0,17	0,24	0,12	0,14	0,26
	N	224	224	224	214	214	224	224	224	224	224	224
	St.Deviation	0,16	0,16	0,15	0,68	0,49	0,26	0,38	0,89	0,33	0,35	0,52
11	Mean	0,10	0,10	0,02	0,07	0,12	0,61	0,54	0,63	0,29	0,37	0,66
	N	41	41	41	41	41	41	41	41	41	41	41
	St.Deviation	0,30	0,30	0,16	0,26	0,33	0,49	0,50	1,62	0,46	0,49	0,73
12	Mean	1,01	1,00	1,00	0,01	0,04	0,47	0,63	0,29	0,41	0,47	0,88
	N	73	73	73	73	73	73	73	73	73	73	73
	St.Deviation	0,12	-	-	0,12	0,20	0,50	0,49	0,86	0,50	0,50	0,76
Total	Mean	0,30	0,23	0,21	0,33	0,26	0,54	0,35	0,24	0,17	0,26	0,43
	N	1 289	1 289	1 289	1 010	1 010	1 289	1 289	1 289	1 289	1 289	1 289
	St.Deviation	0,60	0,42	0,40	0,60	0,44	0,50	0,48	0,98	0,38	0,44	0,62

Table 3.11.: Comparison of the clusters based on the most important variables' means (continued)

Source: SPSS

For the ease of understanding, the 12 clusters were organized into five groups. Below, the descriptions of the clusters are provided according to this grouping.

GOODS

Cluster 10 – Customers with the most favorable payment history

In this cluster, 82 percent of the receivables are due in more than 15 days and 11 percent are due in 15 days. Fortunately, the company boasts 224 customers with such an exemplary payment performance, representing about HUF 1 billion in customer receivables. They do not typically have any negative records from earlier periods, either, thus nearly all of them has a credit line that they very rarely exceed. Repayment, too, was above the average in the period examined, Cluster 4 was the only one to perform even better. The company's record is clean - compromising data can be found only half as frequently as the portfolio average. Considering the managers and owners, this ratio amounts to a mere 12 percent, the lowest in the portfolio. These customers are not the largest ones considering company size; they are over-represented in the second and fourth percentiles by Total Asset Value and among limited companies (so-called kft.'s and rt.'s) by legal form. Their average Total Assets is HUF 829 million, their sales revenue (HUF 1.3 billion) is also below the portfolio average, but at the same time, their accounts payable balance is far above the average. The average open balance of HUF 4.2 million they have with the supplier examined represents nearly 5% of their assets, yet due to their disciplined payment habits, their overdue balance of HUF 531 thousand is much lower than the average. Based on their behavior so far, it is reasonable for the supplier to extend a large credit line to these customers, since the risk they represent is not very high.

Cluster 4 – Accurate customers - have at most 15 days to pay

Out of the obligations of the 283 customers in this group, 83 percent are due within 15 days, while 10 percent is due in more than 15 days. Altogether, they represent HUF 300 million of customer receivables. Repayment frequency is similar to that in Cluster 10, yet a credit line is less common (about 70 percent have one). At 34 percent of all cases, they exceed their credit line far more frequently than Cluster 10, but somewhat less often than the portfolio average. The records of their managers and owners and the company itself are clean, incriminating information can only be found in some 11-13 percent of the cases. However, interestingly enough, they are the ones to appear least

frequently on the credit blacklist out of the entire sample, even far less frequently, than Cluster 10**.** These businesses are typically twice the size of those with the best payment history, with a Total Assets Value of HUF 1.6 billion and sales revenue of HUF 3.9 billion on average. Accordingly, they are over-represented in the fourth and the fifth percentile by company size. Whether compared to their size or to all the other customers, their average open balance of HUF 1 million can not be considered high. Thanks to their payment habits, however, the average overdue balance is extraordinarily low at HUF 102. The cluster primarily includes limited companies (kft.'s and rt.'s).

DELAYERS

Cluster 5 – 1 to 15 days past due

Some 85 percent of the obligations of this 135-element cluster are 1-15 days past due, with only 12 percent becoming due in the future. This is the only cluster, apart from the GOODS, with an above the average repayment ratio (48%) - all other clusters are lagging behind. Credit lines are also more common (65 percent) than the average, but less frequent than in the clusters of GOODS. They are exceeded with a frequency of 44 percent, somewhat above the average. The records of the managers and the owners – as opposed to the GOODS – represent the average. Approximately one out of five customers in the cluster has a negative event affecting its payment habits on its record, which is below the portfolio average. The number of mentions on the blacklist is around the average, too, with 0.21 mentions per element. Average asset value is HUF 1.6 billion, sales amount to HUF 2.4 billion, exceeding the average, positioned between the two clusters of the GOODS. These companies, mainly limited companies (more specifically: kft.'s), are overrepresented in the 3^{rd} – 5^{th} percentiles by company size. Close to Cluster 4 of the GOODS, their average open balance is HUF 1.170 million, but their overdue balance is much higher at HUF 895 thousand on average. This totals to some 154 million in open receivables, out of which HUF 121 million is already past due.

Cluster 7 – 16 to 30 days past due

The seventh cluster only comprises 47 customers. But contrary to the previously discussed clusters, the typical delay only covers 63 percent of all obligations. Nearly 21 percent are not yet due, while 14 percent is only 1-15 days past due. Although cluster averages of small clusters are sometimes less informative, their repayment ratio equals

the portfolio average, lagging far behind the three clusters above. Here, a credit-line is more common than in Cluster 5, yet it is exceeded less frequently. Both indicators imply a behavior more favorable than what is characteristic for the portfolio as a whole. (Even though the latter one might be explained by the fact that if there is no credit line then an open balance of even one single forint signals the exceeding of the credit line – which is at least questionable.) Mentions on the blacklist are less frequent than in any other cluster, the record of the managers, however, only represents the portfolio average, while the record of the company itself contains incriminating events in 36 percent of the cases, way above the portfolio average of 26 percent. Companies' Total Assets amounts to HUF 681 million on average, with sales revenues of HUF 803 million. Their open balance is – partly because of the longer delays and the credit lines extended to them on the grounds of their favorable behavior – higher than that of Cluster 5, namely HUF 1.3 million. The limited company (more specifically, the "kft") is the dominant legal form in the cluster.

Cluster 11 – 31 to 60 days past due

The 41 members of the cluster primarily have obligations 31 to 60 days overdue (83 percent), but delays of 16-30 days and 1-15 days are also recorded (8 percent altogether). Only three customers had paid back anything during the observed period, which is an important difference to the groups mentioned earlier. Some 50 percent exceeded their (previously determined) credit line. The record of the manager/owner and the company contains some kind of negative information in the case of 12 and 15 customers, respectively, and in six cases, repeated occurrences were reported. Apart from the two clusters of the BADS, they performed worst considering the amount of incriminating information, even underperforming the clusters of NON-PAYERS, for which I could not find an acceptable theoretical explanation. In spite of their unfavorable records, some two thirds of all businesses have a credit line. Maybe the reassessment of credit lines is performed less frequently than each 60 days and hence the above-average frequency of credit lines. Average Total Asset Value is similar to that of Cluster 5, sales revenue, however, is somewhat lower at HUF 2.1. Considering company size, these customers can mainly be found in the 1st and 5th percentiles. Within the group, the majority are kft's (a form of limited company), yet their proportion is less than in the whole portfolio, while self-employed entrepreneurs and rt's (a form of limited company) are overrepresented. Their average open balance is

HUF 2.06 million with HUF 1.96 million already overdue – the latter one amounting to almost twice the average of the entire sample. The number of elements in the cluster being low, the sum of their open balances „only" totals to HUF 84 million, representing 3.1 percent of the supplier's total accounts receivable balance.

Cluster 9 – 61 to 90 days past due

This is another small cluster of only 32 customers, 86 percent of the payables of whom is 61-90 days past due. Considering repayment, they are rather similar to Cluster 11, but the frequency of a credit line (41%) and its being exceeded (66%) is far less favorable. The number of mentions on the blacklist is double the sample average, while companies' records look much the same as for Cluster 11. Company size, however, is expressly small as compared to Cluster 11, with a Total Asset Value of HUF 145 million and a sales revenue of a similar order of magnitude. The cluster's composition by legal form does not differ too much from the sample average. These companies typically belong to the first or the third percentile by company size. The average total of all open and overdue balances is similar to that of Cluster 7, at HUF 1.4 million.

NON-PAYERS

Cluster 8 – Group DEF90: customers who are more than 90 days in default

Out of all obligations of the 26 customers in this cluster, 86 percent are 90-120 days past due. Considering repayment habits and the frequency of a credit line and its being exceeded, they resemble Cluster 11 from the DELAYERS. Average company size does not differ too much, either: both Total Assets and sales revenue are a bit higher, customers from this cluster being overrepresented in the third percentile by company size. None of the legal forms is expressly typical for the cluster, but self-employed entrepreneurs are definitely underrepresented. Variables related to companies' track record hover around the average; their being more favorable than those of the otherwise more favorable Cluster 11 is probably a result of the small cluster size. The most important difference from Cluster 11 is, apart from the due date structure, the average open balance and the average balance of overdue accounts both amounting to HUF 4 million. Thus the cluster represents HUF 105 million in open (and all overdue) accounts, a figure almost 25 percent higher than that of Cluster 11, in spite of the latter one having more elements, though being similar in repayment habits and in the exceeding of credit lines.

Cluster 6 – Group DEF120: customers who are more than 120 days in default

The most significant characteristic of the 40 customers in this cluster have in common is that 90 percent of their obligations are 121-150 days past due. The remaining 10 percent belongs to the two neighboring intervals (91-120 and 151-180 days). Repayment habits look more favorable than those of Clusters 8 and 11. The frequency of a credit line differs from that in the DEF90 group, but it is exceeded less often. An important difference from the two aforementioned clusters is company size: their average Total Asset Value, at HUF 237 million, is the smallest among all NON-PAYERS, qualifying these companies mostly for the first percentile. Track record variables are around the average or slightly worse, with 1 out of 4 records containing a negative entry. Self-employed entrepreneurs and, to a minimal extent, limited partnerships (so-called bt.'s) are overrepresented in the cluster. Considering the actual number of companies, kft.'s are the most frequent (24) form, even though their proportion is lower than in other clusters. The average open balance equals HUF 1.14 million, all overdue. Even though the open balance is only half the sample average, the overdue balance is already above the average and it looks especially alarming if compared to the Total Assets of these customers. The cluster's obligations to the supplier in question add up to HUF 45 million in total.

Cluster 3 – Customers who are more than 150 days in default

Out of the total open balance of these 32 customers, 89 percent are 151-180 days past due, while the remaining 11 percent belongs to the two neighboring intervals. The average value of assets, at HUF 817 million, is the most remarkable difference from Clusters 6 and 8. Just like for all other NON-PAYERS, repayment is not characteristic for these customers, either, and they exceed their credit line in 46 percent of all cases. However, a line of credit is extended to them less frequently (56 percent), which still more or less corresponds to the sample average. Managers and owners have an average track record, for the company itself; however, the frequency of negative entries is above the average at 34 percent, the highest figure among NON-PAYERS. The latter holds true for blacklist mentions, as well. The average balance of open and overdue accounts equals HUF 1 million, which is similar to Cluster 6 of the NON-PAYERS (with just the proportion of overdue accounts being higher), but significantly lower than in Cluster 8. Self-employed entrepreneurs are overrepresented in the cluster, while the proportion of

kft.'s, though still the most frequent in number, is expressly low. Based on company size related data – if available at all – they mainly belong to the first percentile.

BADS

Cluster 12 – Customers who are more than 6 months in default

The cluster consist of 73 elements, 96 percent of the total obligations of whom is 180-365 days past due. Repayments were not made in the examined period, with almost no exception at all. Contrary to the customers who are over one year in default, these customers do sometimes (but quite rarely as compared to the sample average) have a credit line, but they exceed it twice as frequently as other customers. Their managers and owners can often be found in the records of already liquidated businesses and the track record of the company itself is worse than the average, too. Interestingly, blacklist mentions were more typical for other clusters with more favorable payment habits. Their asset value and sales revenue is HUF 438 million and 608 million on average, respectively, but the standard deviation of the data was high. It can be said, nevertheless, that customers belonging to the first percentile by Total Assets (but being larger than those in the worst, the third cluster) are overrepresented. The same applies to their open and overdue balance, as well, totaling HUF 2.5 million on average. The fact that the overdue balance is somewhat higher than for the worst, the second cluster, might be due to the supplier not having written off as high a proportion of these receivables as for Cluster 2. Thus the total obligations of the cluster amount to HUF 184 million. Considering their legal form, kft.'s are the most typical, but ten limited partnerships (bt.'s) are also included.

Cluster 2 – The worst customers - over one year in default

This is the cluster of those 93 customers the 99 percent of whose obligations is more than 365 days past due. It is not much of a surprise that the dummy variables for delays above 90 and 120 days (DEF90, DEF120) take the value of 1 and that the BAD variable (combining these two with delays over one year and accounting for not only the occurrence of the default but also for its severity) takes its maximum value of 2. The customers in this group did not pay back anything during the week we examined; they might have had a credit line originally, but they do not have one now. Their open accounts are most probably the results of previously existing credit lines, thus the value of the dummy for exceeding the credit line is taken for 1 in each case, that is, they all

exceed their (now invalid) credit lines. Incriminating entries in the records of the owner, the manager and the company itself are twice as frequent as the portfolio average. There are 21 self-employed entrepreneurs in the cluster, their proportion amounting to twice the figure for the entire sample. The number of kft.'s (45) is rather high, but their proportion is still lower than in other cluster; limited partnerships (bt.'s) are, however, overrepresented. Their average open (and overdue) balance is HUF 2.2 million, exceeding the sample average by almost 10 percent. The average overdue balance of the cluster is, naturally enough, much higher than the portfolio average, as there are no repayments to lessen the total amount of debt. This total balance seems especially high when compared to company size: these customers are probably small; their average Total Asset Value, based on the 41 balance sheets available, amounts to HUF 275 million, but the value highly varies within the sample. This is the only cluster to have an asset turnover rate below one. The supplier should, most probably, write off the HUF 203 million (representing about 8 percent of the portfolio total) owed by the businesses in this cluster.

CASH CUSTOMERS

Cluster 1 – Cash customers

This one is practically the only cluster where the non-clustering variables did not yield a homogenous group. Apparently, these 263 customers do not belong to any of the due-in or past-due intervals, with proportions of only one or two percent for each category. Thus this is where the "zero-balance" clients of the supplier are found, who have either not purchased anything recently or paid in cash. In spite of that, the average balance of open accounts still indicates that they do owe money to the supplier – HUF 1.8 million on average, with 1.5 million already overdue. After all, their average balance does not count among the lowest ones at all. Yet this debt of nearly HUF 493 million has been accumulated by as few as 30 customers. More specifically, there is one specific customer with a debt of HUF 136 million, and the obligations of the four largest debtors add up to HUF 331 million, all of them counting among the ten largest debtors of the portfolio. Their due date structure is, however, similar to those of the other 233 customers in the cluster insofar as that there are no spikes at any one of the intervals - open accounts are equally distributed between the categories. Their behavior and other attributes, however, differ from those of cash customers.

Cash customers rarely have a credit line (8%) and they practically never pay back anything – though admittedly they rarely have any debt to pay for. The track record of the owners and the managers is more favorable than the average, incriminating entries on the record of the company itself; however, are five percentage points more frequent than the portfolio average. This is likely to have a role in the frequent denial of a credit line. (Though, as we saw earlier, this is not necessarily the case for all clusters.) Their average asset value is HUF 351 million, ranking among the smaller customers. Company size might be another explanation for the lack of a credit line, yet we did actually have some counterexamples among the other clusters, especially considering that there were groups with a less favorable asset turnover rate, as well.

The 30 customers whose total debt of HUF 493 million is equally distributed between the due date categories have an average open balance of HUF 16.4 million, out of which 13.2 million is already overdue. One fourth of this balance is yet due and an additional 50 percent is less than 90 days past due. Considering repayment habits and access to a credit line, they greatly resemble Cluster 5 (those with accounts 1-15 days past due). Even though these 30 customers form a well-separable group, most of their open balance having been accumulated by only a few large debtors, I will not treat them as a separate cluster, but rather as examples of some sort of atypical behavior. Therefore, irrespective of these exceptions, I am going to refer to Cluster 1 as the group of cash customers. The variables mentioned in the cluster's description above are listed in *Table 3.12*.

The characterization of our clusters is concluded by Table 3.13.a listing all open and overdue balances in thousand HUF, broken down by cluster. Table 3.13.b presents the distributions by cluster of the sum totals of all accounts in each due date interval.

	Large customers			Cash customers		
	N	Mean	St. deviation	N	Mean	St. deviation
SumOpen	30	16 458 120	30 183 667	233	-	-
SumOverd	30	13 201 553	26 184 090	233	-	-
ny9915a	30	0.16	0.15	233	-	-
ny150a	30	0.10	0.12	233	-	-
L115a	30	0.15	0.14	233	-	-
L1630a	30	0.09	0.09	233	-	-
L3160a	30	0.14	0.12	233	-	-
L6190a	30	0.12	0.15	233	-	-
L91120a	30	0.07	0.12	233	-	-
L121150a	30	0.05	0.11	233	-	-
L151180a	30	0.04	0.08	233	-	-
L181365a	30	0.06	0.13	233	-	-
L366a	30	0.02	0.06	233	-	-
REPAY	30	0.50	0.78	75	0.03	0.16
CRLINE_DUMMY	30	0.73	0.45	233	0.09	0.28
EXCCRLINE_DUMMY	30	0.40	0.50	233	-	-
Blacklist	30	0.80	1.97	233	0.12	0.78
Own & Man_dummy	30	0.27	0.45	233	0.14	0.35
Company_dummy	30	0.20	0.41	233	0.31	0.46
SumASSET08	24	1 038 555	3 207 257	145	351 900	1 799 334
sales08	24	1 484 013	4 272 056	152	619 441	3 848 634
Perc_asset08	30	2.90	1.63	233	1.39	1.39
Perc_sales08	30	3.33	1.67	233	1.64	1.61

Table 3.12.: Cash customers and large, atypical debtors in Cluster 1

Source: SPSS

Clus-ter		Number ents	Sum-Open	Sum-Overd	ny9915	ny150	L115	L1630	L3160	L6190	L91-120	L121-150	L151-180	L181-365	L366
1	CASH CUSTOMERS	263	493 744	396 047	71 443	26 254	57 094	23 021	64 810	104 092	66 972	14 614	14 903	31 390	19 150
2	BADS – over one year in default	93	203 478	203 478	-	-	-	-	-	-	-	-	80	6 586	196 812
3	NON–PAYERS – 121-150 days past due	32	34 214	34 214	-	-	-	-	-	1 546	58	2 985	26 184	3 441	-
4	GOODS – accurate customers	283	300 213	29 076	64 245	206 893	22 596	4 051	587	1 141	352	349	-	-	-
5	DELAYERS – 1-15 days past due	135	154 775	120 804	8 796	25 176	114 247	5 000	983	360	-	-	-	214	-
6	NON-PAYERS – DEF120	40	45 608	45 608	-	-	-	-	-	112	4 050	33 831	7 614	-	-
7	DELAYERS – 16-30 days past due	47	63 827	46 063	8 607	9 157	11 448	32 749	1 710	-	-	79	9	69	-
8	NON-PAYERS – DEF90	26	105 237	105 036	-	201	2 813	4 452	9 070	12 267	70 089	2 552	1 300	2 493	-
9	DELAYERS – 61-90 days past due	32	45 410	45 410	-	-	195	737	5 485	37 997	996	-	-	-	-
10	GOODS – most favorable payment history	224	958 972	119 022	735 193	104 756	52 836	22 056	7 967	9 207	19 080	7 254	608	15	-
11	DELAYERS – 31-61 days past due	41	84 589	80 254	2 564	1 771	5 044	3 883	58 251	10 798	1 646	-	-	633	-
12	BADS – more than 6 months in default	73	184 235	183 147	511	577	1 572	54	165	4 687	2 234	503	7 980	165 548	404
Total		1289	2 674 301	1 408 158	891 359	374 784	267 845	96 002	149 026	182 206	165 478	62 168	58 679	210 388	216 366

Table 3.13.a: Comparison of the clusters by aggregated balances

Source: SPSS (in thousand HUF)

Cluster		Number of elements	Sum-Open	Sum-Overd	ny9915	ny150	L115	L1630	L3160	L6190	L91-120	L121-150	L151-180	L181-365	L366
1	CASH CUSTOMERS	263	18%	28%	8%	7%	21%	24%	43%	57%	40%	24%	25%	15%	9%
2	BADS – over one year in default	93	8%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	91%
3	NON-PAYERS – 121-150 days past due	32	1%	2%	0%	0%	0%	0%	0%	1%	0%	5%	45%	2%	0%
4	GOODS – accurate customers	283	11%	2%	7%	55%	8%	4%	0%	1%	0%	1%	0%	0%	0%
5	DELAYERS – 1-15 days past due	135	6%	9%	1%	7%	43%	5%	1%	0%	0%	0%	0%	0%	0%
6	NON-PAYERS – DEF120	40	2%	3%	0%	0%	0%	0%	0%	0%	2%	54%	13%	0%	0%
7	DELAYERS – 16-30 days past due	47	2%	3%	1%	2%	4%	34%	1%	0%	0%	0%	0%	0%	0%
8	NON-PAYERS – DEF90	26	4%	7%	0%	0%	1%	5%	6%	7%	42%	4%	2%	1%	0%
9	DELAYERS – 61-90 days past due	32	2%	3%	0%	0%	0%	1%	4%	21%	1%	0%	0%	0%	0%
10	GOODS – most favorable payment history	224	36%	8%	82%	28%	20%	23%	5%	5%	12%	12%	1%	0%	0%
11	DELAYERS – 31-61 days past due	41	3%	6%	0%	0%	2%	4%	39%	6%	1%	0%	0%	0%	0%
12	BADS – more than 6 months in default	73	7%	13%	0%	0%	1%	0%	0%	3%	1%	1%	14%	79%	0%
Total		1289	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3.13.b: Comparison of the clusters by the distribution of aged balances

Source: SPSS

As implied by the above description of our groups, non-clustering variables also show differences by cluster. I am going to proceed by testing the significance of these differences. The relationship between two variables might be tested in several ways. First of all, I generated contingency tables for the clusters and the variables in question (included in the Appendix). The statistics for testing the existence and the strength of potential relationships can be found in Tables 3.15.a and 3.15.b. The existence of a relationship between variables can be tested using the Chi-square (χ^2) test. Having found proof for the presence of such a relationship, the correct interpretation also requires that its strength be known. I decided to use Cramer's V, knowing that Sajtos and Mitev (2007) found it to be the most reliable indicator of its kind.

