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**Thünen-Series of Applied Economic Theory**  
**Thünen-Reihe Angewandter Volkswirtschaftstheorie**

Working Paper No. 132

**Does Borrowers' Impatience Disclose their Hidden Information  
about Default Risk?**

by

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# Does Borrowers' Impatience Disclose their Hidden Information about Default Risk?

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## **Abstract**

This chapter provides new evidence on borrowers' hidden information about their riskiness and its link to their impatience. To do so, I analyze consumer loans on the German platform Smava, which has a unique peer-to-peer lending process. Observationally identical but unobservably riskier borrowers offer investors a higher interest rate. This helps them to obtain their loan faster and with a higher probability. Very impatient borrowers who use Smava's instant loan service pay a higher interest rate and have a higher default risk than less impatient borrowers. These findings suggest that borrowers' impatience can be used to screen their riskiness.

Keywords: Asymmetric Information, Financial Intermediation, Consumer loans, Patience

JEL code: G21, D82

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# 1 Introduction

Lenders use contractual variables to reveal their borrowers' privately known riskiness. In recent decades, the literature has identified several screening devices, including loan size (Milde and Riley, 1987), co-signers (Besanko and Thakor, 1987) and collateral (Bester, 1985a). However, the costs incurred by using these devices indicate a need for cheaper instruments.<sup>1</sup>

Among the potential devices to screen borrowers' riskiness, one that has been mainly ignored in the literature thus far is the borrowers' patience. Experimentally soliciting impatient borrowers, Meier and Sprenger (2012) find that these borrowers default more often than more patient ones. However, the authors do not investigate a loan policy designed to screen borrowers' riskiness via their impatience. This raises the question of whether borrowers signal hidden information about their default risk through their impatience.

To answer this question, I analyze the German peer-to-peer platform smava.de, which has a unique lending design. On the platform, loan applicants post a contract offer including their requested loan size and the interest rate they are willing to pay. Based on this offer, investors decide whether and how much to invest in this loan. As soon as the loan application's aggregated supply equals the requested loan size, or after 14 days, applicants obtain their requested loan. Thus, impatient loan applicants can offer a higher interest rate to induce investors to supply their desired loan faster. Further, very impatient loan applicants can make use of Smava's instant loan service. Through this service, Smava proposes an interest rate that is high enough for the applicant to have his loan financed within a few minutes or hours.<sup>2</sup>

This chapter is related to empirical literature on the role of hidden information for loan contract choice. Hidden information is difficult to identify, especially on credit markets (Chiappori and Salanie 2000). To put this into practice, Ausubel (1999) and Agarwal et al. (2010) use market experiments that show that borrowers who accept inferior offers are more likely to default. However, in their analysis, it remains unclear whether interest rate variation causes hidden action or hidden information about default risk drives interest rate.<sup>3</sup> To disentangle hidden information and hidden action, Karlan and Zinman (2009) develop a new market field experiment methodology. Using

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<sup>1</sup>For example, because borrowers do not obtain their desired loan size (Bester, 1985b) or the transfer of collateral incurs a value loss (Chan and Kanatas, 1985).

<sup>2</sup>This information was provided by Smava at the author's request.

<sup>3</sup>Ausubel (1999) only notes that it is unlikely for a small variation in interest rate to cause a significant change in default risk.

this method, they show that a variation in interest rate not only is caused by hidden information but also contributes to hidden action.

With respect to identification of hidden information and hidden action, this chapter is most closely related to Adams et al. (2009). For identification purposes, Adams et al. assume that, conditional on observable information, hidden action depends on size but not directly on interest rate. However, this contradicts Karlan and Zinman's (2009) insights showing that variation in interest rate does also cause hidden action. Thus, my identification assumption is that, conditional on observable information, hidden action only depends on the repayment amount to the extent it increases the default risk via size. From this reasoning, it follows that, if an increase of repayment amount via interest rate residual yields a higher default risk than the same increase of the repayment amount via size, this occurs due to hidden information about default risk.

Another challenge in the literature is to determine whether information is observable or unobservable for investors. Most data sets do not include information collected by loan agents who personally meet loan applicants. On Smava, loan applicants act anonymously from the perspective of investors, who can only observe information provided on the platform. Because I can access the same information as the investors, it is likely that any variation in the interest rate that cannot be explained by observable information exclusively incorporates information that is hidden to investors.

Indeed, the empirical results of this chapter clearly indicate that borrowers' impatience is a key driver for their contract choice and their default risk. A higher repayment amount via size has a weaker effect on default risk than a higher repayment amount via loan rate, conditional on observable information. This strongly suggests that residual loan rate incorporates some hidden information that cannot be explained by hidden action. Highly impatient borrowers who choose Smava's instant loan option pay a higher interest rate and default more often than less impatient borrowers. Moreover, observationally identical but riskier borrowers pay a markup on the interest rate conditional on observable information. As a result, they are more likely to obtain their loans and get them significantly faster. This suggests that impatience always plays an important role. Lenders' observable information affects contract design, as borrowers with an observably higher default risk pay a higher interest rate.

This chapter is organized as follows. Section 2 explains Smava's lending process. Section 3 identifies hidden information about default risk. Section 4 analyzes why borrowers signal hidden information about default risk. Section 5 identifies an alter-

KDF indicator	1	2	3	4	5
KDF ratio	0 to 20 %	20 to 40 %	40 to 60 %	60 to 80 %	80 to 100 %

Table 1: KDF indicator.

native source of hidden information about default risk. Finally, Section 6 concludes the chapter.

## 2 Description of Smava lending process and variables

The observation sample in this study includes all listings posted on Smava, Germany’s peer-to-peer online lending platform, between March 2007 and May 2012. A peer is a private person who is either a borrower or a lender; lending is considered peer-to-peer as a lender directly gives a loan to a borrower. Smava acts only as an intermediary that sets up the lending rules for the peers.

A private person who wants to be a peer on Smava must first verify his or her identity via the postident procedure of the German postal service provider Deutsche Post. Through this identification, Smava collects and verifies information about this private person, including socio-economic variables (name, gender, birthdate, and state of residence in Germany) and risk variables (Schufa rating and KDF indicator). The Schufa rating, which indicates the probability that a private person will default, ranges between A (lowest risk) and M (highest risk).<sup>4</sup> The KDF indicator reflects the private person’s financial burden from the loan. To determine this, Smava calculates the KDF ratio<sup>5</sup> and assigns it to a category between 1 (lowest financial burden) and 4 (highest financial burden), as shown in table 1.<sup>6</sup> In addition, the private person provides his

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<sup>4</sup>The Schufa is a German national credit bureau.