	Pearson Chi-Square			Likelihood Ratio		
	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)
Legal form*	155.27	66	0.00	146.86	66	0.00
Perc_asset08	187.83	55	0.00	191.48	55	0.00
Perc_sales08	184.65	55	0.00	191.39	55	0.00
REPAY	171.59	22	0.00	204.41	22	0.00
CRLINE_DUMMY	453.63	11	0.00	531.47	11	0.00
EXCCRLINE_DUMMY	370.10	11	0.00	427.82	11	0.00
Blacklist**	191.35	110	0.00	116.87	110	0.31
Own & Man dummy	64.16	11	0.00	56.85	11	0.00
Company_dummy	126.18	11	0.00	122.16	11	0.00
COMPANY_PERS	168.28	22	0.00	156.47	22	0.00

Table 3.14.a: Analysis of the relations between the non-clustering variables and the clusters

Source: SPSS

* 50 cells (59.5%) have expected count less than 5. The minimum expected count is .06.

** 113 cells (85.6%) have expected count less than 5. The minimum expected count is .02.

The χ^2 test is not appropriate if the expected count of a cell is below 1 or if at least 20 percent of the cells have an expected count less than 5. The legal form and the blacklist variables obviously violate this condition. For all the other variables, the existence of the relation can be accepted, as the test's null hypothesis (independence) is rejected at each significance levels. In the case of large samples, likelihood ratio equals the value of χ^2 and its meaning is similar for smaller samples, too. The figures in Table 3.14.b indeed confirm the conclusions of the χ^2 test. Blacklist mentions was the only variable not to demonstrate a significant relationship with the cluster classification – but that has already been questioned above, anyway.

	Cramer's V	Approx. Sig.
legal form	0.142	0.000
perc_asset08	0.171	0.000
perc_sales08	0.169	0.000
REPAY	0.291	0.000
CRLINE_DUMMY	0.593	0.000
EXCCRLINE_DUMMY	0.536	0.000
Own & Man dummy	0.223	0.000
Company dummy	0.313	0.000
COMPANY PERS	0.255	0.000

Table 3.14.b: Analysis of the relations between the non-clustering variables and the clusters – Cramer's V

Source: SPSS

The symmetric measure used to assess the strength of the relationship was Cramer's V, which, by definition, takes values between 0 and 1. The existence of a credit line and its being exceeded were the only variables to show a significant, above-moderate relationship with the clusters. For all other behavioral variables, the relationship was found to be moderate. As it was already apparent from the description of the clusters, the legal form – where the χ^2 condition was violated, too – did not show significant differences by cluster, due to the overall proportion of kft.'s being rather high. Instead of the average Total Asset Value and sales revenue variables themselves, only a transformation of them – namely the quintiles – is suited for a contingency table analysis; yet in spite of its significance, the relation is still weaker than moderate.

The ANOVA table under Table 3.15. is also intended to support the significance of the differences between the clusters, at least for the variables the level of measurement of which allows of such an analysis. Thus the null hypothesis of the F-test (asserting that the averages of the variables examined are identical in each cluster) can be rejected. In addition to our conclusions based on the previous contingency table, on the χ^2 test and on Cramer's V, we thereby also established that average Total Asset Value, the average balance of open and overdue accounts and average sales revenue do all show significant differences by cluster. (Though in this latter case, the p-value being 4.7 percent, the existence of a difference is only just about acceptable at the chosen significance level of 5 percent.)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SumOpen	Between Groups	1730268061371155	11	157297096488286	2.261	.010
	Within Groups	88845626981866200	1277	69573709461132		
	Total	90575895043237400	1288			
SumOverd	Between Groups	916674187670814	11	83334017060983	3.088	.000
	Within Groups	34456216526490140	1277	26982158595528		
	Total	35372890714160950	1288			
REPAY	Between Groups	53.195	11	4.836	15.500	.000
	Within Groups	311.361	998	.312		
	Total	364.555	1009			
Purch_DUMMY	Between Groups	35.844	11	3.259	20.373	.000
	Within Groups	159.626	998	.160		
	Total	195.470	1009			
CRLINE_DUMMY	Between Groups	112.537	11	10.231	63.041	.000
	Within Groups	207.237	1277	.162		
	Total	319.773	1288			
EXCCRLINE _DUMMY	Between Groups	83.660	11	7.605	46.758	.000
	Within Groups	207.713	1277	.163		
	Total	291.373	1288			
Blacklist	Between Groups	25.149	11	2.286	2.408	.006
	Within Groups	1212.626	1277	.950		
	Total	1237.775	1288			
Own & Man_dummy	Between Groups	9.245	11	.840	6.082	.000
	Within Groups	176.480	1277	.138		
	Total	185.725	1288			
Company_dummy	Between Groups	24.271	11	2.206	12.598	.000
	Within Groups	223.665	1277	.175		

	Total	247.936	1288			
COMPANY_PERS	Between Groups	58.470	11	5.315	15.418	.000
	Within Groups	440.241	1277	.345		
	Total	498.711	1288			
sumASSET08	Between Groups	266801396496738	11	24254672408794	2.070	.020
	Within Groups	10462941659163640	893	11716619999063		
	Total	10729743055660380	904			
Sales08	Between Groups	845563567482572	11	76869415225688	1.817	.047
	Within Groups	37816159001842590	894	42299954140763		
	Total	38661722569325160	905			

Table 3.15.: ANOVA table of the non-clustering variables and the clusters

Source: SPSS

Finally, the relationships between the non-clustering variables and the clusters are illustrated by Figures 3.3.a – 3.3.e.

Figure 3.3.a: Total Assets and sales revenue vs. clusters

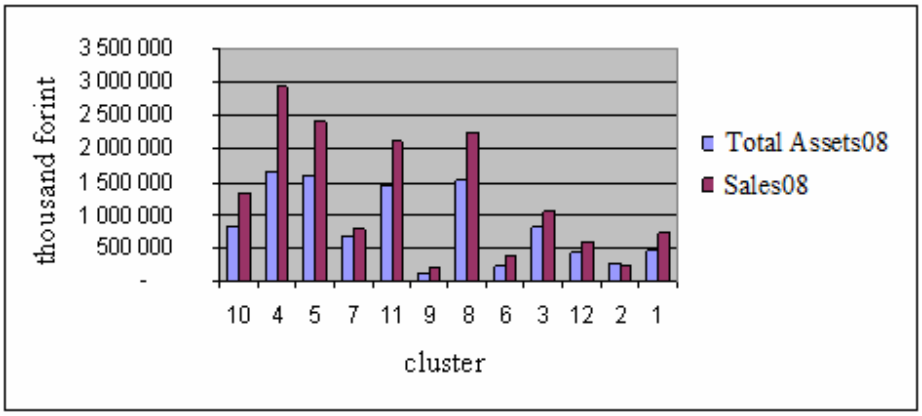


Figure 3.3.b: Open balances vs. clusters

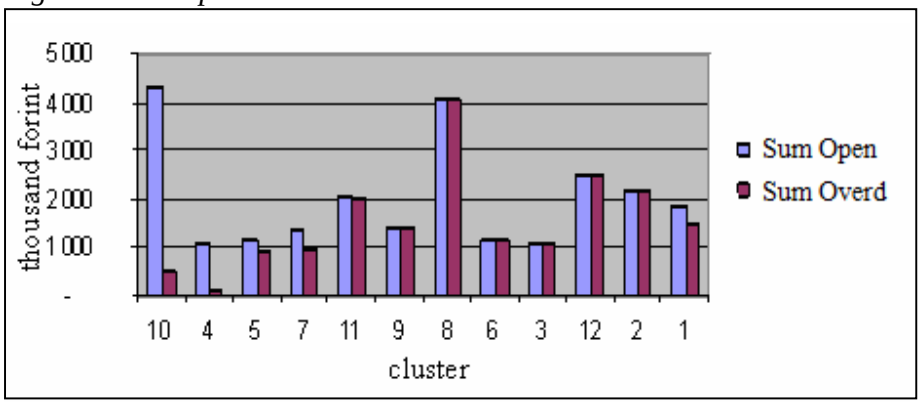


Figure 3.3.c: Repayment vs. clusters

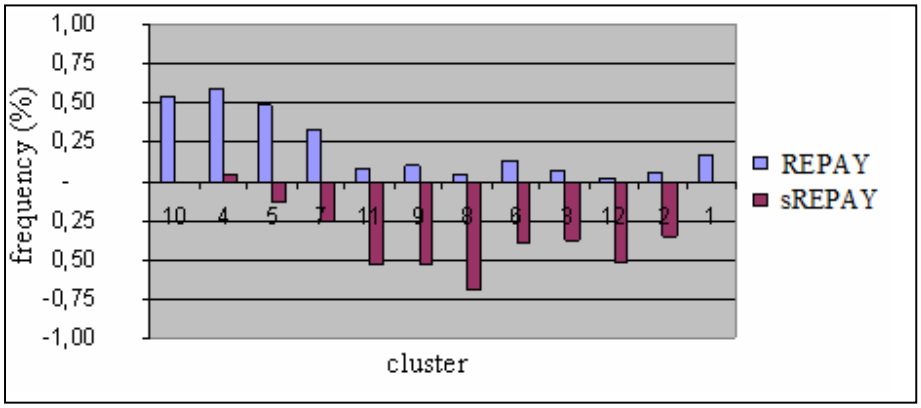


Figure 3.3.d: Credit lines vs. clusters

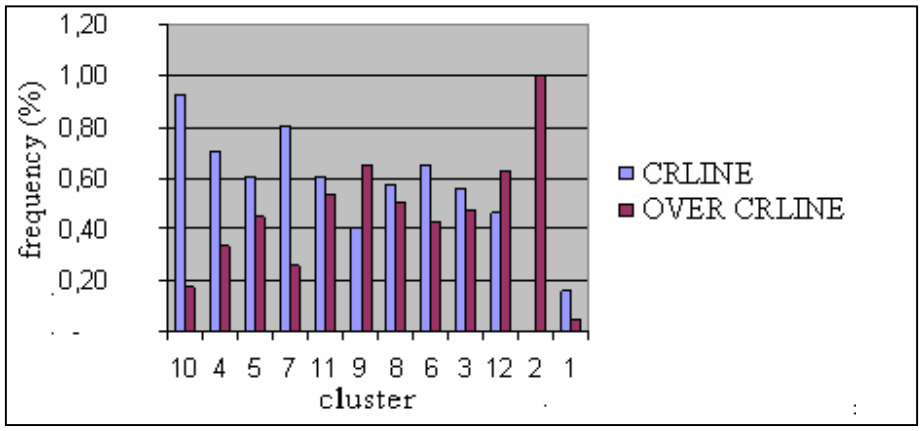
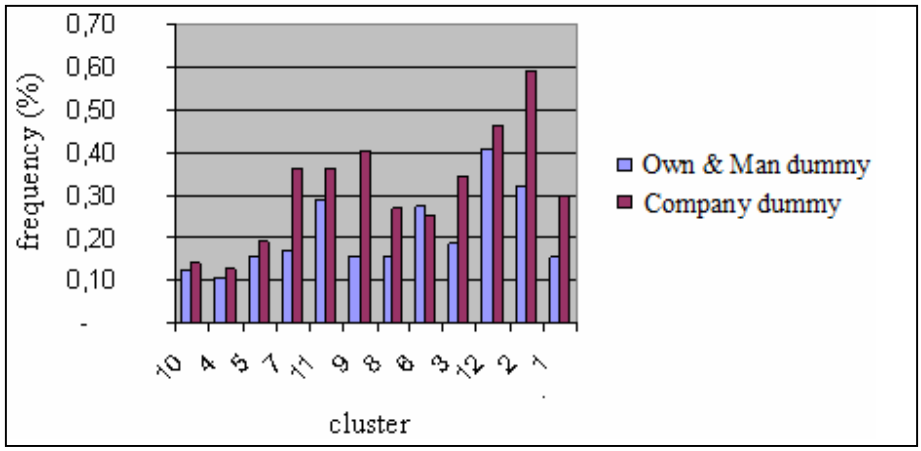


Figure 3.3.e: Track records vs. clusters



Source: Excel, author's graphs

It might need to be explained why the default variables BAD, DEF90 and DEF120 were not included in significance testing. Recalling how we defined these variables, it becomes evident that they are based on the due date structure of the receivables balances, that they are transformations of the variables representing the age structure. Thus, obviously, they are closely related to how the sample was divided into clusters – into the clusters that were generated using the original variables of the due date structure.

Summing up the results of the cluster analysis, we see that we could distinguish four or five larger groups in the sample. The GOODS and the BADS are very different, very far from all the others. The GOODS can be divided into two groups by Total Asset Value (as a proxy variable of company size) and by the balance of open accounts. The smaller businesses have the most favorable payment behavior. They could not even afford to give up on that discipline, as they owe HUF 4.3 million on average in trade credits to the supplier. Companies in Cluster 4, also among the GOODS, are double the size, and the trade credit extended to them is smaller. What concerns behavioral variables, the two groups are identical. Evidently, some customers were allowed to purchase on account even without an officially authorized credit line, thus EXCCRLINE_DUMMY sometimes signaled the exceeding of the credit line even if that was not the case. Accordingly, my explanation for the difference in exceeding the credit line between the two clusters of GOODS is that the proportion of those having been extended a credit line is lower in Cluster 2.

The BADS are markedly different from all the others, as well. They are the customers who are more than six months behind in their payments. Cluster 3, the group of the worst (over one year past due) customers is characterized by the worst possible behavioral variables, companies' size is small, with an average asset value of HUF 275 million, out of which 2.2 million, that is, 8 tenth of a percent is the balance owed to the supplier in question. Customers 181-365 days past due do clearly differ by company size, but their open balance still accounts for more than 7 tenth of a percent of their Total Assets. Their behavioral variables look better, and some still have a credit line with the supplier.

The group of CASH CUSTOMERS is easy to identify, too, as they do not have any open accounts. Most probably, they have either not bought anything recently, or have been

denied a line of credit by the supplier because of their small order size or because of their small company size coupled with worse than average track records.

The distinction between DELAYERS and NON-PAYERS, comprising 7 clusters altogether, is somewhat arbitrary. They are distinguished based on the definition of default used by the banks, that is, anyone whose obligations are more than 90 days past due is considered to be in default (a non-payer). I have denoted clusters 5, 7, 11 and 9 as DELAYERS. Considering open balances, Cluster 11 differs from the others by having an average debt corresponding to the portfolio average of HUF 2 million, while all the other clusters' figures are between 1.1 and 1.4 million. Another obvious difference is company size (measured by average Total Assets). The group with the longest delays, Cluster 9, is the cluster of expressly small businesses, and those in Cluster 7 are below the average, as well. The average asset value of about HUF 1.5 billion of Clusters 5 and 11 does not, however, differ too much from the sample average. These two groups are distinguished by, apart from the aforementioned open balances, their overdue balances. Also, the track record dummies of Cluster 11 (longer delays) are less favorable than those of Cluster 5 (only 15 days past due).

The group of NON-PAYERS consists of less than 100 customers; the clusters representing the last two due date intervals of the DELAYERS were already small, though. It seems that the intermediary behavior patterns in between the well-separated groups of GOODS and BADS are far more difficult to outline, as there are no typical past-due or due-in values between the two extremes. The group of NON-PAYERS is made up of Cluster 8, Cluster 6 and Cluster 3. The most important difference, once again, is company size: Cluster 8 is comprised of larger companies, while Cluster 6 and 3 include small and medium businesses, respectively. Average open balance does not completely follow this pattern: though the largest figure belongs to Cluster 8, again, there is no significant difference between small and medium sized debtors considering open accounts.

The relationships between the clusters and the non-clustering variables also support that we managed to generate homogenous clusters. However, the 11 active plus 1 passive (no open accounts) cluster solution, defined by the 11 due date intervals, might appear to be too trivial. If the 11 variables describing the due date structure are the only ones used to explore relevant payment habits, then the number of clusters to be generated, as suggested

by the dendogram of hierarchical clustering, is between 8 and 12. Thus the number of clusters is appropriate, and therefore the results of the clustering must be accepted, too.

If other variables (apart from due date structure) found to be significant in our above analyses (company size as measured by Total Assets, behavioral dummies, track records) are also included in the clustering and the analysis is run for 3 to 15 clusters, then the majority of open accounts get "crammed" into the first three due date intervals while the real differences between the clusters get reflected in all the other variables. Thus it is exactly the payment patterns that the analysis will not reveal any information about. Accordingly, I decided to accept and present the first, trivial solution.

Given the findings of the cluster analysis, it is important to consider the re-interpretation of pre-existing default-related variables. We have established that, beyond the well-separated groups of the GOODS and the BADS, there also exists a relatively populous "grey zone" comprising 7 clusters: the groups of the DELAYERS and the NON-PAYERS. Consequently, the analysis of payment habits did not yield a clear-cut definition of what should be considered a default – there is no exact limit to tell the supplier when (after how many days) a payment delay should really be taken seriously. Thus there is no reason for us to re-define variables DEF90 and DEF120, I am going to use them in unchanged form.

3.3.2 Payment Habits of Self-Employed Entrepreneurs

Subsample I. contains 224 self-employed entrepreneurs. Besides their open balance and the behavioral variables (repayment, exceeding of the credit line, track record of the company), we also know the gender of these customers. This is exactly what my first hypothesis – comprised of, as is usual in statistics, a null hypothesis and an alternative hypothesis – relates to. I assume that non-payment might be influenced by the entrepreneur's gender.

The hypothesis is based on the literature of micro-lending; experience showed that the repayment rates of women tend to be more favorable. In the context of microlending naturally, this is basically explained by – as cited earlier (Kevane and Wydick, 2001; de Aghion and Morduch, 2000) – the women of Third World countries being much more closely tied to the community by their social network than the men, who are far more mobile. Accordingly, the potential social consequences of a default are more deterring for women than for men. Yet significant differences in repayment rates might have another

explanation. The observation of microlending that „women are good debtors" is built upon the assumption that (and this might have nothing to do with the Third World) men and women are characterized by different levels of risk appetite. And risk appetite, on the other hand, might influence the client's ability and willingness to pay. Accordingly, hypothesis H1 has been formulated as follows:

H1: The non-payment of self-employed entrepreneurs is influenced by their gender.

H1_0a: Variables BAD and „gender" are independent

H1_1a: Variables BAD and „gender" are not independent

H1_0b: Variables DEF90 and „gender" are independent

H1_1b: Variables DEF90 and „gender" are not independent

H1_0c: Variables DEF120 and „gender" are independent

H1_1c: Variables DEF120 and „gender" are not independent

The relation between two variables can be tested in several ways, but the level of measurement of the variables only allows of a contingency table analysis in this case. To find out whether there is a relationship between the variables, the Chi-square (χ^2) test can be used. Having confirmed the existence of a relation, its correct interpretation also requires its strength to be determined – I am going to use Cramer's V for this purpose.
The contingency tables generated by SPSS are included in the Appendix, while Table 3.16. lists the values of Pearson's χ^2. (Any value indicating a significant relation will be highlighted in italics in all similar tables hereinafter.)

	Pearson Chi-Square	Df	Asymp. Sig. (2-sided)
gender – BAD	0.009534	2	0.995244
gender – DEF90	0.007271	1	0.932048
gender – DEF120	0.007846	1	0.929416

Table 3.16.: Relationship between gender and non-payment according to χ^2
Source: SPSS

These particular χ^2 values do not allow of the rejection of the null hypothesis (that is: the independence of the variables) at any generally accepted significance level. Thus,

assuming that the variables are independent, the indicators related to the strength of the relationship will not be listed. The value of χ^2 is influenced by sample size: in the case of small samples, an increase in sample size might result in non-significant relationships becoming significant. Our result not being affected by this attribute of the χ^2 test, we can conclude that gender does not influence non-payment in the sample examined.

My second hypothesis concerning self-employed entrepreneurs is based on the findings of the authors who emphasized the importance of non-financial indicators or occasionally even qualitative information in bankruptcy prediction. For self-employed entrepreneurs, only the „company_dummy" variable is available. Its value is 1 if there has been any kind of tax proceeding against the entrepreneur or if they can not be found, otherwise it is 0. The personal track record of the entrepreneurs could also have been interesting, but the subsample was found to be completely homogenous: none of the listed entrepreneurs had had any connection to companies that had gone bankrupt or been liquidated. This variable, therefore, will not be tested on Subsample I. Accordingly, my second hypothesis, the analyses of which are detailed in Tables 3.17.a-b, is:

H2: The non-payment of self-employed entrepreneurs is influenced by past proceedings against them and non-compliant data reports.

H2_0a: Variables BAD and „company_dummy" are independent

H2_1a: Variables BAD and „company_dummy" are not independent

H2_0b: Variables DEF90 and „company_dummy" are independent

H2_1b: Variables DEF90 and „company_dummy" are not independent

H2_0c: Variables DEF120 and „company_dummy" are independent

H2_1c: Variables DEF90 and „company_dummy" are not independent

	Pearson Chi-Square	Df	Asymp. Sig. (2-sided)
company_dummy - BAD	*12.27942*	*2*	*0.002155*
company_dummy - DEF90	*3.895652*	*1*	*0.048411*
company_dummy - DEF120	*3.826667*	*1*	*0.050443*

Table 3.17.a.: Relationship between company track record and non-payment according to χ^2
Source: SPSS

According to the table, negative entries on entrepreneurs' track record and the existence of obligations over 90 days past due or over 120 days past due are not independent at a significance level of 6 percent. The null hypothesis about the BAD variable can even be rejected at a lower significance level. Table 3.17.b contains the figures indicating the strength of the relationship.

	Cramer's V	Approx. Sig.
company_dummy - BAD	*0.234134*	*0.002156*
company_dummy - DEF90	*0.131876*	*0.048411*
company_dummy - DEF120	*0.130703*	*0.050443*

Table 3.17.b: Strength of the relationship between company track record and non-payment based on Cramer's V
Source: SPSS

The conclusion is similar to that of the χ^2 test. The track record of the company shows a significant relationship with all three non-payment variables. The maximum of Cramer's V for 2x2 contingency tables is 1 (Sajtos-Mitev, 2007). Accordingly, the relations with variables DEF90 and DEF120 are considered significant, though relatively weak.

Thus those self-employed entrepreneurs who have negative entries on their record are more likely to accumulate debts that are over 90 or over 120 days past due, that is, to default on their obligations according to our definition. The more severe the default is (represented by the BAD variable), the more likely it is that one could have found incriminating data in their records, as a kind of pre-warning sign. According to the above, non-payment itself is

in a weak relationship with the track record of the company, while the severity of damage, i.e. the structure of obligations, shows a weak-moderate relationship with incriminating data.

Financial institutions build their behavioral scoring models upon the information gathered through their relationship with the customer. The only data we have about the behavior of the entrepreneurs is whether they are exceeding their credit line right now (EXCCRLINE_DUMMY) and whether they have made any payments/prepayments (REPAY) during the previous week. The main point of my hypotheses is that while the exceeding of the credit line can be considered a negative sign concerning the customer's payment habits / willingness to pay, their making a payment seems to be a positive sign.

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H3: The non-payment of self-employed entrepreneurs and their exceeding of their credit line are related.

H3_0a: Variables BAD and „EXCCRLINE_DUMMY" are independent

H3_1a: Variables BAD and „EXCCRLINE_DUMMY" are not independent

H3_0b: Variables DEF90 and „EXCCRLINE_DUMMY" are independent

H3_1b: Variables DEF90 and „EXCCRLINE_DUMMY" are not independent

H3_0c: Variables DEF120 and „EXCCRLINE_DUMMY" are independent

H3_1c: Variables DEF120 and „EXCCRLINE_DUMMY" are not independent

H4: The non-payment of self-employed entrepreneurs and their previous payments are related.

H4_0a: Variables BAD and „REPAY" are independent

H4_1a: Variables BAD and „REPAY" are not independent

H4_0b: Variables DEF90 and „REPAY" are independent

H4_1b: Variables DEF90 and „REPAY" are not independent

H4_0c: Variables DEF120 and „REPAY" are independent

H4_1c: Variables DEF120 and „REPAY" are not independent

Results are shown in Tables 3.18.a-b. They imply that the null hypothesis asserting the independence of the variables in question can be rejected. The exceeding of the credit line is in a significant, moderately strong relationship with both non-payment itself and its severity. The result sounds reasonable: given that the entrepreneur has debts at least 90 days past due, they probably must have exceeded their credit line already. It is an interesting question, nonetheless, why the supplier let these customers purchase on account beyond their limit, even though they only represent 5 percent of its total accounts receivable balance. The only plausible explanation is that self-employed entrepreneurs are given shorter payment terms than the other customers thus their contribution to the supplier's sales revenue is larger than what their small share of total receivables suggests, and accordingly it has been an important goal to keep these customers. There is also a significant but somewhat weaker relationship between repayment and both non-payment and its severity.

	Pearson Chi-Square	Df	Asymp. Sig. (2-sided)
EXCCRLINE_DUMMY – BAD	*48.6777*	*2*	*0.000000*
EXCCRLINE_DUMMY - DEF90	*38.22956*	*1*	*0.000000*
EXCCRLINE_DUMMY - DEF120	*37.13441*	*1*	*0.000000*
REPAY – BAD	*11.2862*	*2*	*0.003542*
REPAY - DEF90	*11.2858*	*1*	*0.000781*
REPAY - DEF120	*9.971364*	*1*	*0.001590*

Table 3.18.a: Relationship between non-payment and repayment / the exceeding of the credit line according to χ^2

Source: SPSS

	Cramer's V	Approx.Sig.
EXCCRLINE_DUMMY – BAD	*0.466166*	*0.0000*
EXCCRLINE_DUMMY - DEF90	*0.413119*	*0.0000*
EXCCRLINE_DUMMY - DEF120	*0.407159*	*0.0000*
REPAY – BAD	*0.256159*	*0.0035*
REPAY - DEF90	*0.256154*	*0.0008*
REPAY - DEF120	*0.240776*	*0.0016*

Table 3.18.b: Relationship between non-payment and repayment / the exceeding of the credit line according to Cramer's V

Source: SPSS

Thus our findings concerning self-employed entrepreneurs were: their gender does not influence payment habits. The sample, however, seems to support the assertion mentioned in the literature review that variables related to information of a non-financial and occasionally even of a qualitative nature might be important in the prediction of defaults.

3.3.3 Default Prediction on Subsample II

Financial statements (with a varying level of detail) were available for 905 customers out of the entire database. As the last step of the analysis, I am going to estimate a new default prediction model on the available sample, relying on the accounting-based bankruptcy prediction models presented in chapter 3.1.2.2, using the SPSS software suite. In line with previous findings, I am going to analyze several variations of the model and compare their performance. The hypotheses in this subchapter pertain to the relative performance of the different model variations.

3.3.3.1 Methodological Considerations

The first step was the **cleaning of the data**, by checking the consistency of the balance sheet and income statement figures. Afterwards, based on the information in chapter 3.1.2.2, I identified the financial ratios that may possibly be used. Table 3.19. lists these ratios along with all non-financial variables that I used.

The table contains an adjusted form of ROA. The correction aims at the (at least partial) reconciliation of the numerator with the denominator. The Total Asset Value in the denominator is financed from both external and internal (Owner's Equity) sources. At the same time, Earnings Before Taxes (the original numerator) is something that belongs to the owners only, and does not contain the interest paid to creditors any more. Therefore, the indicator will be more consistent if the cash flows going to the creditors are also included in the value of the numerator. Based on the availability of data, Expenses on Financial Transactions was used to estimate Interest Paid.

Name of the variable	Financial ratio
Liab/(Liab+Equ)	Total Liabilities/(Total Liabilities + Owner's Equity)
EBT/NSALES08	Earnings Before Taxes/Net Sales Revenue
EBT/ASSET08	Earnings Before Taxes/Total Assets
EBIT/ASSET08	EBIT/Total Assets
EBITDA/SALES08	EBITDA/Net Sales Revenue
EBIT/SALES08	EBIT/Net Sales Revenue
ROE08	Net Earnings/Owner's Equity (ROE)
CA/CL08	Current Assets/Current Liabilities
LIAB/(EBITDA+INCFIN)08	Total Liabilities/(EBIT + Income from Financial Transactions)
LIAB/EBITDA08	Total Liabilities/EBITDA
EBIT/EXPFIN08	EBIT/Expenses on Financial Transactions
CL/SALES08	Current Liabilities/Net Sales Revenue
CA/ASSET08	Current Assets/Total Assets
TREC/LIAB08	Total Receivables/Total Liabilities
OE/FASSET08	Owner's Equity/Fixed Assets
SALES/ASSETS08	Net Sales Revenue/Total Assets
SALES/NWC08	Net Sales Revenue/Net Working Capital
SALES/EBIT08	Net Sales Revenue/EBIT
ROA*08	(Earnings Before Taxes+Expenses on Financial Transactions)/Total Assets
PROFORD/OE08	Profit on Ordinary Activities/Owner's Equity
NWC/ASSETS08	Net Working Capital/Total Assets
QUICKR08	Cash and Cash Equivalents/Current Liabilities
LTD/OE08	Long-Term Debt/Owner's Equity
TREC/OE08	Total Receivables /Owner's Equity
LTD/(Liab+Equ)	Long-Term Debt/ /(Total Liabilities + Owner's Equity)
TREC/(Liab+Equ)	Total Receivables/(Total Liabilities + Owner's Equity)
SALES/NWC08	Net Sales Revenue/Net Working Capital
CASH/ASSETS08	Cash and Cash Equivalents/Total Assets
CL08/OE08	Current Liabilities/Owner's Equity
CASH/SALES08	Cash and Cash Equivalents/Net Sales Revenue
G_Sales	(Net Sales Revenue 2008/Ne Sales Revenue 2007) -.1
fcff/assets	FCFF/Total Assets

Table: 3.19.a: Financial ratios recommended by literature

Source: the sources of chapter 3.1.2.2

Name of the variable	Interpretation
COMPFORM	Legal form of the company
REPAY	0 – there was no payment; 1 – there was a(t least one) payment; 2 – there was a(t least one) pre-payment
sREPAY	0 – there was no debt to be repaid; 1 – there was a(t least one) payment; -1 – there was no payment, though has an open balance
blacklist_delay_days	For how long (days) was the company on the blacklist altogether?
howmany_blacklist	How many times was the company added to the blacklist?
Comphist_dummy	0 – no incriminating information about the company; 1 – there is incriminating information about the company
Own_&_Man dummy	0 – no incriminating information about the owner or the manager; 1 – there is incriminating information about them
COMP_PERS_DUMMY	0 – no incriminating information about either the company or the owner/manager; 1 – there is incriminating information about either the company or its owner/manager; 2 – there is incriminating information about both the company and its owner/manager
CRLINE_DUMMY	0 – customer has not been extended a credit line; 1 – customer has been extended a credit line
EXCCRLINE_DUMMY	0 – customer has not exceeded their credit line; 1 – customer has exceeded their credit line
GENDER	1 – male; 2 – female
negEquity_dummy	0 – Owner's Equity not negative; 1 – Owner's Equity negative
perc_asset08	Variable takes values from 1 to 5 according to which percentile of the sample the 2008 Total Assets value belongs to. Zero if data missing.

Table 3.19.b: Non-financial variables
Source: author's calculation

The calculation of ROE needs some explanation, too. The correct way is to use the Owner's Equity value from the beginning of the year and the Net Earnings achieved throughout the year. If I had stuck with this formula that would have meant the lack of a ROE figure in 31 cases and, as reported by other sources on the topic, serious interpretational difficulties in an additional 20 cases – even though literature found the discriminative power of ROE to be rather impressive. The reason is that both the numerator and the denominator can take negative values, which, incorrectly, results in a positive value for Return On Equity. Consequently, I decided to calculate a kind of adjusted ROE for these 51 customers, and thus I could at least partially solve the problem. The 2008 closing balance of Owner's Equity was adjusted to estimate its opening balance by subtracting

Balance Sheet Earnings. Thus it is only an economic event affecting some other balance sheet line item of Owner's Equity that could distort the value of this adjusted ROE. Afterwards, there remained 19 customers where the negative values of Owner's Equity and Net Earnings gave a falsely positive value for ROE. These observations – in line with other authors' (e.g. Imre (2008)) practice – were excluded from the analysis.

In the literature of the models used by banks, indicators based on Interest Paid are quite frequent. This piece of information is hardly ever available, yet it can often be substituted by Expenses on Financial Transactions. In our sample, however, some 20 percent do even lack this latter figure, thus the indicator was excluded from the analysis. Another reason for making this decision was that I aim at the prediction of the non-payment of trade credits, which do not necessarily have any interest obligation associated with them like bank loans do.

Because of a lack of data similar in extent to the above case, the balance sheet item Retained Earnings, along with any associated indicators, was also omitted. Unlike the situation with Interest Paid, there is no theoretically acceptable explanation for excluding Retained Earnings from the model, thus the classification power of the model might be compromised to some extent by this involuntary decision.

Another 24 observations were deleted from the database because of missing data. According to the Missing Value Analysis of SPSS, this was acceptable in each case. After the data cleaning process, 857 observations remained in Subsample II.

I made the decision that non-payment shall be identified by the variable DEF90, i.e. by the fact of being more than 90 days in default. First, as noted earlier, the analysis of payment patterns did not yield a clear definition for a default, either. Second, the average delay of Subsample II weighted by volume (outstanding balance) was 55 days, thus by using DEF90, the requirement that a default should be defined as an event more severe than the average delay is met.

As many others had used it in bankruptcy modeling, I also used logistic regression to predict non-payment; from amongst the simpler methods, this is the most widely used one and it is considered rather successful, as well (Falkenstein, 2000; Grunert-Norden-Weber, 2005). Relying on relevant literature (Altman-Sabato, 2007; Falkenstein, 2000; partially Kristóf, 2008a-b) each model variation employed the Forward Stepwise Likelihood Ratio

algorithm with significance levels of 5 percent and 10 percent for entry and removal, respectively. The sample was partitioned into a training and a holdout sample according to the 75% - 25% ratio recommended by literature (e.g. Imre, 2008).

The studies I read all determined the cutoff value in very different ways. The cutoff value of the model is a threshold for the estimated probability of default: if the latter is lower / higher than the cutoff value then the model predicts the client in question to pay on time / to default on the payment, respectively. Oravecz (2008) and Tang-Chi (2005) discuss the determination of cutoff values for default prediction models in detail. Oravecz (2008) distinguishes between theoretical and empirical determination. The theoretical method relies on profit matrices. Money should be lent to the client as long as the expected profit of lending is higher than the expected profit of refusal. Oravecz (2008) even provides a numerical example and according to her empirical results, the cutoff should rather be determined using the theoretical method if and when profit maximization is the goal.

Empirical approaches examine the model's effectiveness for different cutoff values. Yet each author has their own interpretation of effectiveness. Oravecz (2008) sticks with profit maximization, while Tang-Chi (2005) offer a number of different solutions. They cite Altman (1968) having chosen cutoffs based on classification accuracy. Frydman, Altman, and Kao (1985), for example, minimized the number of misclassifications, while Ohlson (1980) opted for the intersection of the probability distributions of good and bad debtors. Current literature primarily features cutoffs given by the largest AUC (area under the curve), arrived at by comparing AUC values calculated using a number of different cutoff values and choosing the one generating the maximum AUC. This is also the method I am going to use in my thesis.

In order to interpret the AUC indicator, however, a brief digression is needed. The performance of classification procedures can be measured by separation statistics, ranking statistics and by prediction error statistics (Oravecz, 2008). AUC, also known as AUROC (area under the ROC) belongs to the second group. The plot that this indicator is based on is the ROC (receiver operating characteristic) curve, a special type of Lorenz curve. It is a graphical plot of the false positive rate (FPR) versus the true positive rate (TPR) as the cutoff threshold varies. In order to determine FPR and TPR, one needs to know the number of observations in the true positive (TP), true negative (TN), false positive (FP) and false

negative (FN) categories. The ratios FPR and TPR are calculated by substituting these inputs into expressions (3.3) and (3.4) (Imre 2008):

$$FPR = \frac{FP}{FP + TN} \tag{3.3}$$

$$TPR = \frac{TP}{TP + FN} \tag{3.4}$$

Each point of the curve denotes the ratios FPR and TPR for one given cutoff value, thus the curve describes the model's classification ability as a function of the cutoff value. The classification ability of random classification is represented by a 45-degree line and the plot of any model giving a perfect classification must pass through the point with coordinates (0;1). The estimated models lie between these two extremes and the further their curve is from the diagonal, the better the classification ability of the model. The AUC / AUROC indicator, representing the size of the area under the ROC, simply quantifies the above relation. Accordingly, random classification has an AUC of 0.5 while an AUC of 1 indicates perfect classification. In practice, an AUC of 0.7 or above is already appropriate (Oravecz, 2008; Imre, 2008; Tang-Chi, 2005).

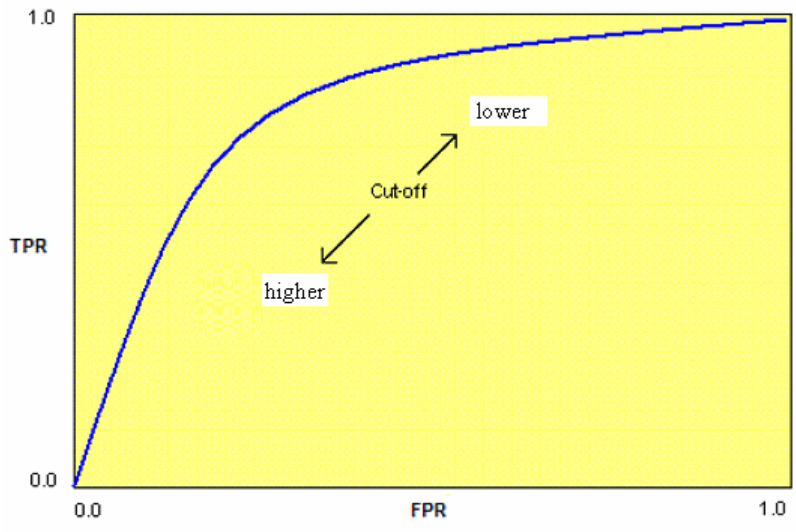


Figure 3.4.: The ROC curve

Source: Imre (2008) p. 60

3.3.3.2 Hypotheses

Based on chapters 3.1.2.2 and 3.1.2.3, I am going to test the following hypotheses, all of which concern the classification ability of our models. Each model incorporates a different set of explanatory variables, but all of them were estimated using the same algorithm (forward stepwise likelihood ratio; significance level for entry 5 percent, significance level for removal: 10 percent).

H5: The classification accuracy of the models incorporating behavioral variables is higher than that of the models relying solely on publicly available data, mainly of a financial nature.

In her paper about a sample of German SMEs, Lehmann (2003) examined whether financial data from sources other than financial statements and, what is more, whether data of an expressly non-financial nature improve the model's performance. Altman, Sabato and Wilson (2010) performed a similar analysis on their own sample, as well. Obviously, taking into account the statistical and the econometric considerations, the goodness-of-fit indices and the classification power of a model that is based on a larger number of relevant variables and that uses a larger number of relevant explanatory variables will inevitably be more favorable. This is exactly the reason why my first hypothesis, formulated on the basis of Altman, Sabato and Wilson (2010), and Lehmann (2003), will most probably be accepted. Therefore, H5 is much more of an illustration, namely to the question to what extent the classification ability of the model can be improved by incorporating additional variables. Our choice of so-called behavioral variables being rather narrow as compared to the range of non-financial indicators recommended by literature, it will be particularly interesting to find out how much a limited set of behavioral variables can improve the performance of the model.