<sup>5</sup>The KDF ratio is calculated in three steps. In the first step, Smava determines monthly payments on all outstanding consumer debts, including loans taken or requested on Smava. In the second step, Smava determines the private person’s personal monthly disposable income. It treats mortgage payments as expenditures and subtracts them from the disposable income. Household savings are not taken into account. Income from other household members can be optionally included who then are liable, too. In the third step, Smava divides the private person’s personal monthly disposable income by his monthly payments on all outstanding consumer debts.

<sup>6</sup>As Smava only publishes the KDF indicator, it provides only a rough estimate of the private person’s personal financial burden. On the platform, the actual income and savings are not observable. Furthermore, nothing is known about the income and wealth of other household members or whether other household members are included in the calculation of the monthly disposable income or not.

or her employment status, which is not verified by Smava.<sup>7</sup>

Smava permits a private person to become a peer only if he or she is at least 18 years old and has a German residence. A peer may be only either a borrower or an investor, but not both. A peer who wants to apply for a loan must have a monthly income of at least EUR 1,000, a KDF ratio not exceeding 67 percent, and a Schufa rating indicating a risk no higher than H.

A private person who becomes a peer does not reveal his or her identity to other market participants. For identification purposes, peers operate under a unique user-name.<sup>8</sup> After the verification process, Smava continuously updates information about the peer.

In the observation sample, 5,902 peers applied for a loan. A peer who applies for a loan posts a contract offer on the platform comprising the requested loan amount, the interest rate, and the desired term of the loan.<sup>9</sup> The loan applicant also chooses the purpose of the loan from a list of 17 options. In addition, he may voluntarily choose to describe the purpose of the loan.

After the listing is posted, investors can review this loan application and evaluate the information provided on Smava's website. In addition, investors take macroeconomic conditions into account. As it is not possible for me to observe what types of external information investors consider, for the purpose of this study I use the average interest rate charged by banks on the consumer loan market in the month of the loan<sup>10</sup> and time fixed effects as a proxy for these conditions.

Based on observable information, each investor can decide whether he wants to contribute to the loan application. If an investor decides to supply a loan, he must place a bid of at least EUR 250 but may not exceed the requested loan amount.<sup>11</sup>

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<sup>7</sup>In addition, the private person can voluntarily provide information about his or her education and family status and may upload a picture. As individuals only sporadically choose to provide this information, however, I have not included it in the analysis. Moreover, I define consumer loans as those raised by blue-collar employees, white-collar employees, public officers or pensioners and investment loans as those raised by businessmen, freelancers or managing partners. After establishing these definitions, I split the sample and compared consumer to investment loans. As these two loan types seem to have a different effect on rate and default risk, and as investment loans were introduced later to the Smava lending platform and thus still constitute a small number of observations, I focus on consumer loans in this study.

<sup>8</sup>Since October 2010, a peer can also comprise two private persons, whereby the second person is the partner who must live in the same household. They are both liable but are treated as one peer. Thus, all information is aggregated, with the exception of the age and gender of the partner, which are suppressed.

<sup>9</sup>The requested loan amount is a multiple of EUR 500 and ranges between EUR 500 and EUR 50,000. The interest rate is a multiple of 0.1 percentage points. The term is either 36 or 60 months.

<sup>10</sup>This information is available from the Deutsche Bundesbank.

<sup>11</sup>The bid must be a multiple of EUR 250; the maximum possible bid is EUR 25,000.

	Fee for borrower		Fee for lender
	36 months	60 months	
March 2007 to February 2009	1 % * size	1 % * size	0 €
February 2009 to May 2010	max (2 % * size, 40 €)	max (2,5 % * size, 40 €)	4 € per bid
June 2010 to May 2012	max (2,5 % * size, 40 €)	max (3,5 % * size, 60 €)	1,35 % * bid size

Table 2: Smava's fee policy.

Due to risk diversification considerations, most investors provide only a small fraction of the amount requested in the application; thus, most loans are financed by many investors together. The application is closed after 14 days or as soon as the aggregated supply equals the requested loan amount. Thus, investors cannot underbid offers from other investors by offering money at a lower interest rate. In contrast, a loan applicant can raise the offered interest rate during the bid period. In this case, all lenders obtain the final rate, which can be higher than the starting rate.

If at least 25 percent of the requested loan amount is supplied, investors are committed by Smava to grant the loan. This occurred for 5,312 applications in the observation sample. If the loan applicant accepts this loan grant, the loan business is legally valid. In total, 4,945 loans were financed. After loans are financed, Smava charges the borrower and lenders a fee. Within my observation period, Smava changed its fee policy several times, as shown in Table 2.

As the exact date of the change of the fee structure is known and changes on average every year, I only control for fee fixed effects rather than year-fixed effects when estimating or controlling for interest rate. After the loan is paid out, the borrower is required to repay installments in monthly annuities.<sup>12</sup> A borrower who wants to repay his loan early is permitted to do so but must compensate his lenders for missed interest payments. Smava records and publishes which installments are repaid on time, repaid early, or not repaid.<sup>13</sup>

<sup>12</sup>As Smava only permits annuity loans, the amount of the monthly installments is the same each month.

<sup>13</sup>A credit is declared as defaulted when the monthly payment is 60 days late.



### 3 Identification of hidden information about default risk

#### 3.1 Empirical strategy

The first goal of this study is to test whether borrowers signal that they have some hidden information about default risk. Even if investors use all available information to evaluate a loan applicant's riskiness, they cannot access as much information as the loan applicant can. Thus, a loan applicant may have some private information about default risk that is hidden from investors. In this case, the applicant's default risk is higher or lower as known to the applicant than as evaluated by investors. This private information about default risk may have an impact on the applicant's contract offer; if so, investors can use the contract offer as a signal to infer hidden information about the applicant's default risk. However, in trying to identify this hidden information, they face two main obstacles, as illustrated in Figure 1.

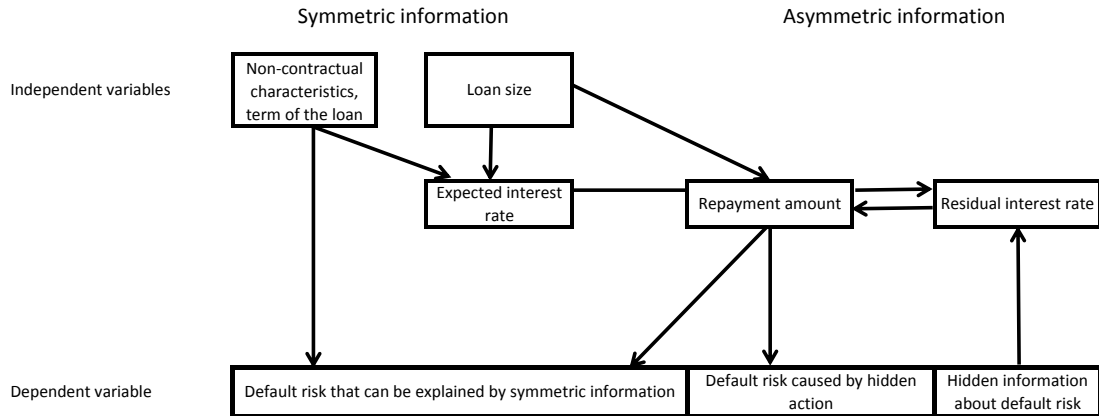


Figure 1: Empirical strategy to identify hidden information about default risk.