By behavioral variables I mean the body of information that might accumulate in the course of a supplier-customer relationship, thus more specifically: whether the customer has made a payment during the previous period, the existence of a line of credit and whether it has been exceeded. Hereinafter, the names of the models incorporating such variables will include the expression "BEHAV" (referring to behavioral scoring). Any other variable (financial and non-financial indicators) can be obtained even for new customers, with more or less effort. This is the case with financial statements, the track

record of the owner and the manager, the company's record concerning other partners (e.g. tax-like arrears, bankruptcy proceedings) and whether the company has ever been put on a publicly accessible blacklist and if so, for how long. (For instance on the list of those with significant tax-like arrears or on one of the "non-payers' lists" continuously updated by certain market actors.) Hereinafter, the names of the models estimated using only variables of this kind will include the expression „NEW", indicating that the results are applicable to new customers, as well.

H6: The classification accuracy of the models relying solely on non-financial variables is not worse than that of the models using financial data only.

Even though the range of non-financial information available to me is rather limited, I still intend to compare the discriminative power of financial statement data with that of other, non-financial data based on Altman, Sabato and Wilson (2010) and Lehman (2003). One of the motives for formulating this hypothesis was that in 2009, when the data were recorded, the claims management company (they asked to remain anonymous) that provided me with the database had made recommendations to its client – the supplier – on the line of credit to be extended to each customer primarily based on non-financial indicators, that is, on a kind of expert system.

H7: The model's classification ability improves if we use the principal components derived from the financial ratios by principal component analysis as the inputs of the logistic regression instead of using the individual financial ratios themselves as explanatory variables.

Factor analysis was reported to have been used for such purposes both in international and Hungarian literature. By creating four factors from the variables used to predict bankruptcy, Hámori (2001) managed to control the multicollinearity of strongly associated variables. Kristóf (2008a-b) based his calculations on Hámori's (2001) work. Kristóf (2008a-b) concluded, that the AUC value (and thus the classification power, too) of the models employing principal component analysis is higher than that of the models estimated by the individual indicators themselves. (Hereinafter the names of the models based on the results of a principal component analysis will include the expression „PCA".)

3.3.3.3 Default Prediction Models for the Customer Portfolio Examined

Two variations of the model built upon individual financial ratios (instead of principal components) will be presented first. The models relying solely on behavioral variables come second, and finally, the performance of PCA-supported models will also be assessed.

1. MULTIVAR_NEW_015

The model variation named „MULTIVAR_NEW_015" uses nothing else but publicly available data (no behavioral indicators), thus it can be used for new customers, too. The number "015" indicates that the optimal (AUC-maximizing) cutoff value is 15 percent. Accordingly, clients are classified as good debtors if their estimated probability of default is below 15 percent, and "bad" (i.e. non-paying) customers otherwise. For this very model, the results are presented in detail, but the outputs of all the other models, though available in the Appendix, will not be analyzed individually.

Variables in the Equation (MULTIVAR_NEW_015)

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 6	howmany_blacklist	.245	.087	8.023	1	.005	1.278
	Liab_Tdebt08	2.436	.404	36.274	1	.000	11.429
	OE_FASSET08	.005	.002	3.732	1	.053	1.005
	SALES_ASSETS08	-.226	.086	6.882	1	.009	.798
	CASH_ASSETS08	1.786	.674	7.026	1	.008	5.964
	fcff_assets	.775	.209	13.734	1	.000	2.171
	Constant	-3.183	.347	84.241	1	.000	.041

Table: 3.20.: Parameters of model MULTIVAR_NEW_015
Source: SPSS

According to the SPSS-output, the significant explanatory variables of customer default in the case of new customers are: the number of blacklist mentions, Total Liabilities/Total Debt, Net Sales Revenue/Total Assets, Cash and Cash Equivalents/Total Assets, and FCFF/Total Assets. The fact, for example, that Customer 'A' has been mentioned on a blacklist one single time results in their odds ($\frac{p}{1-p}$) becoming 1.278 times the odds of an

arbitrary Customer ‘B’ whose significant variables are identical to those of Customer ‘A’ except that Customer ‘B’ has never been added to any blacklist.

Model Summary (MULTIVAR_NEW_015)

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	511.963(a)	.058	.099
2	498.222(a)	.079	.134
3	490.464(a)	.090	.154
4	483.700(a)	.100	.170
5	476.435(a)	.110	.188
6	470.034(a)	.119	.204

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

Table 3.21.: Goodness-of-fit indices for model MULTIVAR_NEW_015
Source: SPSS

From amongst the goodness-of-fit indices, Nagelkerke R^2 is the easiest to interpret, because it works like the coefficient of multiple determination, taking values between 0 and 1 (Oravecz, 2008). Consequently, the explanatory power of our model for new customers, relying solely on publicly available information, is 20.4 percent.

In order to find the cutoff value with the maximum AUC, I estimated the model for various cutoff values between 0.1 and 0.9. I found that the optimal cutoff value must be between 0.1-0.2. The decision of where to put the cutoff within this range was facilitated by the method of Tang-Chi (2005). They plotted the graphs of the quotients FNR and FPR, and also TNR and TPR as a function of the cutoff value. The two curves intersect at the cutoff value resulting in the maximum AUC, as it was confirmed by the systematic analysis of AUC in Tang-Chi (2005). Along this line of thought, I found that the MULTIVAR-NEW model’s FNR and FPR curves (and the TNR and TPR curves, as well) intersect where at a cutoff value of 0.15 (Figure 3.5.). This value was also confirmed by our SPSS calculations for the training sample, as illustrated by Table 3.22. and the related ROC curves in Figure 3.6.a.

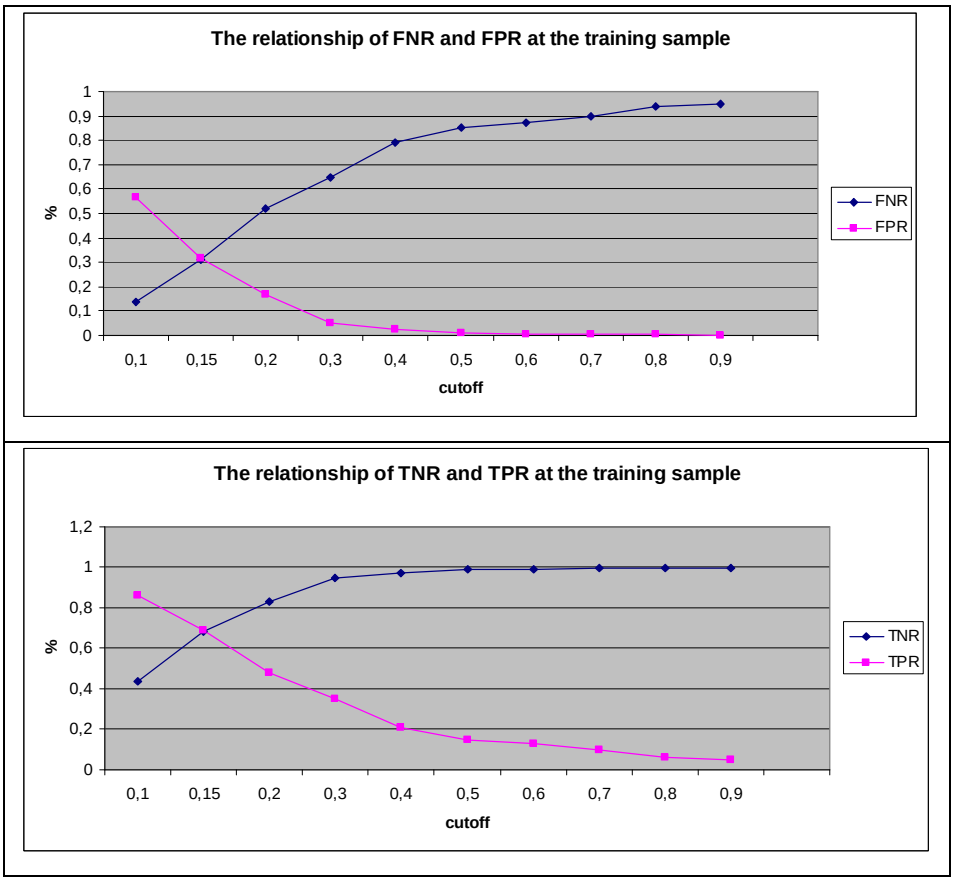


Figure 3.5.: Intersections of FNR and FPR, and TNR and TPR for the training sample
Source: Author's calculation based on SPSS outputs

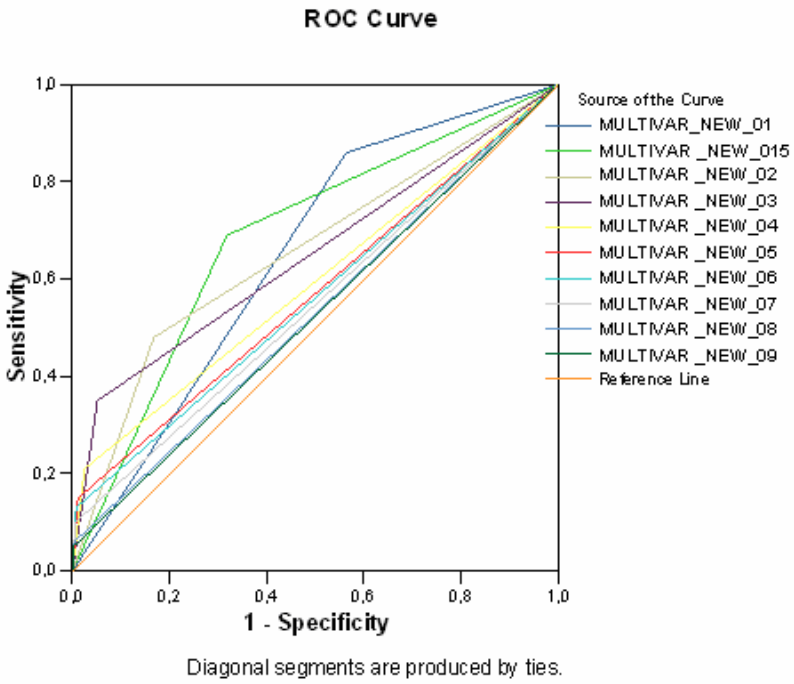


Figure 3.6.a: ROC curves of the training sample for different cutoff values
Source: SPSS

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MULTIVAR_NEW_01	.648	.027	.000	.595	.701
MULTIVAR _NEW_015	**.686**	**.029**	**.000**	**.629**	**.743**
MULTIVAR _NEW_02	.656	.032	.000	.593	.720
MULTIVAR _NEW_03	.649	.034	.000	.583	.716
MULTIVAR _NEW_04	.593	.034	.003	.526	.659
MULTIVAR _NEW_05	.569	.034	.028	.503	.635
MULTIVAR _NEW_06	.561	.033	.052	.496	.627
MULTIVAR _NEW_07	.547	.033	.135	.482	.612
MULTIVAR _NEW_08	.528	.033	.373	.464	.592
MULTIVAR _NEW_09	.524	.032	.446	.460	.588

a Under the nonparametric assumption
b Null hypothesis: true area = 0.5

Table 3.22.a: AUC values of the training sample for different cutoff values
Source: SPSS

By applying the results of the training sample to the holdout sample we find that the cutoff value of 15 percent is too low; a threshold of 20 percent would have yielded a higher AUC, the 5 percent significance level of which would not have been questionable.

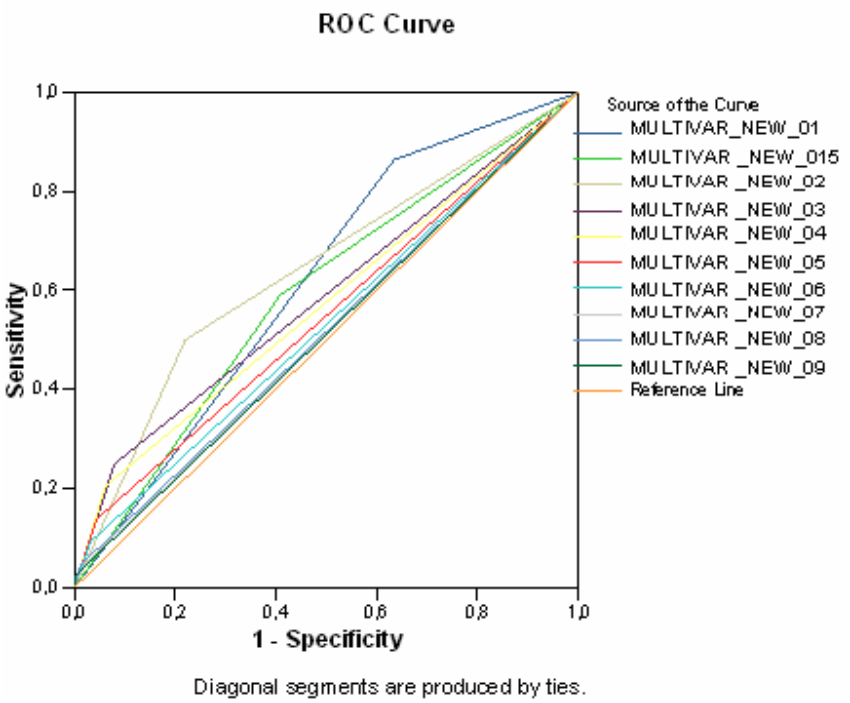


Figure 3.6.b: ROC curves of the holdout sample for different cutoff values
Source: SPSS

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
SOKVALT_NEW_01	.615	.044	.020	.528	.702
SOKVALT_NEW_015	.591	.048	.063	.497	.686
SOKVALT_NEW_02	.640	.049	.004	.543	.737
SOKVALT_NEW_03	.585	.052	.082	.484	.686
SOKVALT_NEW_04	.572	.052	.144	.471	.673
SOKVALT_NEW_05	.547	.051	.340	.447	.647
SOKVALT_NEW_06	.530	.051	.539	.431	.629
SOKVALT_NEW_07	.514	.050	.782	.416	.611
SOKVALT_NEW_08	.517	.050	.735	.419	.615
SOKVALT_NEW_09	.511	.050	.817	.414	.609

The test result variable(s): SOKVALT_NEW_01, SOKVALT_NEW_015, SOKVALT_NEW_02, SOKVALT_NEW_03, SOKVALT_NEW_04, SOKVALT_NEW_05, SOKVALT_NEW_06, SOKVALT_NEW_07, SOKVALT_NEW_08, SOKVALT_NEW_09 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a Under the nonparametric assumption
b Null hypothesis: true area = 0.5

Table 3.22.b: AUC values of the holdout sample for different cutoff values
Source: SPSS

2. MULTIVAR_BEHAV_015

The next step was the addition of behavioral information collected in the course of the customer-supplier relationship to the model based on individual financial ratios and publicly available non-financial data. Otherwise, the modeling process is identical to that of model MULTIVAR_NEW_015.

Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 8(h)	howmany_blacklist	.209	.107	3.859	1	.049	1.233
	blacklist_delay_days	.004	.002	3.744	1	.053	1.004
	Liab/Tdebt08	2.273	.429	28.077	1	.000	9.712
	OE_FASSET08	.006	.003	4.969	1	.026	1.006
	SALES_ASSETS08	-.192	.091	4.438	1	.035	.826
	CASH_ASSETS08	1.967	.705	7.791	1	.005	7.149
	fcff_assets	.736	.216	11.585	1	.001	2.087
	EXCCRLINE _DUMMY (1)	-1.536	.256	36.043	1	.000	.215
	Constant	-2.380	.373	40.645	1	.000	.093

Table 3.23.: Parameters of model MULTIVAR_BEHAV_015
Source: SPSS

According to the SPSS-output, the number of blacklist mentions, Total Liabilities/Total Debt, Owner's Equity/Fixed Assets, Net Sales Revenue/Total Assets, Cash and Cash Equivalents/Total Assets, and FCFF/Total Assets turned out to be significant explanatory variables, once again. At the same time, the exceeding of the credit line was also found to be an explanatory variable and the number of blacklist days was just a tiny bit away from being significant, too.

The outputs of the model can be found in the Appendix. The incorporation of behavioral variables significantly improved the goodness-of-fit indices, though that is not much of a surprise whenever new, relevant variables are added to a model. Nagelkerke R^2 increased from 0.204 to 0.298. Using the optimal (15 percent) cutoff value, the AUC of the training sample was 0.751, which does differ from 0.5 at any level of significance. This time, the model also performed well on the holdout sample: its AUC value of 0.683 significantly differs from the 0.5 figure of random classification.

3. BEHAV_015

This model, based on non-financial indicators only, is needed to test hypothesis H6. Its inputs are non-financial variables, exclusively. Even though the studies discussed in the methodological chapter used a rather wide range of data, my database was limited to the following variables: legal form of the company, repayment, number and duration of blacklist mentions, track record of the company and related persons, and the existence and the exceeding of a credit line. Therefore this model, similar to Altman's ZETA-model, also includes the ln(Total Assets) indicator as a proxy variable of company size. Similarly, negative Owner's Equity balances were also taken into account through a dummy variable. Final results are listed in Table 3.24. The indicators found to be significant were: track record of the company (comphist_dummy), payment habits, exceeding of the credit line and negative owner's equity.

Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 6(f)	howmany_blacklist	.264	.102	6.664	1	.010	1.303
	blacklist_delay_days	.004	.002	3.725	1	.054	1.004
	comphist_dummy(1)	-.614	.271	5.156	1	.023	.541
	sREPAY_DUMMY			6.552	2	.038	
	sREPAY_DUMMY(1)	-.400	.268	2.220	1	.136	.670
	sREPAY_DUMMY(2)	-.968	.384	6.354	1	.012	.380
	EXCCRLINE_DUMMY(1)	-1.528	.247	38.305	1	.000	.217
	negEquity_dummy	1.562	.414	14.233	1	.000	4.767
	Constant	-.258	.307	.707	1	.401	.772

Table 3.24.: Parameters of model BEHAV015 *Source: SPSS*

Again, the model's detailed outputs can be found in the APPENDIX. The goodness-of-fit indices did not, as compared to model MULTIVAR_NEW_015 (using publicly available data only), deteriorate, but on the contrary, they actually improved. Nagelkerke R^2 increased from 0.204 to 0.234. Again with a cutoff of 15 percent, the AUC values of the training and the holdout sample were 0.703 and 0.693, both of which significantly differ from the 0.5 figure of random classification.

4. PCA_NEW_015

According to hypothesis H7, factor analysis might improve the classification accuracy of classification models. Thus I am going to develop two model variations (using publicly available data first and then adding behavioral variables) where financial ratios are replaced by factors generated by principal component analysis (PCA).

All financial ratios that were observed for the entire portfolio were included in the principal component analysis. Many of the quotients having similar interpretations, the finding that the variables are suitable for factor analysis (see Table 3.25.) is less of a surprise.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.571
Bartlett's Test of Sphericity	Approx. Chi-Square	37451.248
	Df	465
	Sig.	.000

Table 3.25.: Data Suitability for PCA
Source: SPSS

Though literature generally reports fewer factors (Hámori, for instance, mentions 5), the "eigenvalue greater than one" rule yields 10 principal components. Having run test for fewer factors, both the factor analysis and the logistic model the inputs of which it is intended to deliver deteriorated in performance. Thus I accepted 10 as the number of factors, arrived at by performing a principal component analysis with Varimax rotation. This way, principal components account for 77 percent of the total variance. For detailed outputs, please consult the Appendix. The ten principal components, named according to their content, were:

1. Return on Assets
2. Profitability
3. Leverage
4. Net current assets structure
5. Debt service
6. Liquidity
7. Receivables and Liabilities ratios

8. Return on Owner's Equity
9. Asset structure, financing
10. Sales Revenue

The parameters of the logit model estimated using the 10 principal components are given in Table 3.26. Significant explanatory variables for the default of new customers were: number of blacklist mentions, track record of the company, 'Return on Assets' factor, the factor describing the structure and ratio of receivables and liabilities, and the factor describing the structure and the financing of assets.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 7(f)	FAC1_3	-.930	.215	18.680	1	.000	.394
	FAC7_3	.302	.105	8.220	1	.004	1.353
	FAC9_3	.266	.110	5.858	1	.016	1.305
	howmany_blacklist	.258	.087	8.850	1	.003	1.295
	comphist_dummy(1)	-.622	.259	5.787	1	.016	.537
	Constant	-1.353	.223	36.904	1	.000	.259

Table 3.26.: Parameters of model PCA_NEW_015

Source: SPSS

The value of Nagelkerke R^2 is the lowest so far, only detecting a determination of 15.7 percent. Using the cutoff value optimal for the training sample, 15 percent, the AUC-indicated performance of the model does not exceed that of model MULTIVAR_NEW_015, only achieving a value of 0.660 versus the 0.686 figure of the model based on individual indicators. The holdout sample, however, yielded a particularly promising value of 0.663. Both AUC values in question, nonetheless, do significantly differ from 0.5.

5. PCA_BEHAV_015

By expanding the PCA-based model with our behavioral variables, we arrive at the model presented in Table 3.27. The variables related to repayment and the exceeding of the credit line are added to the parameters of model PCA_NEW_015. The model's explanatory power is, according to Nagelkerke R^2, 27.2 percent, thus weaker than that of model

MULTIVAR_BEHAV_015. At the optimal cutoff level (15 percent, again), the AUC values of the training sample and the holdout sample are 0.713 and 0.707, respectively. Which implies, once again, that even though it is model MULTIVAR_BEHAV_015 that better classifies the training sample, it is outperformed by the PCA-based model as far as the holdout sample is concerned.

Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 7	FAC1_3	-.878	.223	15.535	1	.000	.415
	FAC7_3	.307	.112	7.451	1	.006	1.359
	FAC9_3	.319	.122	6.876	1	.009	1.376
	howmany_blacklist	.319	.094	11.416	1	.001	1.376
	comphist_dummy(1)	-.639	.276	5.372	1	.020	.528
	sREPAY_DUMMY			7.101	2	.029	
	sREPAY_DUMMY(1)	-.427	.273	2.453	1	.117	.652
	sREPAY_DUMMY(2)	-1.023	.391	6.859	1	.009	.360
	EXCCRLINE_DUMMY(1)	-1.470	.250	34.496	1	.000	.230
	Constant	-.141	.312	.204	1	.651	.869

Table 3.27.: Parameters of model PCA_BEHAV_015

Source: SPSS

1.1.1.4. Modeling Results and Hypothesis Evaluation

Based on the literature on relevant methodologies, I examined three hypotheses concerning the logit models classifying customers either as payers or non-payers. The comparison of my models also serves the purpose of evaluating these hypotheses.

H5: The classification accuracy of the models incorporating behavioral variables is higher than that of the models relying solely on publicly available data, mainly of a financial nature.

In order to test the above hypothesis, we need to compare model MULTIVAR_NEW_015 to MULTIVAR_BEHAV_015 and model PCA_NEW_015 to PCA_BEHAV_015. The aspects of comparison are listed in Tables 3.28.a-b.

Entire sample	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
MULTIVAR_NEW_015	470.034	0.119	0.204
MULTIVAR_BEHAV_015	429.552	0.175	0.298
PCA_NEW_015	489.223	0.092	0.157
PCA_BEHAV_015	441.029	0.159	0.272

Table 3.28.a: Testing of hypothesis H5 – goodness-of–fit indices

Source: SPSS, edited by the author

Training sample	AUC	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MULTIVAR_NEW_015	0.686	0.029	0.000	0.628	0.743
MULTIVAR_BEHAV_015	0.750	0.027	0.000	0.698	0.803
PCA_NEW_015	0.660	0.030	0.000	0.601	0.719
PCA_BEHAV_015	0.713	0.028	0.000	0.658	0.769
Holdout sample					
MULTIVAR_NEW_015	0.591	0.048	0.063	0.497	0.686
MULTIVAR_BEHAV_015	0.683	0.046	0.000	0.593	0.774
PCA_NEW_015	0.663	0.046	0.001	0.574	0.753
PCA_BEHAV_015	0.707	0.045	0.000	0.618	0.796

Table 3.28.b: Testing of hypothesis H5 – AUC

Source: SPSS, edited by the author

Table 3.28.a shows three goodness-of–fit indices. The estimation algorithm minimizes the value of -2Loglikelihood, thus: the lower the better. Concerning Cox-Snell R^2 values, however, it is the higher values that are more favorable. This indicator, by the way, compares the likelihood value to the empty model (Oravecz, 2008; Kovács, 2006, Sajtos and Mitev, 2007). The interpretation of Nagelkerke R^2 has already been discussed earlier.

The theoretical implication that the incorporation of the behavioral variables into the models would improve model fit has been confirmed by all three indicators. For the individual indicator based model and for the PCA-based model, Nagelkerke R^2 improved by 9 and almost 12 hundredths, respectively. Nagelkerke R^2 can take values between 0 and 1, and concerning its interpretation, it can be said that the behavioral variables improved the explanatory power of the model by about 10 percentage points.

In line with our expectations, the classification power of the models also incorporating behavioral variables proved to be significantly better in each case. Compared to the theoretical lower and upper limit of AUC (0.5 and 1), the improvement – between 4 and 9 hundredths, depending on the model – is considered significant. It could also be observed that any one of the models including behavioral variables performed better than any one of the previously presented models not including such inputs, thus the models that also account for behavioral aspects outperformed the others even for different sets of financial explanatory variables. The conclusions, also valid for the holdout sample, are illustrated in Figure 3.7.

On the whole, the testing of hypothesis H5 has fulfilled its function by illustrating, based on the models I estimated, the improvement in classification accuracy that can be achieved by incorporating behavioral variables – which is actually in line with the conclusions formulated in the literature we reviewed, as well.

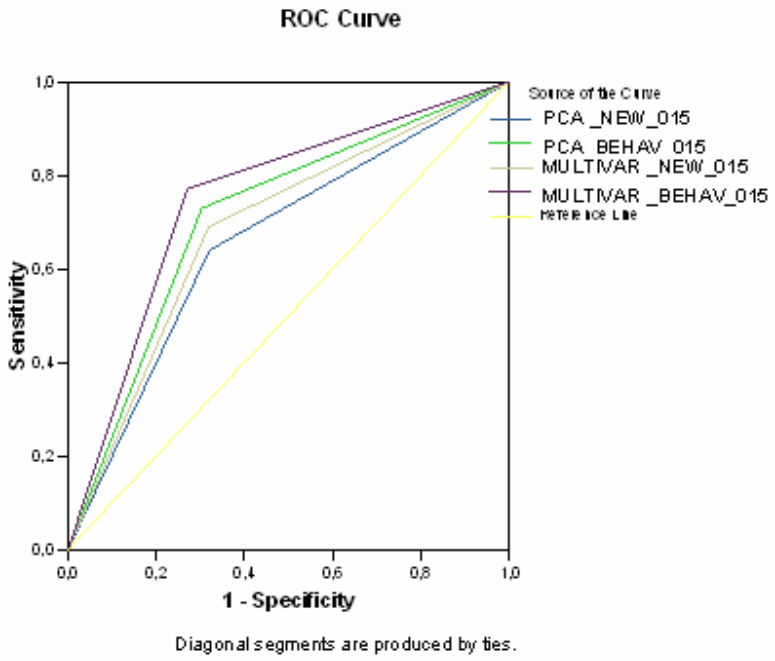


Figure 3.7.a: ROC curves for the training sample

Source: SPSS

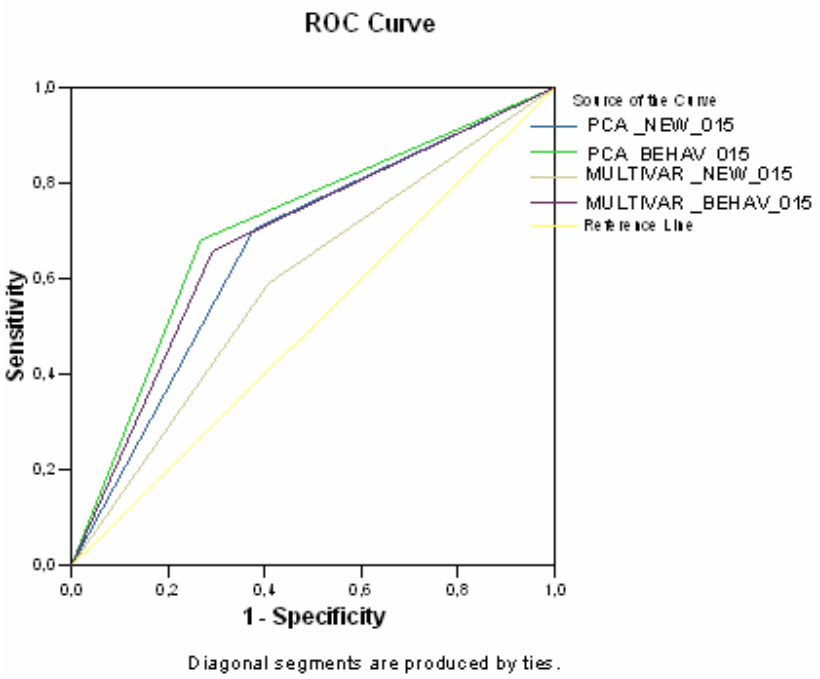


Figure 3.7.b: ROC curves for the holdout sample

Source: SPSS

H6: The classification accuracy of the models relying solely on non-financial variables is not worse than that of the models using financial data only.

Model BEHAV_015, only employing behavioral and non-financial indicators as explanatory variables, was estimated for the purpose of testing this hypothesis. The goodness-of–fit indices and the AUC values of both the training sample and the holdout sample (see Tables 3.29.a-b) all support that replacing financial ratios with variables describing other dimensions of companies' behavior yielded a better-performing model. Based on the presented models, hypothesis H6 has been accepted, that is, the classification accuracy of the models relying solely on behavioral variables is not worse than that of the models using financial data only. As an interesting note: the acceptance of hypothesis H6 also explains the practice of the claims management company providing my database – namely, that they can successfully determine the credit lines to be extended to customers based primarily on behavioral variables and only secondarily on financial data.

Entire sample	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
MULTIVAR_NEW_015	470,034	0,119	0,204
PCA_NEW_015	489,223	0,092	0,157
BEHAV_015	457,414	0,137	0,234

Table 3.29.a: Testing of hypothesis H6 – goodness-of-fit indices

Source: SPSS, edited by the author

Training sample	AUC	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MULTIVAR_NEW_015	0,686	0,029	0,000	0,628	0,743
PCA_NEW_015	0,660	0,030	0,000	0,601	0,719
BEHAV_015	0,703	0,029	0,000	0,646	0,760
Holdout sample					
MULTIVAR_NEW_015	0,591	0,048	0,063	0,497	0,686
PCA_NEW_015	0,663	0,046	0,001	0,574	0,753
BEHAV_015	0,693	0,047	0,000	0,602	0,785

Table 3.29.b: Testing of hypothesis H6 – AUC

Source: SPSS, edited by the author

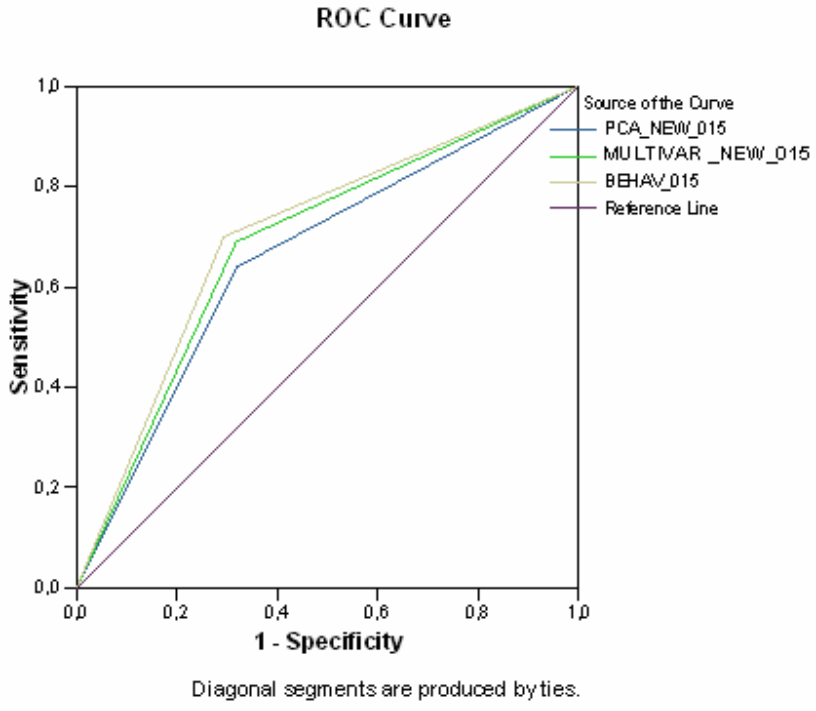


Figure 3.8.a: ROC curves for the training sample *Source: SPSS*

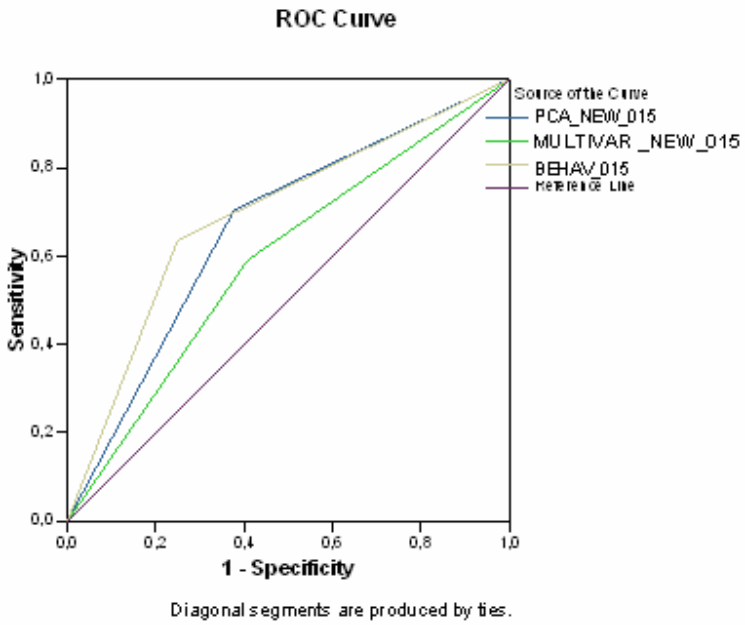


Figure 3.8.b: ROC curves for the holdout sample

Source: SPSS

H7: The model's classification ability improves if we use the principal components derived from the financial ratios by principal component analysis as the inputs of the logistic regression instead of using the individual financial ratios themselves as explanatory variables.

The testing of hypothesis H7 requiring the exact same models as those compared in the section about hypothesis H6 (i.e. MULTIVAR_NEW_015 vs. MULTIVAR_BEHAV_015 and PCA_NEW_015 vs. PCA_BEHAV_015), my conclusions will be based on Tables 3.28.a-b and on Figure 3.7.

Whether comparing the models for new customers or the variations using behavioral variables, it was always the models relying on individual indicators that turned out to have a better fit. In the total ranking of the four models, behavioral models come first (in line with hypothesis H5), followed by the models for new customers.

Considering the training sample, the ranking of the models by classification power is similar. On the holdout sample, however, PCA-based models consistently outperform their individual-indicator-based counterparts. On the whole, according to the AUC values for the holdout sample, it is model PCA_BEHAV_015 that classifies most accurately, followed by

MULTIVAR_BEHAV_015. Thus not even the use of principal components can make up for the advantage of a model also incorporating behavioral variables. These two models ranked best on the training sample, as well, but in reverse order.

Based of the above, hypothesis H7 could not be clearly rejected. The results of the models on the holdout sample do, as a matter of fact, definitely support the idea formulated in hypothesis H7.

On the whole, the indicators measuring the fit and the classification power of our models did indeed assist us in testing the hypotheses, as they took different values for the different models. If, however, their absolute value is compared to any of the empirical studies cited in present thesis, we find that the performance of my models is below that of similar models presented in literature. The reason lies in the definition of the dependent variable.

First, the exploration of payment patterns did not yield a delay interval that would clearly describe non-payment. Therefore my decision to follow the Basel Accord, and thus use DEF90, was somewhat arbitrary. I re-estimated the models using the variable DEF120, but the fit and the AUC of the models did not demonstrate consistent improvement on the training and the holdout samples. Thus there was still no reason to replace variable DEF90 as the indicator describing non-payment.

Another possible explanation for the performance of the models is as follows. A company not paying to its supplier is far less severe as a credit risk event than bankruptcy is. When making its decision when or whether to pay its supplier, the company's willingness to pay is at least as important as its ability to do so, as also evinced by the good results of model BEHAV_015.

Imre (2008), who developed models for the prediction of bank loan defaults (delays beyond 90 days, in accordance with the default-definition of Basel II), drew the same conclusion at the end of his dissertation. Thus, most probably, the financial data of bankrupt businesses can be better distinguished from that of non-bankrupt businesses than the data of payers can be from that of non-payers. That is, bankruptcy prediction models were also suitable for the prediction of payment delays beyond 90 days, but prediction accuracy remained below the usual level of bankruptcy prediction models. Adopting the reasoning of Imre (2008), a delay beyond 90 days on one's bank loan payment is a "weaker" event than bankruptcy, yet it is an even less severe credit risk situation if it is

„only” the supplier who has to wait more than 90 days for their money. Consequently, I regard the goodness-of-fit indices and the AUC values of my models as appropriate in spite of the fact that literature frequently reports of better performing models.

Summary

If the customer's non-payment appears at the neighbor members of the supply chain, it will develop into a chain-debt. Whether we concentrate only to one non-payer, or to the chain of non-payers we chose a widespread topic. At the point where the paying willingness and the paying ability are separated both the sociologists and the jurists can find a research topic; regulatory questions, motivations of the economical actors and the paying norms are all waiting for examination. Systematic risk, the topic of trade credit, the corporate liquidity, the corporate risk management or the contract theoretical models can be all possible approaches within the frame of economics.

Because the small- and medium sized enterprises (SME) are effected the worst in the queuing of receivables, the financing of the SME sector, the examination of the access to external financing can also help to understand the aspect of queuing. Wider in the topic of enterprise promotion the problem is unavoidable, it is a question of policy and support, whether we have to do against this on a central level. A possible analysis framework for chain debt are network theory models. If the same problem is analyzed from the aspect of debt holders, within the default of borrowers – participating in the same supply chain – can be correlated the bank's credit portfolio, a contagion can take place, and by this we have reached a special problem of the bank's credit risk.

I have only appointed couple of topics from this multicolored palette. The main thread of the theoretical chapters of the dissertation is connected to the credit rationing which is a consequence of non-payment of the customer and of the delayed fulfillment of payables. The third chapter contains the empirical analysis; it also models the non-payment of the customers.

Microfinance provides joint liability as a possible solution for credit rationing. The topic was presented in the first chapter. In order to understand the mechanism of joint liability, firstly I presented the main outcomes of microfinancing, especially the more important topics of group lending. Although many sources were provided for me, it is important to note that there are many uncovered fields, numerous uncovered research directions within the topic.

My description concentrates on group constructions relying mainly on the works of Stiglitz (1990), Ghatak and Guinnane (1999) and Morduch (1999). I examine how market failures

can be eliminated by group lending. According to their results the clients with different risk level previously know the attributes of other borrowers, or they screen each other at lower costs than the lender. Based on the information gathered during the screening they form groups. According to several authors they are organized into homogenous groups, and during the duration of the loan they are carrying out monitoring. The monitoring helps to decide whether to punish clients who do not pay. The theoretical part of the chapter partially deals with the controversial points of the results and the major views. I particularly write on social capital because the typical target group of microfinance has especially strong social ties which can serve as a kind of collateral. Instead of the physical collateral the borrowers are risking their social capital and their reputation, if they are not paying off their debts.

In the first chapter of the dissertation the previous empirical results are also discussed. The empirical researches - partially refuting the pertinence of the theoretical results - contributed to the debate between group and individual loans. According to the most recent studies, the two constructions are not competing with each other, instead they are techniques of microlending which can be applied for different client circles in parallel.

In any case, it can be seen, that the clients can cumulate some initial capital with group loans, and by doing so they can gain access to the individual loans further on, which are customized and are providing greater amounts than the group constructions.

The topics of sustainability and profitability also appeared in the literature. An other interesting question is whether micro-financing is an effective tool in the struggle against poverty, or not, and whether a more effective tool can be found next to similar expenses.

From the aspect of the second part of the dissertation, a central element of the thesis is the realization of joint liability in developed, Western countries is, what is not confuted by the previous empirical results. I also present the recent theoretical models – in accordance with the results of the various loan programs – and conclude that joint liability can be replaced with dynamic incentives (conditional loan renewal, sequential lending). Dynamic incentives have an other advantage too; namely they are cheaper for the borrowers than joint liability. Because joint liability can put too high expenses for the successful clients, thus the opinion of the authors on this constructional element is not unified. It is debated whether the credit rationing decreasing effect of joint liability can counterbalance the high

extra expenses connected to the construction, namely the extra weights caused by the non-paying partners.

In the second part of the thesis - while keeping an eye on the above mentioned open question – I elaborated contract theoretical models for bank financing of a supplier and his customer where the contractors face moral hazard and asymmetric information. I concluded, that if the non-paying customer is liquidated by his/her partners in the first period then the borrowing capacity of the supplier decreases in case of the non-paying customer. However if the bank offers a liquidity loan to the non-paying customer, the supplier's will not be additionally credit rationed. But the bank opts for continuation (for the further financing of the customer) more rarely, than it would be optimal for the two contractors. That is why I have examined whether credit rationing decreases if the customer-supplier relationship, which is a hidden dependence between the borrowers, is made explicit, and it serves as special collateral in the loan contract; or the extra weights of joint liability dominates positive effects of joint liability.

The aspects of comparison of the models are credit rationing, the owner's expected NPV, what is measuring the utility of the two contractors, the profit-maximizing continuation rule of the bank and also the social welfare.

Joint liability can really decrease credit rationing partially. The continuation with individual liability is providing a higher borrowing capacity to the two contractors than joint liability. Joint liability only dominates the construction where the non-paying customer is liquidated by the partners.