Default risk can be driven by either symmetric information, which is observable to both lenders and borrowers, or asymmetric information, which is observable to borrowers but not to lenders.

In the first step of my empirical strategy, I disentangle the effects of symmetric from asymmetric information on interest rate. To identify the effects of symmetric information on interest rate, I assume that symmetric information has a causal effect on interest rate, but not vice versa. I explain the interest rate conditional on symmetric information comprising of non-contractual characteristics, term of the loan and size. Based on the expected interest rate, I calculate the residual interest rate that cannot

be explained by symmetric information.

In the second step, I identify whether asymmetric information can be traced to hidden information or to hidden action. Ausubel (1999), Agarwal et al. (2010) and Adams et al. (2009) assume that only size, and not residual interest rate, affects hidden action. However, this assumption contradicts Karlan and Zinman’s (2009) empirical evidence that residual interest rate does cause hidden action. Thus, my identification assumption is that, controlling for observable information, hidden action depends on the repayment amount. The reasoning behind this assumption is that a larger repayment amount increases the borrowers’ private costs to repay the loan as a function of effort. As the borrowers’ action is hidden from their lenders, these higher costs give the borrowers an incentive to reduce their effort. Loan size and residual interest rate affect hidden action insofar as they influence the repayment amount. If an increase in the repayment amount via interest rate residual yields a higher default risk than the same increase in the repayment amount via size, I assume that this additional risk is caused by hidden information.

To identify hidden action, I also control for the KDF indicator to capture the effect of a higher repayment amount. This indicator is determined by the KDF ratio, as shown in table 1. While the ratio increases with the repayment amount, the KDF indicator only varies as a result of a sufficiently large change in the KDF ratio. Thus, the KDF ratio is an imperfect measure of the effect of repayment amount on hidden action.<sup>14</sup>

Directly controlling for repayment amount causes multicollinearity problems with the interest rate residual. By definition, a higher residual interest rate increases the repayment amount. For this reason, I control for loan size instead of repayment amount. Estimation results show that the effect of the repayment amount on default risk via size is relatively small compared to the effect of the repayment amount on default risk via residual interest rate. Thus, a higher default risk due to a higher residual interest rate cannot be justified only by the repayment amount.<sup>15</sup>

A potential concern with my analysis is that interest rate incorporates information about default risk that is only observable to investors, but not by the present researcher. In this case, observationally identical borrowers have a different default risk for their lenders. This matters insofar as lenders presumably charge a higher

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<sup>14</sup>Other observable characteristics are not influenced by a loan. While it is natural to assume that a loan request does not change socio- or macroeconomic characteristics, German law forbids the inclusion of the anticipated effect of a loan request on default risk in the Schufa rating.

<sup>15</sup>In a robustness check using total repayment amount instead of loan size, residual rate still had a significantly positive and important effect on default.

interest rate if this additional information indicates relatively higher riskiness. Figure 2 illustrates that, on Smava, borrowers with a worse Schufa rating pay a higher interest rate. As I cannot explain this higher interest rate by risk characteristics that

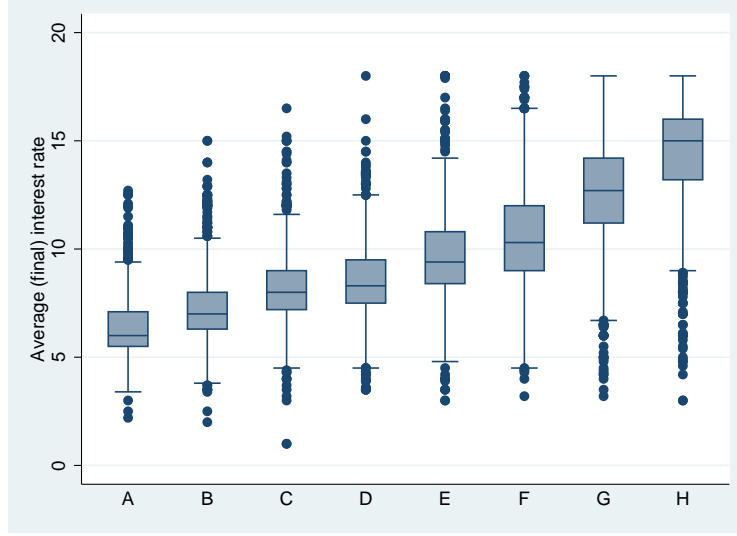


Figure 2: Average interest rate conditional on Schufa rating.

are observable to me, it translates to a higher residual interest rate. In extreme cases, this fact indicates that variation in the residual interest rate is due only to investors' additional information about their borrowers' default risk.

It is improbable that this concern will arise, as loan applicants on Smava act anonymously and investors only have access to the same information that I am able to observe in conducting this research.<sup>16</sup> Moreover, as investors are private households, I expect that they evaluate available information less professional than I do, indicating that my results actually underestimate the true effects.<sup>17</sup>

Note that my identification assumption implies loan size increases default risk not only because of hidden action but also because of hidden information. The fact that borrowers have some hidden information about default risk can also induce them to request a larger loan (Bester 1985b, Adams et al. 2009). A loan applicant who privately knows that he has a higher default risk than observed by investors may

<sup>16</sup>Using my empirical strategy, samples including bank loans are less eligible than my observation sample as loan officers may collect some private information about their borrowers' riskiness that researchers are usually unable to observe.

<sup>17</sup>For example, I show that lenders misinterpret the KDF indicator and thus supply a larger loan if it indicates a higher risk. Moreover, investors may observe risk-relevant information that is not available on the platform, such as macroeconomic conditions. To account for this, I use as a proxy the average consumer loan interest rate that banks charge on the consumer loan market, as well as time-fixed effects.

both request a higher loan size and be willing to pay a higher interest rate (Bester, 1985b). This implies that loan size may incorporate not only hidden action but also some hidden information, as shown in figure 1.<sup>18</sup> As size pools hidden action and some hidden information, using its effect via repayment amount as a proxy for hidden action underestimates the true effect of hidden information on default risk.

### 3.2 Identification of hidden information

I first identify the effects of symmetric information on the rate for any loan  $i$ . To do so, I specify an OLS model to regress interest rate  $r_i$  on  $X_i$ , which denotes non-contractual information and term of the loan, and on loan size  $s_i$ :

$$r_i = \beta X_i + \gamma f(s_i) + \tilde{r}_i \quad (1)$$

where  $\tilde{r}_i$  is the error term, and  $\gamma f(s_i) \equiv \gamma_1 s_i + \gamma_2 s_i^2$ . For my baseline estimation, I use the (final) loan interest rate.