The utility of the two contractors is measured by the owner's expected NPV. It is not surprising, that the supplier prefers to have the least responsibility possible for the continuation of the loan, while the risk of continuation is taken by the bank and the customer. To the contrary, the customer prefers joint liability – since the weights of continuation then are partially given to the supplier. Even if we suppose the possibility of compensation between the two contractors, then by examining their expected owner's NPV the construction of joint liability is only the second most advantageous construction for the two contractors together.

Social welfare is measured by the expected NPV. The allocation of liability is only redistributing the utility amongst the contracting parties, it does not affect social welfare.

If the bank prefers joint liability, then despite of the above, the bank can force the two firms to a sub-optimal financing form. However at the perfectly competitive market by examining the profit-maximizing decision rule and the expected net pledgeable income maximalization, we also had to abort this possibility. Although the liquidity loan and also one portion of the loan provided for the supplier in the zero period, will be guaranteed doubled; the motivation of the two contractors decreases. To compensate the change in the motivation, the absolute value of the income pledged to the bank can not exceed the level of the pledgeable, individual continuation income.

To sum up the results of modeling the spread joint liability between the customer and his/her supplier in a Bondian (2004) sense, is not suitable to decrease credit rationing as special collateral. As some the authors state about group loans that liability for the partners leads to excessive expenses; we will reach a similar conclusion between the two neighbor members of the supply chain. The conclusion is interesting because the alternatives in the two cases are not identical. At the individual loans there is no relationship between the clients, who would have belonged to the same group in a group construction. However in the case of the customer and the supplier, the dependence between the two contractors does not disappear in an individual construction, because the supplier is still exposed to credit risk on the trade credit provided. The extra weights of the customer's credit risk will not disappear, but they lead to additional credit rationing in any individual construction.

By examining the different variations of the models, I have found that the conclusions are robust. Only the model variation of factoring shows an interesting result. Although factoring does not decrease credit rationing, but it results in a higher expected profit for the bank than simple individual liability does. That is the reason why the bank determines a less strict continuation rule whit factoring than in the simple continuation model. Thus, it can happen that the two contractors - in order to provide a less strict continuation rule an ex ante - have to decrease the size of the project and to choose the construction with factoring.

The last, the third section of my thesis deals with the empirical research. The analysis is connected to one of the starting points of the second section: the non-paying customer. The question examined in this third chapter is, due to the nature of available data, more general, only focusing on the characterization of the phenomenon 'late-payer customer' instead of the consequences of non-paying customers. The study is unique in its kind, as there is no

data source publicly accessible to academics on the changes in the volume of outstanding and late receivables except for quarterly macro-level accounts receivable statistics. Even if it was not the entire debt chain, I could at least examine the trade credit portfolio of one given company, thereby contributing to Hungarian literature in the topic.

As the first step of the actual analysis, I performed a cluster analysis in order to find the major payment patterns in the customer portfolio. The final 12 clusters were determined by K-mean clustering. The groups of the GOODS (are not late) and the BADS (who are late over 180 days) and the CASH PAYERS are easy to isolate. The distinction between DELAYERS and NON-PAYERS, comprising 7 clusters altogether, is somewhat arbitrary. They are distinguished based on the definition of default used by the banks, that is, anyone whose obligations are more than 90 days past due is considered to be in default (a non-payer). In both of the groups we can find clusters including small, medium and larger firms, where in some cases even the behavioral variables can differ. The relationships between the clusters and the non-clustering variables also support that we managed to generate homogenous clusters.

Second, I explored the relationship between late payments and other customer-specific pieces of information, employing methodologies appropriate for the level of measurement of each variable. According to the contingency tables the gender does not influence the paying habits, but the excess of the credit limit and the track record of the firm shows a significant relationship with the patterns of paying. The result is in concord with the message of the literature on bankruptcy models, credit risk scoring and credit risk; namely, the not financial, perhaps qualitative information are significantly important inputs of the lending decision generally. In addition, the smaller the firm the more important the non financial information.

As a third step of the empirical I applied the methodology of bankruptcy models to model the non-payment of customers. I have estimated the logit-models with different inputs for the prediction of customer's payment delays beyond 90 days. The comparison of the models classification accuracy shows non-financial information enhanced the accuracy of the model in every case, which I have measured with AUC, an indicator used in current literature.

Factor analysis was reported to have been used both in international and Hungarian literature improve t**he model's classification ability. C**omparing the models estimated in the previous chapters, it was always the models relying on individual indicators that turned out to have a better classification power on the training sample. On the holdout sample, however, PCA-based models consistently outperform their individual-indicator-based counterparts.

The goodness-of–fit indices and the AUC values of both the training sample and the holdout sample all support that replacing financial ratios with variables describing other dimensions of companies' behavior yielded a better-performing model. The result also explains the practice of the claims management company providing my database – namely, that they can successfully determine the credit lines to be extended to customers based primarily on behavioral variables and only secondarily on financial data.

The success of the BEHAV_015 model suggests that the receivables managing company could improve its decision making mechanism by collecting more behavioral information. The literature recommends for instance the age of the customer relationship, the age of the buying company, the number of the employees, the education of the leaders of the firm, the leader's experience measured in years in the industry, the variability of the balance of the received trade credit, the industry and its industrial bankruptcy rate. There is also a further research question related, namely to examine the classification power of other non-financial indicators.

The goodness of fit and the classification power of the models are slightly weaker than the similar values of the bankruptcy and scoring models. A possible reason is that suppliers are generally paid late. A delay on supplier payables does not mean such a severe event of credit risk with serious consequences like bankruptcy or a delay towards a bank. Imre (2008), who developed models for the prediction of bank loan defaults (delays beyond 90 days, in accordance with the default-definition of Basel II), drew the same conclusion at the end of his dissertation. Thus, most probably, the financial data of bankrupt businesses can be better distinguished from that of non-bankrupt businesses than the data of payers can be from that of non-payers. Adopting the reasoning of Imre (2008), a delay beyond 90 days on one's bank loan payment is a "weaker" event than bankruptcy, yet it is an even less severe credit risk situation if it is „only" the supplier who has to wait more than 90 days for

their money. Consequently, I regard the goodness-of-fit indices and the AUC values of my models as appropriate in spite of the fact that literature frequently reports of better performing models.

All of this however brings up another research question: could the models be improved if I reformulated the definition of customer non-payment which was the dependent variable in the logit models? This non-payment definition would be probably customized to the industry which the customer belongs to. It has to be an early signal about illiquidity and insolvency to assure that the supplier has still enough time to make suitable steps for the collection of the receivables. On the other hand the delay classified as non-payment should be sufficiently long to differ from the common, average delays of 50-60 days in the examined portfolio, so it can be modeled as a dependant variable and can be predicted in advance.

There would be additional research possibilities for the future if chronological data would be available for the aged balance of open receivables. First the circle of the behavioral variables could be broadened by a detailed knowledge on historical paying and purchasing habits. Second, the stability of the paying patterns could be tested. There is an interesting question, whether a customer from the current database classified as a delayer (between 31-60 days) was in the same due date interval in an earlier point of time, or he/she had belonged to the group of 16-30 days delayers earlier. This last finding would mean that the client is permanently falling behind towards the longer delays. It is also possible, that until a particular due date interval the classification is stabile, afterwards the customer stops his/her payments and his/her classification is going to be worse by the time. If the latter supposition is true, then the observation of this threshold in the due date structure can help to construct a non-payment definition. If the historical value of open balances is available, then there is an opportunity to control and the test the results and the prediction power of the logistic models which are classifying the paying and the non-paying customers.

4 APPENDIX[12]

[12] Source: SPSS outputs

1. Contingency Tables of Cluster Analysis

1. Table: Contingency table for cluster membership and legal form of the company (Kft – limited liability company, Bt – unlimited partnership, Rt – privately/publicly held share companies, Kkt – a kind of partnership, Kht – nonprofit company, EV - self-employed entrepreneur)

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
COMPFORM	Kft	Count	191	45	18	195	94	23	18	16	20	145	23	48	836
		% within COMPFORM	22,8%	5,4%	2,2%	23,3%	11,2%	2,8%	2,2%	1,9%	2,4%	17,3%	2,8%	5,7%	100,0%
		% within Cluster Number of Case	57,4%	48,4%	58,1%	73,9%	72,9%	59,0%	69,2%	64,0%	62,5%	70,0%	62,2%	65,8%	64,9%
	Bt	Count	48	13	4	22	11	6	4	4	6	17	3	10	148
		% within COMPFORM	32,4%	8,8%	2,7%	14,9%	7,4%	4,1%	2,7%	2,7%	4,1%	11,5%	2,0%	6,8%	100,0%
		% within Cluster Number of Case	14,4%	14,0%	12,9%	8,3%	8,5%	15,4%	15,4%	16,0%	18,8%	8,2%	8,1%	13,7%	11,5%
	Rt	Count	10	2	1	16	5	0	2	2	1	15	2	5	61
		% within COMPFORM	16,4%	3,3%	1,6%	26,2%	8,2%	,0%	3,3%	3,3%	1,6%	24,6%	3,3%	8,2%	100,0%
		% within Cluster Number of Case	3,0%	2,2%	3,2%	6,1%	3,9%	,0%	7,7%	8,0%	3,1%	7,2%	5,4%	6,8%	4,7%

	Foreign	Count	2	1	0	0	7	0	0	0	1	0	0	2	13
		% within COMPFORM	15,4%	7,7%	,0%	,0%	53,8%	,0%	,0%	,0%	7,7%	,0%	,0%	15,4%	100,0%
		% within Cluster Number of Case	,6%	1,1%	,0%	,0%	5,4%	,0%	,0%	,0%	3,1%	,0%	,0%	2,7%	1,0%
	Kkt	Count	0	1	0	2	1	0	0	0	0	0	0	0	4
		% within COMPFORM	,0%	25,0%	,0%	50,0%	25,0%	,0%	,0%	,0%	,0%	,0%	,0%	,0%	100,0%
		% within Cluster Number of Case	,0%	1,1%	,0%	,8%	,8%	,0%	,0%	,0%	,0%	,0%	,0%	,0%	,3%
	Kht	Count	0	0	0	1	0	0	0	0	0	1	1	0	3
		% within COMPFORM	,0%	,0%	,0%	33,3%	,0%	,0%	,0%	,0%	,0%	33,3%	33,3%	,0%	100,0%
		% within Cluster Number of Case	,0%	,0%	,0%	,4%	,0%	,0%	,0%	,0%	,0%	,5%	2,7%	,0%	,2%
	EV	Count	82	31	8	28	11	10	2	3	4	29	8	8	224
		% within COMPFORM	36,6%	13,8%	3,6%	12,5%	4,9%	4,5%	,9%	1,3%	1,8%	12,9%	3,6%	3,6%	100,0%
		% within Cluster Number of Case	24,6%	33,3%	25,8%	10,6%	8,5%	25,6%	7,7%	12,0%	12,5%	14,0%	21,6%	11,0%	17,4%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within COMPFORM	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

2. Table: Contingency table for cluster membership and repayment

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
REPAY	,00	Count	132	88	29	101	60	34	22	24	30	115	36	72	743
		% within REPAY	17,8%	11,8%	3,9%	13,6%	8,1%	4,6%	3,0%	3,2%	4,0%	15,5%	4,8%	9,7%	100,0%
		% within Cluster Number of Case	75,4%	94,6%	93,5%	52,9%	65,9%	87,2%	84,6%	96,0%	93,8%	58,4%	97,3%	98,6%	73,6%
	1,00	Count	32	5	2	67	19	5	3	1	1	60	1	1	197
		% within REPAY	16,2%	2,5%	1,0%	34,0%	9,6%	2,5%	1,5%	,5%	,5%	30,5%	,5%	,5%	100,0%
		% within Cluster Number of Case	18,3%	5,4%	6,5%	35,1%	20,9%	12,8%	11,5%	4,0%	3,1%	30,5%	2,7%	1,4%	19,5%
	2,00	Count	11	0	0	23	12	0	1	0	1	22	0	0	70
		% within REPAY	15,7%	,0%	,0%	32,9%	17,1%	,0%	1,4%	,0%	1,4%	31,4%	,0%	,0%	100,0%
		% within Cluster Number of Case	6,3%	,0%	,0%	12,0%	13,2%	,0%	3,8%	,0%	3,1%	11,2%	,0%	,0%	6,9%
Total		Count	175	93	31	191	91	39	26	25	32	197	37	73	1010
		% within REPAY	17,3%	9,2%	3,1%	18,9%	9,0%	3,9%	2,6%	2,5%	3,2%	19,5%	3,7%	7,2%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

3. Table: Contingency table for cluster membership and purchasing

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
purch_DUMMY	,00	Count	123	93	31	122	44	39	20	24	30	116	33	70	745
		% within purch_DUMMY	16,5%	12,5%	4,2%	16,4%	5,9%	5,2%	2,7%	3,2%	4,0%	15,6%	4,4%	9,4%	100,0%
		% within Cluster Number of Case	70,3%	100,0%	100,0%	63,9%	48,4%	100,0%	76,9%	96,0%	93,8%	58,9%	89,2%	95,9%	73,8%
	1,00	Count	52	0	0	69	47	0	6	1	2	81	4	3	265
		% within purch_DUMMY	19,6%	,0%	,0%	26,0%	17,7%	,0%	2,3%	,4%	,8%	30,6%	1,5%	1,1%	100,0%
		% within Cluster Number of Case	29,7%	,0%	,0%	36,1%	51,6%	,0%	23,1%	4,0%	6,3%	41,1%	10,8%	4,1%	26,2%
Total		Count	175	93	31	191	91	39	26	25	32	197	37	73	1010
		% within purch_DUMMY	17,3%	9,2%	3,1%	18,9%	9,0%	3,9%	2,6%	2,5%	3,2%	19,5%	3,7%	7,2%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

4. Table: Contingency table for cluster membership and credit line

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
HITELKERET_DUMMY	,00	Count	234	93	14	80	52	14	5	11	19	13	14	39	588
		% within CRLINE_DUMMY	39,8%	15,8%	2,4%	13,6%	8,8%	2,4%	,9%	1,9%	3,2%	2,2%	2,4%	6,6%	100,0%
		% within Cluster Number of Case	70,3%	100,0%	45,2%	30,3%	40,3%	35,9%	19,2%	44,0%	59,4%	6,3%	37,8%	53,4%	45,6%
	1,00	Count	99	0	17	184	77	25	21	14	13	194	23	34	701
		% within CRLINE_DUMMY	14,1%	,0%	2,4%	26,2%	11,0%	3,6%	3,0%	2,0%	1,9%	27,7%	3,3%	4,9%	100,0%
		% within Cluster Number of Case	29,7%	,0%	54,8%	69,7%	59,7%	64,1%	80,8%	56,0%	40,6%	93,7%	62,2%	46,6%	54,4%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within CRLINE_DUMMY	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

5. Table: Contingency table for cluster membership and exceeding of credit line

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
EXCCRLINE_DUMMY	,00	Count	249	0	16	174	71	23	19	12	11	176	17	27	795
		% within EXCCRLINE_DUMMY	31,3%	,0%	2,0%	21,9%	8,9%	2,9%	2,4%	1,5%	1,4%	22,1%	2,1%	3,4%	100,0%
		% within Cluster Number of Case	74,8%	,0%	51,6%	65,9%	55,0%	59,0%	73,1%	48,0%	34,4%	85,0%	45,9%	37,0%	61,7%
	1,00	Count	84	93	15	90	58	16	7	13	21	31	20	46	494
		% within EXCCRLINE_DUMMY	17,0%	18,8%	3,0%	18,2%	11,7%	3,2%	1,4%	2,6%	4,3%	6,3%	4,0%	9,3%	100,0%
		% within Cluster Number of Case	25,2%	100,0%	48,4%	34,1%	45,0%	41,0%	26,9%	52,0%	65,6%	15,0%	54,1%	63,0%	38,3%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within EXCCRLINE_DUMMY	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

6. Table: Contingency table for cluster membership and track record of the owner and the manager

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
Own_&_Man_dummy	,00	Count	285	63	25	235	109	28	21	21	27	181	26	43	1064
		% within Own_&_Man_dummy	26,8%	5,9%	2,3%	22,1%	10,2%	2,6%	2,0%	2,0%	2,5%	17,0%	2,4%	4,0%	100,0%
		% within Cluster Number of Case	85,6%	67,7%	80,6%	89,0%	84,5%	71,8%	80,8%	84,0%	84,4%	87,4%	70,3%	58,9%	82,5%
	1,00	Count	48	30	6	29	20	11	5	4	5	26	11	30	225
		% within Own_&_Man_dummy	21,3%	13,3%	2,7%	12,9%	8,9%	4,9%	2,2%	1,8%	2,2%	11,6%	4,9%	13,3%	100,0%
		% within Cluster Number of Case	14,4%	32,3%	19,4%	11,0%	15,5%	28,2%	19,2%	16,0%	15,6%	12,6%	29,7%	41,1%	17,5%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within Own_&_Man_dummy	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

7. Table: Contingency table for cluster membership and company history

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
comphist_dummy	,00	Count	240	38	20	230	103	29	16	18	19	177	25	39	954
		% within comphist_dummy	25,2%	4,0%	2,1%	24,1%	10,8%	3,0%	1,7%	1,9%	2,0%	18,6%	2,6%	4,1%	100,0%
		% within Cluster Number of Case	72,1%	40,9%	64,5%	87,1%	79,8%	74,4%	61,5%	72,0%	59,4%	85,5%	67,6%	53,4%	74,0%
	1,00	Count	93	55	11	34	26	10	10	7	13	30	12	34	335
		% within comphist_dummy	27,8%	16,4%	3,3%	10,1%	7,8%	3,0%	3,0%	2,1%	3,9%	9,0%	3,6%	10,1%	100,0%
		% within Cluster Number of Case	27,9%	59,1%	35,5%	12,9%	20,2%	25,6%	38,5%	28,0%	40,6%	14,5%	32,4%	46,6%	26,0%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within comphist_dummy	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

8. Table: Contingency table for cluster membership and company and personal track record

Crosstab

			Cluster Number of Case												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
COMP_PERS	,00	Count	212	30	18	206	86	20	13	14	17	159	19	26	820
		% within COMP_PERS	25,9%	3,7%	2,2%	25,1%	10,5%	2,4%	1,6%	1,7%	2,1%	19,4%	2,3%	3,2%	100,0%
		% within Cluster Number of Case	63,7%	32,3%	58,1%	78,0%	66,7%	51,3%	50,0%	56,0%	53,1%	76,8%	51,4%	35,6%	63,6%
	1,00	Count	101	41	9	53	40	17	11	11	12	40	13	30	378
		% within COMP_PERS	26,7%	10,8%	2,4%	14,0%	10,6%	4,5%	2,9%	2,9%	3,2%	10,6%	3,4%	7,9%	100,0%
		% within Cluster Number of Case	30,3%	44,1%	29,0%	20,1%	31,0%	43,6%	42,3%	44,0%	37,5%	19,3%	35,1%	41,1%	29,3%
	2,00	Count	20	22	4	5	3	2	2	0	3	8	5	17	91
		% within COMP_PERS	22,0%	24,2%	4,4%	5,5%	3,3%	2,2%	2,2%	,0%	3,3%	8,8%	5,5%	18,7%	100,0%
		% within Cluster Number of Case	6,0%	23,7%	12,9%	1,9%	2,3%	5,1%	7,7%	,0%	9,4%	3,9%	13,5%	23,3%	7,1%
Total		Count	333	93	31	264	129	39	26	25	32	207	37	73	1289
		% within COMP_PERS	25,8%	7,2%	2,4%	20,5%	10,0%	3,0%	2,0%	1,9%	2,5%	16,1%	2,9%	5,7%	100,0%
		% within Cluster Number of Case	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

2. The contingency tables of Subsample I.

9. Table: Contingency table for gender and variable BAD

Crosstab

			BAD			Total
			,00	1,00	2,00	
GENDER	1,00	Count	139	28	27	194
		% within GENDER	71,6%	14,4%	13,9%	100,0%
		% within BAD	86,9%	87,5%	87,1%	87,0%
	2,00	Count	21	4	4	29
		% within GENDER	72,4%	13,8%	13,8%	100,0%
		% within BAD	13,1%	12,5%	12,9%	13,0%
Total		Count	160	32	31	223
		% within GENDER	71,7%	14,3%	13,9%	100,0%
		% within BAD	100,0%	100,0%	100,0%	100,0%

10. Table: Contingency table for gender and DEF90

Crosstab

			DEF90		Total
			,00	1,00	
GENDER	1,00	Count	139	55	194
		% within GENDER	71,6%	28,4%	100,0%
		% within DEF90	86,9%	87,3%	87,0%
	2,00	Count	21	8	29
		% within GENDER	72,4%	27,6%	100,0%
		% within DEF90	13,1%	12,7%	13,0%
Total		Count	160	63	223
		% within GENDER	71,7%	28,3%	100,0%
		% within DEF90	100,0%	100,0%	100,0%