A potential concern with using interest rate is that Smava has a non-linear fee structure and changes its fee policy over time (see figure 2), resulting in two effects: 1) there is no linear relationship between interest rate and the internal rate of return, and 2) a borrower and his lenders have a different internal rate of return, which is non-linearly related. To account for this, I run two additional regressions with both the borrower's and the lenders' average internal rate of return.<sup>19</sup> The monthly annuity of loan application  $i$  at the end of every loan month is therefore

$$annuity_i = s_i \frac{r_i^{month} (1 + r_i^{month})^{T_i}}{(1 + r_i^{month})^{T_i} - 1} \quad (2)$$

where  $T$  denotes the term of the loan and  $r^{month} = r/12$ .<sup>20</sup> The borrower's internal rate of return  $IRR_i^{borrower}$  equates

$$s_i - F_i^{borrower} = -annuity_i \sum_{t=1}^{T_i} (1 + IRR_i^{borrower})^{-t} \quad (3)$$

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<sup>18</sup>Adams et al. (2009) use variation of down payments to identify the effect of hidden information about default risk on loan size.

<sup>19</sup>To prevent biases caused by different average bid sizes between loans, I use the average number of bidders in the sample to calculate the lenders' fee.

<sup>20</sup>Smava divides the annual loan interest rate by 12 to calculate the annuity.

and his lenders' internal rate of return  $IRR_i^{lenders}$  equates

$$-(s_i + F_i^{lenders}) = annuity_i \sum_{t=1}^{T_i} (1 + IRR_i^{lenders})^{-t} \quad (4)$$

where  $F$  denotes the fee, which differs between a borrower and his lenders. Because of this fee, a borrower actually obtains  $s_i - F_i^{borrower}$ , whereas his lenders invest  $s_i + F_i^{lenders}$ . During the term of the loan, the borrower repays his annuities to his lenders at the end of every month.

Table 3 shows how observable information affects the interest rate, the internal rate of return for a borrower and the internal rate of return for investors, respectively.<sup>21</sup> Not surprisingly, borrowers with an observationally higher risk pay a significantly higher interest rate. In the first instance, the requested interest rate decreases with age, while rate increase with age squared. On average, male borrowers pay less than female borrowers. The banks' monthly average consumer loan interest rate has a significantly positive effect on interest rate, whereas contractual characteristics and loan-specific information do not have a significant impact on interest rate.

To identify hidden information about default risk, I calculate residual rate, with the assumption that residual rate incorporates not only the borrower's private information about default risk  $\theta$  but also some randomness:

$$\tilde{r}_i = \theta_i + \tilde{u}_i \quad (5)$$

Next, I rescale  $\tilde{r}_i$  by the generated regressor  $\hat{r}_i$ . The rescaled  $\tilde{r}_i$  still underlies the same uncertainty as  $r_i$ <sup>22</sup>. Thus, using residual rate as a regressand yields consistent estimations with a valid interference.

### 3.3 Hidden information and default risk

Next, I test whether the residual interest rate incorporates some hidden information about default risk. However, in the observation sample, only 895 of 5,026 loans could have come to the end of their loan term. As it allows me to work with the full sample, I estimate default risk using Cox's (1972) proportional hazard model. This accounts for

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<sup>21</sup>I report the squared loan size, as I will show in the next section that loan size non-linearly increases default risk.

<sup>22</sup>Wooldridge (2002, p. 115) discusses only estimators (in my case  $\hat{r}_i$ ) as generated regressors. As this approach ignores sampling variation, some uncertainty must be added to guarantee a valid inference.

Table 3: **Identification of the effect of observable information on interest rate.** OLS regression with the dependent variable interest rate in column 1, internal rate of return for borrower in column 2, and internal rate of return for lenders in column 3. As internal rate of return already includes fees, changes in Smava's fee policy are captured as dummies in column 1 but not in columns 2 and 3.

	(1)		(2)		(3)	
	Interest rate		IRR borrower		IRR lenders	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
<i>Contractual characteristics</i>						
Size (€1,000s)	0.009	(0.009)	-0.009	(0.011)	0.011	(0.010)
Size squared(€1,000s)	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)
Term (60 months=1)	0.009	(0.052)	-0.376***	(0.059)	0.234***	(0.057)
<i>Risk characteristics</i>						
Schufa rating						
B	0.778***	(0.069)	0.849***	(0.079)	0.817***	(0.076)
C	1.653***	(0.082)	1.825***	(0.094)	1.749***	(0.091)
D	2.159***	(0.083)	2.358***	(0.095)	2.281***	(0.091)
E	3.184***	(0.083)	3.531***	(0.095)	3.409***	(0.092)
F	4.029***	(0.083)	4.463***	(0.095)	4.325***	(0.091)
G	6.073***	(0.079)	6.801***	(0.090)	6.598***	(0.087)
H	7.810***	(0.091)	8.851***	(0.104)	8.575***	(0.100)
KDF indicator						
2	0.178*	(0.078)	0.168	(0.089)	0.187*	(0.085)
3	0.367***	(0.075)	0.384***	(0.086)	0.393***	(0.083)
4	0.701***	(0.080)	0.763***	(0.092)	0.774***	(0.088)
<i>Socio-economic characteristics</i>						
Age	-0.049***	(0.010)	-0.052***	(0.012)	-0.052***	(0.011)
Age squared	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)
Gender (male=1)	-0.126**	(0.047)	-0.146**	(0.054)	-0.149**	(0.052)
Job fixed effects	Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes	
<i>Loan-specific information</i>						
Membership, ln	-0.005	(0.017)	-0.001	(0.020)	0.005	(0.019)
Description, ln	0.000	(0.013)	0.008	(0.015)	-0.008	(0.015)
Purpose fixed effects	Yes		Yes		Yes	
<i>Macroeconomic conditions</i>						
Banks' interest rate	0.696***	(0.199)	1.969***	(0.161)	1.416***	(0.155)
Month fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Fee fixed effects	Yes		No		No	
Constant	1.893	(1.397)	-3.872***	(1.078)	-0.718	(1.035)
R sq	0.797		0.775		0.807	
Adj. R squ	0.794		0.772		0.805	
F-test	269.915		243.752		296.467	
p value	0.000		0.000		0.000	
Observations	5026		5026		5026	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

the default pattern of the loan over time and with it for right-censored observations. The probability that a loan  $i$  defaults at  $t$ , given that it has not defaulted before  $t$ , is

$$h(t | X_i, s_i, \tilde{r}_i) = h_0(t) \exp(\beta X_i + \gamma s_i + \delta f(\tilde{r}_i)) \quad (6)$$

where  $h(t | X_i, s_i, \tilde{r}_i)$  denotes the proportional hazard rate,  $t$  the number of months the loan is running,  $h_0(t)$  the baseline hazard,  $X_i$  the observable information for lenders,  $s_i$  the loan size,  $\tilde{r}_i$  the residual rate and  $\delta f(\tilde{r}_i) \equiv \delta_1 \tilde{r}_i + \delta_2 \tilde{r}_i^2$ . The main assumption of this model is that the baseline hazard  $h_0(t)$  depends only on  $t$ . This implies that  $X$ ,  $s$  and  $\tilde{r}$  only shift the proportional hazard rate, but do not change the default pattern over time.

Figure 3 shows the time pattern of the hazard rate for a loan with a Schufa rating of A (lower line), E (middle line) and H (upper line). Borrowers with a lower-risk

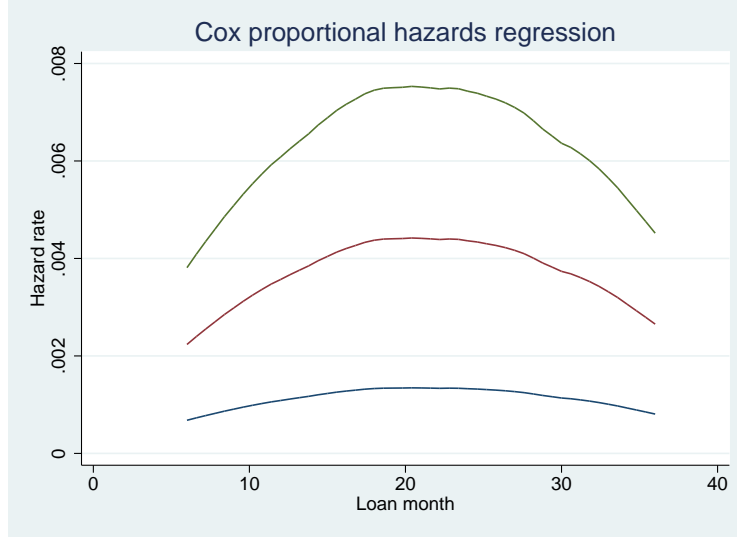


Figure 3: Hazard rate conditional on Schufa rating of A (lower line), E (middle line) and H (upper line).

Schufa rating (with a lower line) have a lower hazard rate for every loan month. The hazard rate increases non-linearly with the loan month, reaches its maximum at around loan month 21, and then decreases again.

As it is difficult to interpret the hazard rate intuitively, in addition, I calculate the probability that loan  $i$  with term  $T$  will be fully repaid:

$$S_i(T) = \exp \left\{ - \int_0^T h(t | X_i, s_i, \tilde{r}_i) dt \right\}. \quad (7)$$

Figure 4 shows this repayment probability as a function of the term of the loan, conditional on its Schufa rating - A (upper line), E (middle line) and H (lower line). Repayment probability decreases with the term of the loan, and borrowers with a lower-risk Schufa rating (higher line) have a higher repayment probability. To interpret figure 4, suppose, for example, that the term of the loan is 36 months. For this loan, a borrower with a Schufa rating of A has a repayment probability of more than 95 percent, which drops to less than 90 percent for a rating of E and only around 80 percent for a rating of H. This shows that there is a considerable variation of default risk conditional on the borrower's Schufa rating.

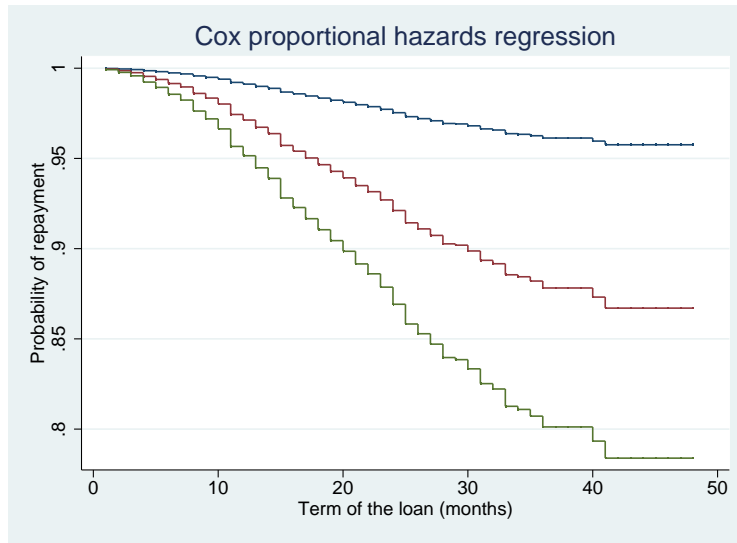


Figure 4: Probability of repayment of the loan conditional on Schufa rating of A (upper line), E (middle line) and H (lower line).

Using a proportional hazard rate estimation, I suppose that the baseline hazard solely depends on  $t$ . This constant relative hazard assumption is reasonable if the log-log probability of the repayment, as a function of the loan month conditional on the Schufa rating, shows a parallel pattern. As an example, see figure 5. It compares such a function with Schufa rating D to loans with another Schufa rating and finds this parallel pattern. Running the same test with the other Schufa ratings shows similar results.

Table 4 shows the results of a proportional hazard rate estimation.<sup>23</sup> In column 1, I control for residual interest rate; in column 2, for internal rate of return for a borrower; and in column 3, for internal rate of return for investors.<sup>24</sup> To make coefficients

<sup>23</sup>Loans repaid early are treated as being repaid until the last observation period.

<sup>24</sup>I only include fee dummies if I control for interest rate, as the internal rate of return already



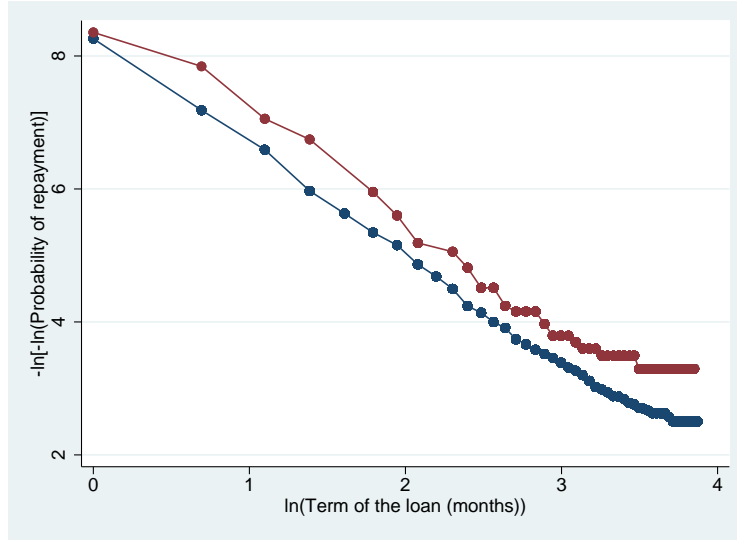


Figure 5: Survival rate function of Schufa rating D (upper line) is nearly parallel to survival rate function of the other Schufa ratings (lower line).

interpretable, table 4 displays the coefficients in exponentiated form, which is denoted as hazard ratio. Interest rate residual has a significant, non-linear, but mainly positive effect on hazard ratio. A one percent higher residual interest rate increases the hazard ratio by 26.5 percent, while its square decreases the hazard ratio by 0.5 percent. Controlling for internal rate of return in columns 2 and 3 improves the significance level to the 0.1 percent level. Meanwhile, a one percent higher residual internal rate of return increases the hazard ratio by 27.1 for borrowers and 21.1 percent for lenders, while its square decreases the hazard ratio by 0.8 and 0.5 percent, respectively.