11. Table: Contingency table for GENDER and DEF120

Crosstab

			DEF120		
			,00	1,00	Total
GENDER	1,00	Count	142	52	194
		% within GENDER	73,2%	26,8%	100,0%
		% within DEF120	87,1%	86,7%	87,0%
	2,00	Count	21	8	29
		% within GENDER	72,4%	27,6%	100,0%
		% within DEF120	12,9%	13,3%	13,0%
Total		Count	163	60	223
		% within GENDER	73,1%	26,9%	100,0%
		% within DEF120	100,0%	100,0%	100,0%

12. Table: Contingency table for company history and variable BAD

Crosstab

			BAD			
			,00	1,00	2,00	Total
comphist_dummy	,00	Count	121	25	14	160
		% within comphist_dummy	75,6%	15,6%	8,8%	100,0%
		% within BAD	75,2%	78,1%	45,2%	71,4%
	1,00	Count	40	7	17	64
		% within comphist_dummy	62,5%	10,9%	26,6%	100,0%
		% within BAD	24,8%	21,9%	54,8%	28,6%
Total		Count	161	32	31	224
		% within comphist_dummy	71,9%	14,3%	13,8%	100,0%
		% within BAD	100,0%	100,0%	100,0%	100,0%

13. Table: Contingency table for company history and DEF90

Crosstab

			DEF90		
			,00	1,00	Total
comphist_dummy	,00	Count	121	39	160
		% within comphist_dummy	75,6%	24,4%	100,0%
		% within DEF90	75,2%	61,9%	71,4%
	1,00	Count	40	24	64
		% within comphist_dummy	62,5%	37,5%	100,0%
		% within DEF90	24,8%	38,1%	28,6%
Total		Count	161	63	224
		% within comphist_dummy	71,9%	28,1%	100,0%
		% within DEF90	100,0%	100,0%	100,0%

14. Table: Contingency table for company history and DEF120

Crosstab

			DEF120		
			,00	1,00	Total
comphist_dummy	,00	Count	123	37	160
		% within comphist_dummy	76,9%	23,1%	100,0%
		% within DEF120	75,0%	61,7%	71,4%
	1,00	Count	41	23	64
		% within comphist_dummy	64,1%	35,9%	100,0%
		% within DEF120	25,0%	38,3%	28,6%
Total		Count	164	60	224
		% within comphist_dummy	73,2%	26,8%	100,0%
		% within DEF120	100,0%	100,0%	100,0%

15. Table: Contingency table for exceeding of credit line and variable BAD

Crosstab

			BAD			Total
			,00	1,00	2,00	
EXCCRLINE_ DUMMY	,00	Count	107	13	0	120
		% within EXCCRLINE_ DUMMY	89,2%	10,8%	,0%	100,0%
		% within BAD	66,5%	40,6%	,0%	53,6%
	1,00	Count	54	19	31	104
		% within EXCCRLINE_ DUMMY	51,9%	18,3%	29,8%	100,0%
		% within BAD	33,5%	59,4%	100,0%	46,4%
Total		Count	161	32	31	224
		% within EXCCRLINE_ DUMMY	71,9%	14,3%	13,8%	100,0%
		% within BAD	100,0%	100,0%	100,0%	100,0%

16. Table: Contingency table for exceeding of credit line and variable DEF90

Crosstab

			DEF90		Total
			,00	1,00	
EXCCRLINE_ DUMMY	,00	Count	107	13	120
		% within EXCCRLINE_ DUMMY	89,2%	10,8%	100,0%
		% within DEF90	66,5%	20,6%	53,6%
	1,00	Count	54	50	104
		% within EXCCRLINE_ DUMMY	51,9%	48,1%	100,0%
		% within DEF90	33,5%	79,4%	46,4%
Total		Count	161	63	224
		% within EXCCRLINE_ DUMMY	71,9%	28,1%	100,0%
		% within DEF90	100,0%	100,0%	100,0%

17. Table: Contingency table for exceeding of credit line and variable DEF120

Crosstab

			DEF120		
			,00	1,00	Total
EXCCRLINE_ DUMMY	,00	Count	108	12	120
		% within EXCCRLINE_ DUMMY	90,0%	10,0%	100,0%
		% within DEF120	65,9%	20,0%	53,6%
	1,00	Count	56	48	104
		% within EXCCRLINE_ DUMMY	53,8%	46,2%	100,0%
		% within DEF120	34,1%	80,0%	46,4%
Total		Count	164	60	224
		% within EXCCRLINE_ DUMMY	73,2%	26,8%	100,0%
		% within DEF120	100,0%	100,0%	100,0%

18. Table: Contingency table for repayment and variable BAD

Crosstab

			BAD			
			,00	1,00	2,00	Total
REPAY	,00	Count	79	30	29	138
		% within REPAY	57,2%	21,7%	21,0%	100,0%
		% within BAD	72,5%	93,8%	93,5%	80,2%
	1,00	Count	25	2	2	29
		% within REPAY	86,2%	6,9%	6,9%	100,0%
		% within BAD	22,9%	6,3%	6,5%	16,9%
	2,00	Count	5	0	0	5
		% within REPAY	100,0%	,0%	,0%	100,0%
		% within BAD	4,6%	,0%	,0%	2,9%
Total		Count	109	32	31	172
		% within REPAY	63,4%	18,6%	18,0%	100,0%
		% within BAD	100,0%	100,0%	100,0%	100,0%

19. Table: Contingency table for repayment and variable DEF90

Crosstab

			DEF90		Total
			,00	1,00	
REPAY	,00	Count	79	59	138
		% within REPAY	57,2%	42,8%	100,0%
		% within DEF90	72,5%	93,7%	80,2%
	1,00	Count	25	4	29
		% within REPAY	86,2%	13,8%	100,0%
		% within DEF90	22,9%	6,3%	16,9%
	2,00	Count	5	0	5
		% within REPAY	100,0%	,0%	100,0%
		% within DEF90	4,6%	,0%	2,9%
Total		Count	109	63	172
		% within REPAY	63,4%	36,6%	100,0%
		% within DEF90	100,0%	100,0%	100,0%

20. Table: Contingency table for repayment and variable DEF120

Crosstab

			DEF120		Total
			,00	1,00	
REPAY	,00	Count	82	56	138
		% within REPAY	59,4%	40,6%	100,0%
		% within DEF120	73,2%	93,3%	80,2%
	1,00	Count	25	4	29
		% within REPAY	86,2%	13,8%	100,0%
		% within DEF120	22,3%	6,7%	16,9%
	2,00	Count	5	0	5
		% within REPAY	100,0%	,0%	100,0%
		% within DEF120	4,5%	,0%	2,9%
Total		Count	112	60	172
		% within REPAY	65,1%	34,9%	100,0%
		% within DEF120	100,0%	100,0%	100,0%

3. Outputs of LOGIT models on Subsample II

21. Table: Goodness-of-fit indices for model MULTIVAR_BEHAV_015

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	502,619(a)	,072	,123
2	472,797(a)	,115	,197
3	462,050(a)	,130	,223
4	451,661(b)	,145	,247
5	444,086(b)	,155	,265
6	439,171(b)	,162	,276
7	433,144(b)	,170	,290
8	429,552(b)	,175	,298

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.
b Estimation terminated at iteration number 6 because parameter estimates changed by less than ,001.

22. Table: The AUC values of model MULTIVAR_BEHAV_015 at different cutoff values on the training sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MULTIVAR_BEHAV_01	,703	,027	,000	,651	,755
MULTIVAR_BEHAV_015	,751	,027	,000	,698	,803
MULTIVAR_BEHAV_02	,737	,029	,000	,680	,794
MULTIVAR_BEHAV_03	,692	,033	,000	,628	,756
MULTIVAR_BEHAV_04	,632	,034	,000	,565	,699
MULTIVAR_BEHAV_05	,618	,034	,000	,551	,685
MULTIVAR_BEHAV_06	,586	,034	,006	,520	,653
MULTIVAR_BEHAV_07	,557	,033	,070	,492	,623
MULTIVAR_BEHAV_08	,547	,033	,135	,482	,612
MULTIVAR_BEHAV_09	,518	,032	,566	,455	,581

a Under the nonparametric assumption
b Null hypothesis: true area = 0.5

23. Table: The AUC values of model MULTIVAR_BEHAV_015 at different cutoff values on the holdout sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MULTIVAR_BEHAV_01	,680	,043	,000	,597	,764
MULTIVAR_BEHAV_015	,683	,046	,000	,593	,774
MULTIVAR_BEHAV_02	,688	,047	,000	,595	,780
MULTIVAR_BEHAV_03	,621	,051	,014	,521	,721
MULTIVAR_BEHAV_04	,609	,052	,027	,507	,711
MULTIVAR_BEHAV_05	,579	,052	,109	,477	,681
MULTIVAR_BEHAV_06	,559	,052	,229	,458	,660
MULTIVAR_BEHAV_07	,536	,051	,460	,437	,636
MULTIVAR_BEHAV_08	,531	,051	,527	,432	,630
MULTIVAR_BEHAV_09	,523	,050	,644	,424	,621

a Under the nonparametric assumption
b Null hypothesis: true area = 0.5

24. Table: Goodness-of-fit indices for model BEHAV_015

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	502,803(a)	,072	,123
2	486,494(a)	,096	,164
3	473,590(a)	,114	,196
4	468,116(a)	,122	,209
5	460,938(a)	,132	,226
6	457,414(a)	,137	,234

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

25. Table: The AUC values of model BEHAV_015 at different cutoff values on the training sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BEHAV_01	,669	,028	,000	,614	,724
BEHAV_015	,703	,029	,000	,647	,760
BEHAV_02	,695	,029	,000	,638	,753
BEHAV_03	,665	,033	,000	,599	,730
BEHAV_04	,614	,034	,000	,547	,681
BEHAV_05	,592	,034	,003	,525	,659
BEHAV_06	,559	,033	,061	,493	,625
BEHAV_07	,544	,033	,162	,479	,609
BEHAV_08	,514	,032	,656	,451	,577
BEHAV_09	,505	,032	,874	,443	,567

The test result variable(s): BEHAV_01, BEHAV_015, BEHAV_02, BEHAV_03, BEHAV_04, BEHAV_05, BEHAV_06, BEHAV_07, BEHAV_08, BEHAV_09 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

b Null hypothesis: true area = 0.5

26. Table: The AUC values of model BEHAV_015 at different cutoff values on the holdout sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BEHAV_01	,688	,044	,000	,603	,774
BEHAV_015	,693	,047	,000	,602	,785
BEHAV_02	,682	,047	,000	,589	,774
BEHAV_03	,647	,051	,003	,547	,748
BEHAV_04	,607	,052	,030	,504	,709
BEHAV_05	,604	,052	,033	,502	,707
BEHAV_06	,562	,052	,206	,461	,663
BEHAV_07	,531	,051	,527	,432	,630
BEHAV_08	,520	,050	,689	,421	,618
BEHAV_09	,511	,050	,817	,414	,609

The test result variable(s): BEHAV_01, BEHAV_015, BEHAV_02, BEHAV_03, BEHAV_04, BEHAV_05, BEHAV_06, BEHAV_07, BEHAV_08, BEHAV_09 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

b Null hypothesis: true area = 0.5

27. Table: Goodness-of-fit indices for model PCA_NEW_015

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	519,311(a)	,047	,080
2	509,621(a)	,062	,105
3	501,529(a)	,074	,126
4	496,432(a)	,081	,139
5	491,576(a)	,088	,151
6	487,537(a)	,094	,161
7	489,223(a)	,092	,157

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

28. Table: The AUC values of model PCA_NEW_015 at different cutoff values on the training sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Pca_new_01	,620	,028	,000	,565	,674
Pca_new_02	,640	,033	,000	,576	,704
Pca_new_03	,565	,033	,039	,500	,631
Pca_new_04	,570	,034	,025	,505	,636
Pca_new_05	,562	,033	,048	,497	,628
Pca_new_06	,545	,033	,151	,480	,610
Pca_new_07	,533	,033	,294	,469	,597
Pca_new_08	,523	,032	,464	,460	,587
Pca_new_09	,519	,032	,546	,456	,582
Pca_new_015	,660	,030	,000	,601	,719

The test result variable(s): Pca_new_01, Pca_new_02, Pca_new_03, Pca_new_04, Pca_new_05, Pca_new_06, Pca_new_07, Pca_new_08, Pca_new_09, Pca_new_015 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

b Null hypothesis: true area = 0.5

29. Table: The AUC values of model PCA_NEW_015 at different cutoff values on the holdout sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Pca_new_01	,596	,045	,052	,508	,684
Pca_new_02	,614	,050	,020	,517	,712
Pca_new_03	,563	,051	,202	,462	,663
Pca_new_04	,553	,051	,281	,452	,653
Pca_new_05	,530	,051	,539	,431	,629
Pca_new_06	,533	,051	,498	,434	,633
Pca_new_07	,517	,050	,735	,419	,615
Pca_new_08	,520	,050	,689	,421	,618
Pca_new_09	,511	,050	,817	,414	,609
Pca_new_015	,663	,046	,001	,574	,753

The test result variable(s): Pca_new_01, Pca_new_02, Pca_new_03, Pca_new_04, Pca_new_05, Pca_new_06, Pca_new_07, Pca_new_08, Pca_new_09, Pca_new_015 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

b Null hypothesis: true area = 0.5

30. Table: Goodness-of-fit indices for model PCA_BEHAV_015

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	502,619(a)	,072	,123
2	488,357(a)	,093	,159
3	468,173(a)	,122	,208
4	459,435(a)	,134	,229
5	453,209(b)	,143	,244
6	448,510(b)	,149	,255
7	441,029(b)	,159	,272

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

b Estimation terminated at iteration number 6 because parameter estimates changed by less than ,001.

31. Table: The AUC values of model PCA_BEHAV_015 at different cutoff values on the training sample

Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Pca_behav_01	,712	,026	,000	,662	,762
Pca_behav_015	,713	,028	,000	,658	,769
Pca_behav_02	,713	,030	,000	,653	,772
Pca_behav_03	,679	,033	,000	,615	,744
Pca_behav_04	,622	,034	,000	,556	,689
Pca_behav_05	,585	,034	,007	,519	,652
Pca_behav_06	,567	,034	,033	,501	,633
Pca_behav_07	,553	,033	,092	,488	,618
Pca_behav_08	,538	,033	,227	,474	,603
Pca_behav_09	,524	,032	,446	,460	,588

The test result variable(s): pca_behav_01, pca_behav_015, pca_behav_02, pca_behav_03, pca_behav_04, pca_behav_05, pca_behav_06, pca_behav_07, pca_behav_08, pca_behav_09 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

b Null hypothesis: true area = 0.5

32. Table: The AUC values of model PCA_BEHAV_015 at different cutoff values on the holdout sample

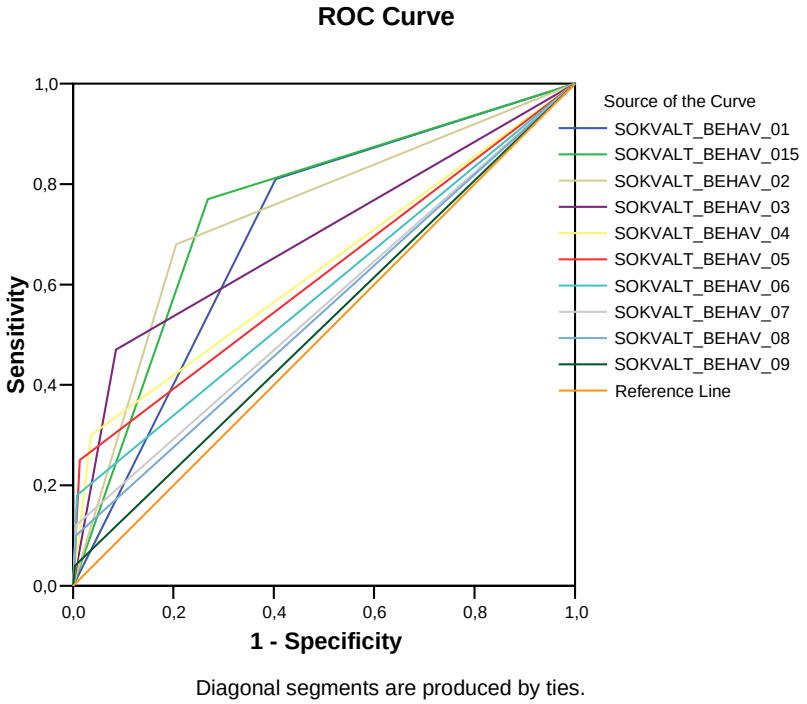
Area Under the Curve

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Pca_behav_01	,668	,045	,001	,580	,755
Pca_behav_015	,707	,045	,000	,618	,796
pca_behav_02	,693	,048	,000	,598	,787
pca_behav_03	,673	,051	,000	,574	,773
pca_behav_04	,646	,052	,003	,544	,748
pca_behav_05	,598	,052	,045	,496	,701
pca_behav_06	,573	,052	,135	,472	,675
pca_behav_07	,531	,051	,527	,432	,630
pca_behav_08	,531	,051	,527	,432	,630
pca_behav_09	,520	,050	,689	,421	,618

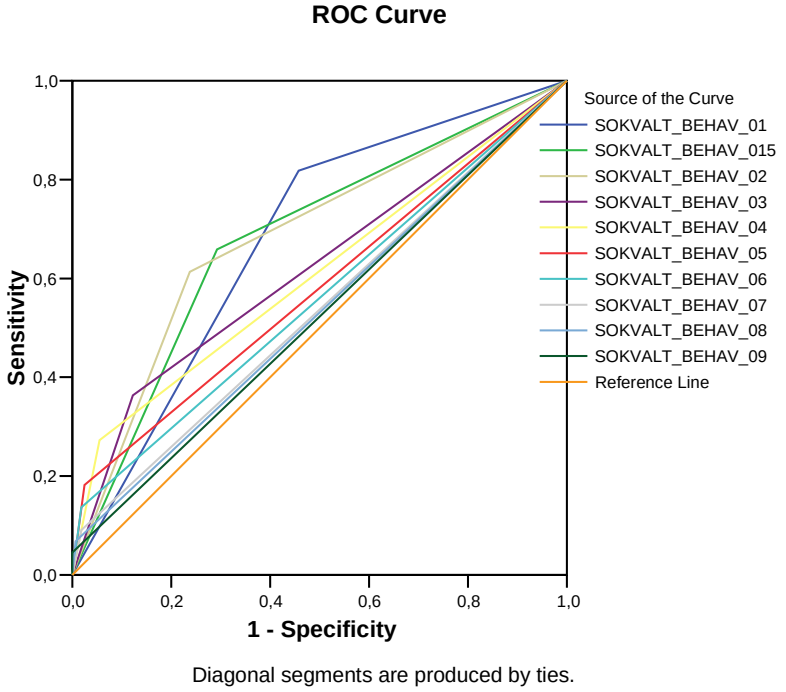
The test result variable(s): pca_behav_01, pca_behav_015, pca_behav_02, pca_behav_03, pca_behav_04, pca_behav_05, pca_behav_06, pca_behav_07, pca_behav_08, pca_behav_09 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a Under the nonparametric assumption