Although I focus on interest rate residual, the effect of other contractual characteristics is similarly interesting. For all columns, I find that a €1,000 larger loan causes a 4.3 to 4.4 percent higher hazard ratio, while its square causes a 0.1 percent lower hazard ratio. If KDF indicates that the loan imposes a higher financial burden on the borrower, the default risk is significantly higher. If the Schufa rating is worse, the default risk tends to be higher.<sup>25</sup> A longer term of the loan significantly increases default risk.

Socio-economic characteristics also play a small role for default risk. When a borrower is one year older, the hazard ratio is expected to decrease by 6.9 percent, while squared age increases it by 0.1 percent. Gender is still significant at the 1 percent level, but its effect is not statistically significant. The variable 'includes fees' is also included in the regressions.

<sup>25</sup>These results are robust and do not change when same regressions are run without residual interest rate or loan size.

Table 4: **Hidden information and default risk.** Cox proportional hazard regression with dependent variable hazard ratio (exponentiated hazard rate). Column 1 controls for residual interest rate as well as for fee dummies, column 2 controls for residual internal rate of return for a borrower and column 3 controls for residual internal rate of return for lenders.

	(1)		(2)		(3)	
	Hazard ratio		Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>						
Residual interest rate	1.265**	(0.092)				
Residual interest rate squared	0.995*	(0.003)				
Residual IRR borrower			1.271***	(0.058)		
Residual IRR borrower squared			0.992***	(0.002)		
Residual IRR lenders					1.212***	(0.062)
Residual IRR lenders squared					0.995*	(0.002)
Size (€1,000s)	1.044***	(0.007)	1.043***	(0.007)	1.044***	(0.007)
Size squared(€1,000s)	0.999***	(0.000)	0.999***	(0.000)	0.999***	(0.000)
Term (60 months=1)	1.131***	(0.037)	1.145***	(0.037)	1.147***	(0.037)
<i>Risk characteristics</i>						
Schufa rating						
B	1.446***	(0.083)	1.447***	(0.083)	1.447***	(0.083)
C	1.756***	(0.109)	1.758***	(0.109)	1.754***	(0.109)
D	1.286***	(0.089)	1.295***	(0.089)	1.289***	(0.089)
E	3.491***	(0.195)	3.531***	(0.198)	3.494***	(0.196)
F	2.637***	(0.152)	2.641***	(0.152)	2.632***	(0.151)
G	3.689***	(0.201)	3.656***	(0.199)	3.635***	(0.198)
H	6.089***	(0.342)	6.092***	(0.343)	6.030***	(0.339)
KDF indicator						
2	1.976***	(0.143)	1.985***	(0.143)	1.987***	(0.143)
3	2.726***	(0.189)	2.760***	(0.191)	2.753***	(0.191)
4	3.272***	(0.227)	3.305***	(0.229)	3.298***	(0.229)
<i>Socio-economic characteristics</i>						
Age	0.931***	(0.005)	0.931***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.919**	(0.026)	0.919**	(0.026)	0.921**	(0.026)
Job fixed effects	Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes	
<i>Loan-specific information</i>						
Membership, ln	1.091***	(0.012)	1.093***	(0.012)	1.091***	(0.012)
Description, ln	0.904***	(0.009)	0.910***	(0.009)	0.910***	(0.009)
Purpose fixed effects	Yes		Yes		Yes	
<i>Macroeconomic conditions</i>						
Banks' interest rate	2.218***	(0.242)	1.679***	(0.142)	1.653***	(0.139)
Month fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Fee fixed effects	Yes		No		No	
Pseudo R sq	0.037		0.037		0.037	
AIC	143451.040		143476.630		143469.962	
BIC	144171.422		144177.542		144170.874	
p value	0.000		0.000		0.000	
Observations	124853		124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

percent level; males have a 7.9 to 8.1 percent lower hazard risk than females.

A potential concern for large samples is that, although regressors are significant at a low confidence level, they do not contribute to the relative quality of the regression. Thus, including such a significant regressor may increase the likelihood but overfit the model. Thus, although the residual interest rate is significant, it may be relatively unimportant for the default risk. One way to address this concern is to discuss the size of the exponentiated coefficient. The estimation results suggest that an increase in the residual interest has a strong impact on the hazard rate. To understand this, regard column 3. On average, the hazard ratio increases by 71.86 percent per riskier Schufa class; this percentage changes by 43.92 percent when regarding only classes A to G.<sup>26</sup> This change is relatively small compared to the impact of the internal rate of return for investors. A one percent higher residual internal rate of return increases the hazard ratio by 21.2 percent, while its square only decreases the ratio by 0.5 percent.

Another potential concern is that a higher residual interest rate may only be due to hidden action. Specifically, a higher interest rate increases the repayment amount, which may affect hidden action and thus default risk. To understand why this is improbable, consider column 1 of table 4, which shows that a one percent higher interest rate, on average, increases hazard ratio by 26.5 percent, while its square decreases it by 0.5 percent. To understand what a higher interest rate means for the repayment amount, consider a loan with the average loan size of €6,259.14 and the average interest rate of 9.53 percent. In this case, a one percent higher interest rate increases the repayment amount by €62.59. The repayment amount would increase to the same extent if I increased the size by €57.14.<sup>27</sup> According to column 1 of table 4, an increase of the repayment amount via size increases the hazard ratio by 0.25 percent, while increasing via the square of the size only increases the hazard ratio by 0.006 percent.<sup>28</sup> This means that the effect of the repayment amount on the hazard ratio is remarkably small. Thus, for the most part, the significant positive link between residual interest rate and default risk cannot be explained by hidden action.

In table 4, I suggest that residual rate is non-linearly related to hazard ratio. However, a simple interpretation of the exponentiated coefficients does not aid in deciding whether a linear or a non-linear effect of interest rate on hazard rate implies a

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<sup>26</sup>The average increase of the hazard ratio for the seven Schufa classes A to H is  $(6.030 - 1)100\%/7 = 71.86\%$ , while for the six Schufa classes A to G it is  $(3.635 - 1)100\%/6 = 43.92\%$ .

<sup>27</sup> $9.53\% \times €57.14 = €62.59$

<sup>28</sup>As I only regard the small interval of €1,000, I suppose that the percentage increase of hazard ratio is linear with the size. This results in an increase of  $4.4\% \times €57.14 / €1,000 = 0.25\%$  and for its square  $0.1\% \times €57.14 / €1,000 = 0.006\%$ .

better goodness of fit. To address this concern, I use the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). To the term  $-2\ln(L)$ , AIC adds the penalty term  $2p$  and BIC adds the penalty term  $\ln(N)p$ , where  $L$  is the maximized log-likelihood, which uses  $p$  parameters. BIC differs from AIC in that it additionally accounts for sample size  $N$ . For both criteria, a lower value indicates a better fit of the model.<sup>29</sup>

Tables 5, 6 and 7 show the estimation results controlling for residual interest rate, residual internal rate of return for a borrower and residual internal rate of return for investors respectively. Each table contains three columns. The first column does not control for rate, the second includes rate linearly, and the third includes rate non-linearly by additionally including its square.

Both information criteria suggest that residual interest rate, residual internal rate of return for a borrower and residual internal rate of return for investors are important determinants of the hazard rate. For the best goodness of fit, the AIC suggests to control for rate and its square in table 5, while the BIC suggests to control for internal rate of return non-linearly in table 6 and for interest rate linearly in tables 5 and 7.<sup>30</sup>

## 4 Why borrowers signal hidden information about default risk

### 4.1 Empirical strategy

The main result found in the previous section is that observationally identical borrowers signal their privately known default risk via interest rate that cannot be explained by symmetric information. That means that from the perspective of lenders, unobservably riskier borrowers pay a higher interest rate despite the fact that doing so implies higher costs for the borrowers. This raises the question of why borrowers signal their hidden information about default risk in this way.

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<sup>29</sup>In determining whether rate is important, the absolute value of the information criterion does not play a role. A high absolute value results from a large number of parameters. While a reduction in the number of parameters may improve the goodness of fit, it does not change the importance of residual rate as a regressor of hazard rate.

<sup>30</sup>Another concern may be that residual interest rate may underlie uncertainty, in the sense of that the error term follows a normal distribution, although the Cox proportional hazard rate estimation supposes a lognormal distribution. To address this concern, I ran several robustness checks using bootstrapping with residuals randomly drawn from the sample according to a log-normal distribution. The results do not change.

Table 5: **Hidden information and default risk - robustness check with residual interest rate.** Cox proportional hazard regression with dependent variable hazard ratio, which is the exponentiated hazard rate. As a robustness check, column 1 controls for residual interest rate, column 2 controls for residual interest rate, column 3 controls for residual interest rate and its square. A lower AIC or BIC indicates a better fit of the model. Changes in Smava's fee policy are captured by dummies in all columns.

	(1)		(2)		(3)	
	Hazard ratio		Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>						
Residual interest rate			1.096***	(0.008)	1.265**	(0.092)
Residual interest rate squared					0.995*	(0.003)
Size (€1,000s)	1.048***	(0.007)	1.044***	(0.007)	1.044***	(0.007)
Size squared(€1,000s)	0.999***	(0.000)	0.999***	(0.000)	0.999***	(0.000)
Term (60 months=1)	1.187***	(0.039)	1.131***	(0.037)	1.131***	(0.037)
<i>Risk characteristics</i>						
Schufa rating						
B	1.457***	(0.083)	1.446***	(0.083)	1.446***	(0.083)
C	1.778***	(0.110)	1.755***	(0.109)	1.756***	(0.109)
D	1.306***	(0.090)	1.283***	(0.088)	1.286***	(0.089)
E	3.573***	(0.199)	3.466***	(0.194)	3.491***	(0.195)
F	2.668***	(0.153)	2.631***	(0.151)	2.637***	(0.152)
G	3.607***	(0.196)	3.679***	(0.200)	3.689***	(0.201)
H	5.809***	(0.324)	6.035***	(0.338)	6.089***	(0.342)
KDF indicator						
2	1.975***	(0.143)	1.979***	(0.143)	1.976***	(0.143)
3	2.758***	(0.191)	2.724***	(0.189)	2.726***	(0.189)
4	3.325***	(0.231)	3.267***	(0.227)	3.272***	(0.227)
<i>Socio-economic characteristics</i>						
Age	0.931***	(0.005)	0.931***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.921**	(0.026)	0.922**	(0.026)	0.919**	(0.026)
Job fixed effects	Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes	
<i>Loan-specific information</i>						
Membership, ln	1.094***	(0.012)	1.090***	(0.012)	1.091***	(0.012)
Description, ln	0.907***	(0.009)	0.903***	(0.009)	0.904***	(0.009)
Purpose fixed effects	Yes		Yes		Yes	
<i>Macroeconomic conditions</i>						
Banks' interest rate	2.278***	(0.249)	2.217***	(0.242)	2.218***	(0.242)
Month fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Fee fixed effects	Yes		Yes		Yes	
Pseudo R sq	0.036		0.037		0.037	
AIC	143594.800		143453.120		143451.040	
BIC	144295.712		144163.767		144171.422	
p value	0.000		0.000		0.000	
Observations	124853		124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

Table 6: **Hidden information and default risk - robustness check with residual internal rate of return for borrower.** Cox proportional hazard regression with dependent variable hazard ratio, which is the exponentiated hazard rate. As a robustness check, column 1 does not control for residual internal rate of return for a borrower, column 2 controls for residual internal rate of return for a borrower, column 3 controls for residual internal rate of return for a borrower and its square. A lower AIC or BIC indicates a better fit of the model.

	(1)		(2)		(3)	
	Hazard ratio		Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>						
Residual IRR borrower			1.075***	(0.007)	1.271***	(0.058)
Residual IRR borrower squared					0.992***	(0.002)
Size (€1,000s)	1.048***	(0.007)	1.044***	(0.007)	1.043***	(0.007)
Size squared(€1,000s)	0.999***	(0.000)	0.999***	(0.000)	0.999***	(0.000)
Term (60 months=1)	1.199***	(0.039)	1.147***	(0.037)	1.145***	(0.037)
<i>Risk characteristics</i>						
Schufa rating						
B	1.454***	(0.083)	1.447***	(0.083)	1.447***	(0.083)
C	1.773***	(0.110)	1.754***	(0.109)	1.758***	(0.109)
D	1.307***	(0.090)	1.290***	(0.089)	1.295***	(0.089)
E	3.575***	(0.199)	3.481***	(0.195)	3.531***	(0.198)
F	2.660***	(0.152)	2.626***	(0.151)	2.641***	(0.152)
G	3.577***	(0.194)	3.627***	(0.197)	3.656***	(0.199)
H	5.776***	(0.322)	5.972***	(0.335)	6.092***	(0.343)
KDF indicator						
2	1.988***	(0.143)	1.991***	(0.144)	1.985***	(0.143)
3	2.782***	(0.193)	2.756***	(0.191)	2.760***	(0.191)
4	3.351***	(0.232)	3.298***	(0.229)	3.305***	(0.229)
<i>Socio-economic characteristics</i>						
Age	0.930***	(0.005)	0.931***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.923**	(0.026)	0.925**	(0.026)	0.919**	(0.026)
Job fixed effects	Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes	
<i>Loan-specific information</i>						
Membership, ln	1.095***	(0.012)	1.091***	(0.012)	1.093***	(0.012)
Description, ln	0.911***	(0.009)	0.910***	(0.009)	0.910***	(0.009)
Purpose fixed effects	Yes		Yes		Yes	
<i>Macroeconomic conditions</i>						
Banks' interest rate	1.725***	(0.146)	1.691***	(0.143)	1.679***	(0.142)
Month fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Pseudo R sq	0.036		0.037		0.037	
AIC	143606.783		143489.369		143476.630	
BIC	144288.225		144180.546		144177.542	
p value	0.000		0.000		0.000	
Observations	124853		124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