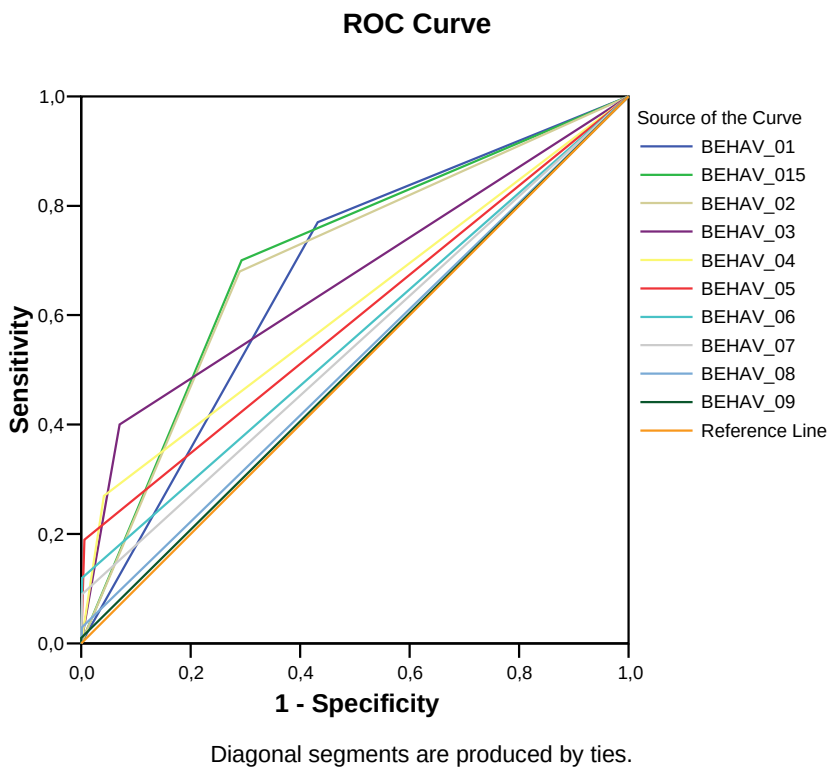
b Null hypothesis: true area = 0.5



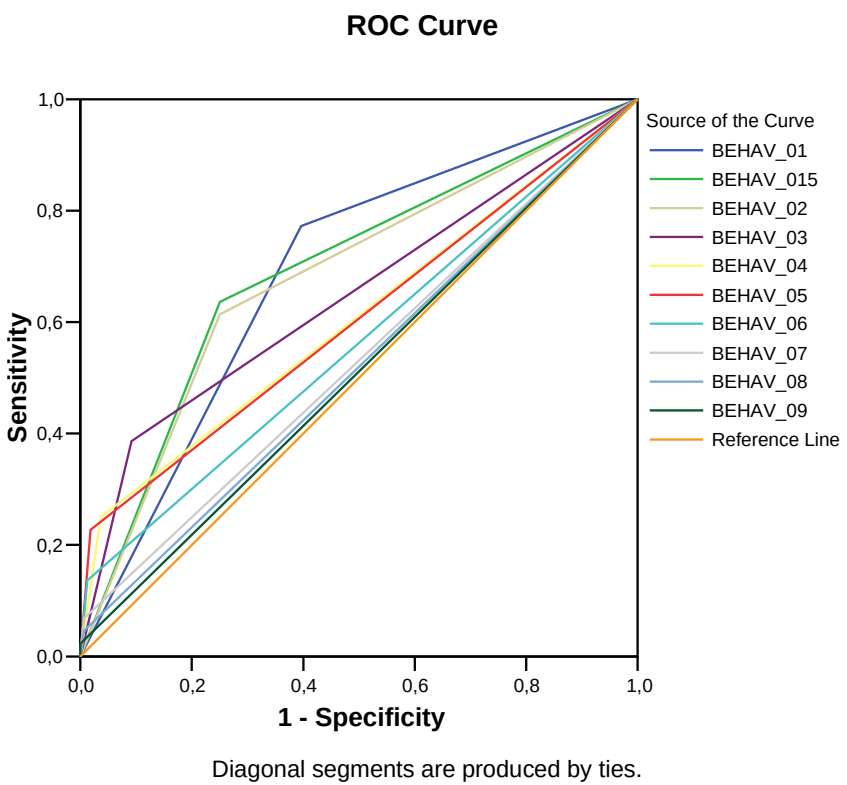
1. ábra: The ROC curves of model MULTIVAR_BEHAV_015 at different cutoff values on the training sample
Source: SPSS



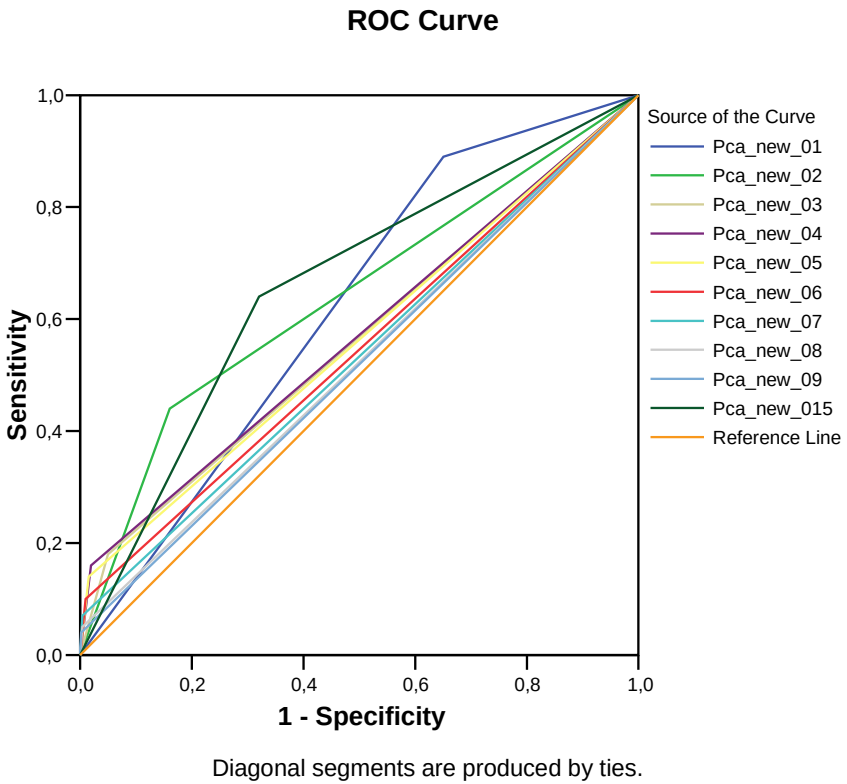
2. ábra: The ROC curves of model MULTIVAR_BEHAV_015 at different cutoff values on the holdout sample
Source: SPSS



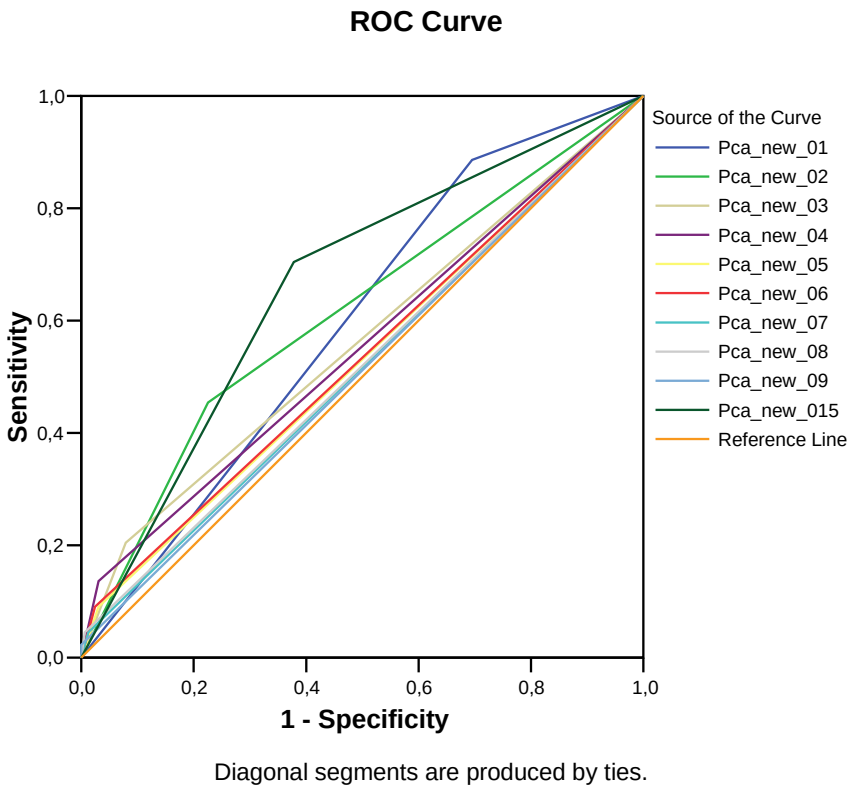
3. ábra: The ROC curves of model BEHAV_015 at different cutoff values on the training sample
Source: SPSS



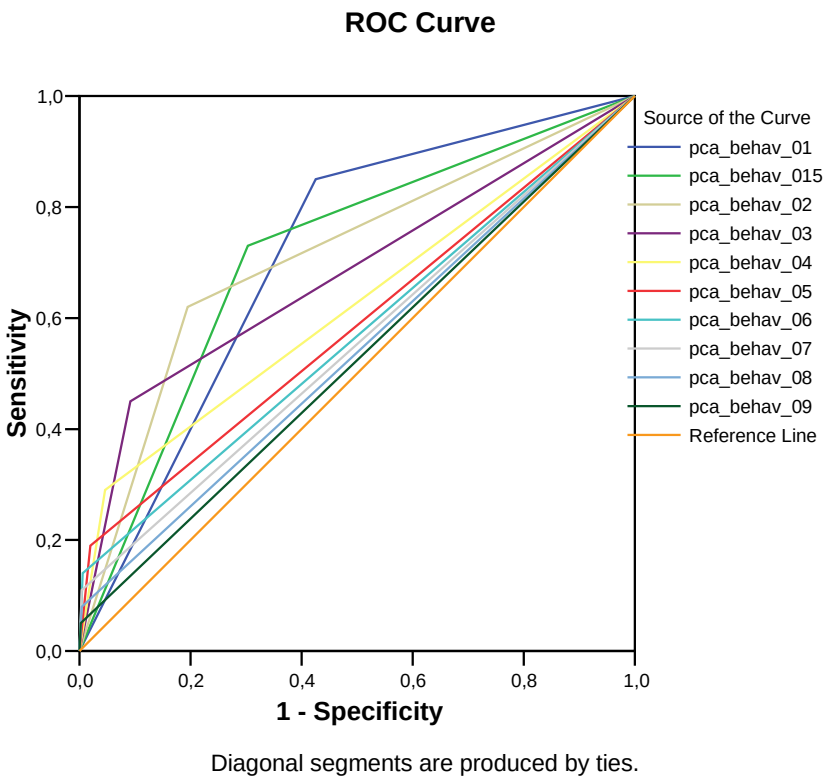
4. ábra: The ROC curves of model BEHAV_015 at different cutoff values on the holdout sample
Source: SPSS



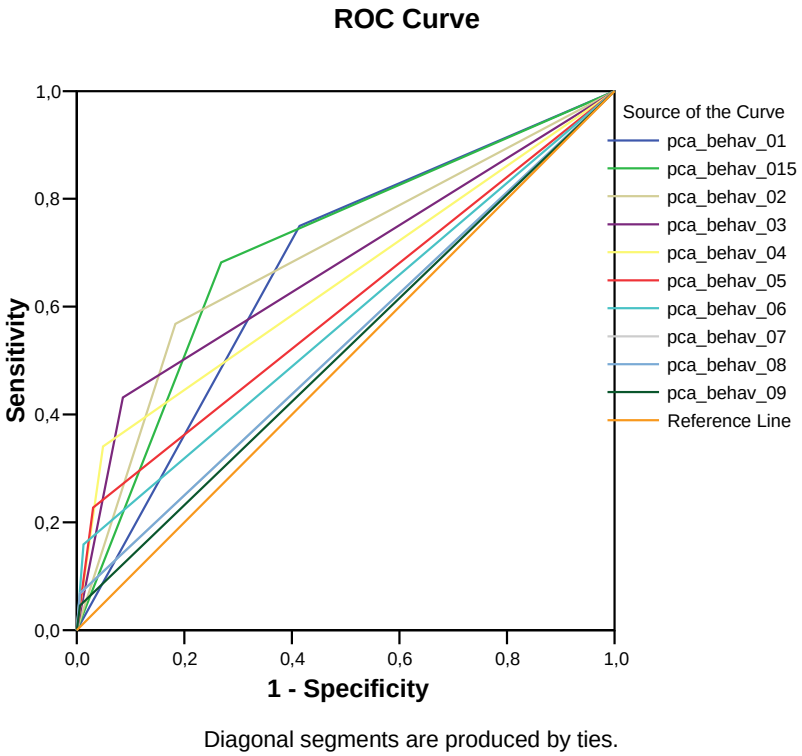
5. ábra: The ROC curves of model PCA_NEW_015 at different cutoff values on the training sample
Source: SPSS



6. ábra: The ROC curves of model PCA_NEW_015 at different cutoff values on the holdout sample
Source: SPSS



7. ábra: The ROC curves of model PCA_BEHAV_015 at different cutoff values on the training sample
Source: SPSS



8. ábra: The ROC curves of model PCA_BEHAV_015 at different cutoff values on the holdout sample
Source: SPSS

33. Table: Rotated Component Matrix of PCA

Rotated Component Matrix(a)

	Component									
	1	2	3	4	5	6	7	8	9	10
Liab/(Liab+Equ)	-,647	,022	,024	-,057	,025	-,365	,577	,087	,121	,189
EBT/NSALES08	,059	,974	-,016	,004	-,164	,008	,007	,055	,015	,010
EBT/ASSET08	,952	,053	,006	-,021	-,011	,017	-,037	,088	,027	,055
EBIT/ASSET08	,937	,055	,003	-,025	-,012	-,003	-,003	,096	,038	,072
EBITDA/SALES08	,038	,981	,035	-,016	,041	-,004	,029	,038	,022	-,016
EBIT/SALES08	,033	,984	,033	-,035	-,003	-,005	,028	,035	,030	-,012
ROE08	,067	-,010	,111	,001	-,005	,028	-,111	,851	-,106	-,021
CA/CL08	,010	,003	,001	,954	,005	,229	,034	-,002	-,016	-,031
CA_Equ08	,020	,005	,957	-,001	,043	-,005	,006	,002	-,001	,064
LIAB/(EBITDA+INCFIN)08	,006	,033	-,023	,005	,827	,022	-,031	-,016	-,046	,038
LIAB/EBITDA08	,005	-,003	,005	,005	,895	-,026	-,011	-,009	,003	,006
CL_SALES08	,017	-,311	,205	-,009	,592	-,019	,103	,050	,081	-,095
CA/ASSET08	-,036	,036	,077	,036	,014	,004	-,054	,087	,875	,117
TREC/LIAB08	,000	,003	-,007	,962	-,008	,133	-,078	,007	,005	-,014
OE/FASSET08	,105	,015	-,002	-,040	,006	,221	-,089	-,227	,404	-,099
SALES/ASSETS08	-,505	,047	,003	-,035	-,052	,034	-,061	,123	,232	,413
SALES/NWC08	,042	-,007	,041	,009	-,015	-,016	,064	-,003	,136	,291
SALES/EBIT08	-,011	,000	,029	,002	-,026	-,083	,081	,055	,188	-,802
ROA*08	,950	,054	,006	-,026	-,013	,003	-,023	,087	,019	,057
PROFORD/OE08	,048	,090	-,328	-,006	,018	-,004	,092	,747	,105	-,024
NWC/ASSETS08	,654	,013	,072	,076	-,010	,385	-,254	-,076	,315	-,145
QUICKR08	,011	,001	-,005	,151	,001	,871	,145	,019	-,035	-,023
LTD/OE08	,024	,008	,590	,007	,044	,000	,164	-,061	,158	-,148
TREC/OE08	,019	,006	,983	-,001	,035	-,014	,006	-,044	,027	,021
LTD/(Liab+Equ)	,085	,028	,058	,006	,011	,217	,817	-,074	-,213	-,070

TREC/(Liab+Equ)	-,642	,023	,023	-,057	,024	-,365	,580	,097	,122	,189
CASH/ASSETS08	,024	-,038	-,026	-,070	-,020	,600	-,067	,027	,372	,209
CL08/OE08	,007	,004	,899	-,004	,007	-,002	-,099	-,027	-,083	,121
CASH/SALES08	,035	-,971	,023	-,007	,045	,025	,020	,045	,008	-,011
fcff/assets	-,709	,041	-,051	-,080	-,068	,167	-,242	,032	-,030	-,108
FCFF_D	-,057	,045	-,007	-,906	-,008	,256	-,028	,005	-,011	-,049

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 9 iterations.

34. Table: Component score coefficient matrix of PCA

Component Score Coefficient Matrix

	Component									
	1	2	3	4	5	6	7	8	9	10
Liab/(Liab+Equ)	-,068	-,001	-,002	,004	-,006	-,130	,311	,038	,134	,099
EBT/NSALES08	,003	,243	,002	,008	-,045	,006	,002	,015	-,004	,000
EBT/ASSET08	,223	-,001	-,008	-,014	-,011	-,055	,059	,039	,020	,092
EBIT/ASSET08	,225	-,002	-,010	-,015	-,013	-,064	,079	,042	,031	,105
EBITDA/SALES08	-,003	,254	,011	,001	,064	,004	,008	,004	,001	-,025
EBIT/SALES08	-,003	,253	,011	-,006	,041	,003	,008	,001	,007	-,022
ROE08	-,019	-,020	,089	-,002	-,009	,053	-,093	,624	-,113	-,046
CA/CL08	-,020	,009	,002	,345	,003	,097	,042	,011	-,020	-,012
CA_Equ08	-,006	,002	,302	-,001	-,010	,010	-,016	,052	-,030	,035
LIAB/(EBITDA+INCFIN)08	-,009	,048	-,037	-,001	,457	,029	-,051	-,019	-,049	,051
LIAB/EBITDA08	-,006	,041	-,031	,001	,488	-,003	-,040	-,015	-,005	,016
CL_SALES08	,005	-,057	,045	-,007	,295	-,001	,059	,049	,067	-,093
CA/ASSET08	-,001	-,005	,005	,025	,000	-,082	,003	,037	,628	,036
TREC/LIAB08	-,024	,009	,000	,354	-,002	,026	-,044	,014	-,002	,001
OE/FASSET08	,007	,005	-,019	-,023	,006	,070	-,003	-,161	,285	-,096
SALES/ASSETS08	-,107	,008	,002	-,004	-,017	,045	-,084	,077	,123	,326

SALES/NWC08	,033	-,008	,000	,008	-,011	-,014	,047	-,020	,084	,252
SALES/EBIT08	-,029	-,001	,027	,000	-,031	-,081	,080	,067	,208	-,747
ROA*08	,225	-,001	-,008	-,016	-,013	-,062	,067	,038	,016	,094
PROFORD/OE08	,007	,003	-,067	,000	,015	,023	,064	,511	,070	-,056
NWC/ASSETS08	,103	-,001	,014	,007	-,003	,129	-,062	-,045	,198	-,102
QUICKR08	-,048	,004	,008	,011	,010	,550	,177	,053	-,103	,002
LTD/OE08	,007	,001	,180	,001	-,005	-,002	,118	-,012	,123	-,161
TREC/OE08	-,006	,003	,308	-,001	-,016	-,002	-,013	,021	-,005	-,006
LTD/(Liab+Equ)	,073	,001	,007	-,015	-,017	,218	,585	-,050	-,125	-,058
TREC/(Liab+Equ)	-,067	-,002	-,002	,004	-,006	-,130	,313	,045	,134	,099
CASH/ASSETS08	-,026	-,015	-,013	-,051	-,001	,337	,026	,027	,195	,179
CL08/OE08	-,015	,004	,286	-,002	-,022	,011	-,093	,031	-,099	,096
CASH/SALES08	,019	-,252	,008	-,011	-,022	,011	,032	,056	,019	-,004
fcff/assets	-,207	,021	,008	-,033	-,017	,137	-,214	,054	-,054	-,122
FCFF_D	-,030	,008	,005	-,352	,005	,208	,000	,017	-,044	-,048

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

35. Table: Classification table of model MULTIVAR_NEW_015

Classification Table(c)

Observed			Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			DEF90		Percentage Correct	DEF90		Percentage Correct
			,00	1,00		,00	1,00	
Step 6	DEF90	,00	357	167	68,1	97	67	59,1
		1,00	31	69	69,0	18	26	59,1
	Overall Percentage				68,3			59,1

a Selected cases minta EQ 1
b Unselected cases minta NE 1
c The cut value is ,150

36. Table: Classification table of model MULTIVAR_BEHAV_015

Classification Table(c)

Observed			Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			DEF90		Percentage Correct	DEF90		Percentage Correct
			,00	1,00		,00	1,00	
Step 8	DEF90	,00	381	143	72,71	114	50	69,51
		1,00	24	76	76,0	16	28	63,64
	Overall Percentage				73,24			68,3

a Selected cases minta EQ 1
b Unselected cases minta NE 1
c The cut value is ,150

37. Table: Classification table of model BEHAV_015

Classification Table(c)

	Observed		Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			DEF90		Percentage Correct	DEF90		Percentage Correct
			,00	1,00		,00	1,00	
Step 6	DEF90	,00	371	154	70,7	123	41	75,0
		1,00	30	70	70,0	16	28	63,6
	Overall Percentage				70,6			72,6

a Selected cases minta EQ 1
b Unselected cases minta NE 1
c The cut value is ,150

38. Table: Classification table of model PCA_NEW_015

Classification Table(c)

	Observed		Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			DEF90		Percentage Correct	DEF90		Percentage Correct
			,00	1,00		,00	1,00	
Step 7	DEF90	,00	356	168	67,9	102	62	62,2
		1,00	36	64	64,0	13	31	70,5
	Overall Percentage				67,3			63,9

a Selected cases minta EQ 1
b Unselected cases minta NE 1
c The cut value is ,150

39. Table: Classification table of model PCA_ BEHAV_015

Classification Table(c)

Observed			Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			DEF90		Percentage Correct	DEF90		Percentage Correct
			,00	1,00		,00	1,00	
Step 7	DEF90	,00	365	159	69,7	120	44	73,2
		1,00	27	73	73,0	14	30	68,2
	Overall Percentage				70,2			72,1

a Selected cases minta EQ 1
b Unselected cases minta NE 1
c The cut value is ,150

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