Table 7: **Hidden information and default risk - robustness check with residual internal rate of return for investors.** Cox proportional hazard regression with dependent variable hazard ratio, which is the exponentiated hazard rate. As a robustness check, column 1 does not control for residual internal rate of return for lenders, column 2 controls for residual internal rate of return for lenders, column 3 controls for residual internal rate of return for lenders and its square. A lower AIC or BIC indicates a better fit of the model.

	(1)		(2)		(3)	
	Hazard ratio		Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>						
Residual IRR lenders			1.083***	(0.007)	1.212***	(0.062)
Residual IRR lenders squared					0.995*	(0.002)
Size (€1,000s)	1.048***	(0.007)	1.044***	(0.007)	1.044***	(0.007)
Size squared(€1,000s)	0.999***	(0.000)	0.999***	(0.000)	0.999***	(0.000)
Term (60 months=1)	1.199***	(0.039)	1.148***	(0.037)	1.147***	(0.037)
<i>Risk characteristics</i>						
Schufa rating						
B	1.454***	(0.083)	1.446***	(0.083)	1.447***	(0.083)
C	1.773***	(0.110)	1.751***	(0.109)	1.754***	(0.109)
D	1.307***	(0.090)	1.285***	(0.088)	1.289***	(0.089)
E	3.575***	(0.199)	3.463***	(0.194)	3.494***	(0.196)
F	2.660***	(0.152)	2.622***	(0.151)	2.632***	(0.151)
G	3.577***	(0.194)	3.620***	(0.197)	3.635***	(0.198)
H	5.776***	(0.322)	5.964***	(0.334)	6.030***	(0.339)
KDF indicator						
2	1.988***	(0.143)	1.991***	(0.144)	1.987***	(0.143)
3	2.782***	(0.193)	2.750***	(0.190)	2.753***	(0.191)
4	3.351***	(0.232)	3.293***	(0.228)	3.298***	(0.229)
<i>Socio-economic characteristics</i>						
Age	0.930***	(0.005)	0.931***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.923**	(0.026)	0.924**	(0.026)	0.921**	(0.026)
Job fixed effects	Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes	
<i>Loan-specific information</i>						
Membership, ln	1.095***	(0.012)	1.090***	(0.012)	1.091***	(0.012)
Description, ln	0.911***	(0.009)	0.910***	(0.009)	0.910***	(0.009)
Purpose fixed effects	Yes		Yes		Yes	
<i>Macroeconomic conditions</i>						
Banks' interest rate	1.725***	(0.146)	1.657***	(0.140)	1.653***	(0.139)
Month fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Pseudo R sq	0.036		0.037		0.037	
AIC	143606.783		143473.076		143469.962	
BIC	144288.225		144164.253		144170.874	
p value	0.000		0.000		0.000	
Observations	124853		124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

To answer this question, it may be informative to consider Smava's unique lending design. After the loan application is posted, the bid period starts. This period can last up to 14 days, but it is closed earlier when investors fully supply the requested loan amount. Thus, loan applicants may offer a higher interest rate to induce investors to provide the loan faster or with a higher probability.

## 4.2 Probability of obtaining the requested amount

To analyze how a higher interest rate affects the probability of obtaining the requested loan amount, I include loan applications that are not financed. Consider a loan application  $i$  with  $X_i$ , which denotes symmetric information except loan size, and a request of size  $D_i$ . Based on the OLS estimation of interest rate in the previous section, the loan applicant is expected to offer a rate of interest

$$\hat{r}_i = \hat{\beta}X_i + \hat{\gamma}f(D_i) \quad (8)$$

where  $\hat{\beta}$  and  $\hat{\gamma}$  denote the coefficients from estimation (1), and  $\hat{\gamma}f(D_i) \equiv \hat{\gamma}_1D_i + \hat{\gamma}_2D_i^2$ .<sup>31</sup> However, I observe that the actual interest rate of loan application  $i$  is  $r_i$ ; that is, it deviates by  $\tilde{r}_i$  from  $\hat{r}_i$ . According to the results of the previous section, a higher  $\tilde{r}_i$  incorporates some of borrowers' hidden information about a higher default risk.

One potential benefit of a higher residual interest rate may be that it increases investors' willingness to supply a higher  $S_i$ . To test this, I specify the Tobit model

$$S_i = \begin{cases} S_i^* = \beta X_i + \delta f(\tilde{r}_i) + \varepsilon_i & \text{if } S_i^* < D_i \\ D_i & \text{if } S_i^* \geq D_i \end{cases} \quad (9)$$

As I can only observe supply  $S_i^*$  if  $S_i^* < D_i$ . If  $S_i^* \geq D_i$ , I observe only  $D_i$ ; thus, I only know that investors are willing to supply at least as much as loan applicants demand.

Table 8 shows the estimation results. Columns 1 and 2 include all loan applications, while columns 3 and 4 include only those loans that are financed. Also, columns 1 and 3 control for interest rate, while columns 2 and 4 control for the internal rate of return for investors.

For all columns, a higher interest rate residual induces investors to supply signif-

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<sup>31</sup>Note that here  $\hat{\gamma}_1$  and  $\hat{\gamma}_2$  are multiplied by  $D_i$  and not by  $S_i$ . Thus, during the bid period, I suppose that  $S_i = D_i$ . While this applies for most observations in my sample, it also helps me to understand how  $D_i$  affects the speed and probability of obtaining a loan.



Table 8: **Hidden information and supply.** Tobit regression with the dependent variable loan supply. As supply can only be observed if it is smaller than  $Demand_i$  and larger than zero, the model has a lower limit of zero and an upper limit of  $Demand_i$ , which can vary with every loan application  $i$ . Columns 1 and 2 contain all loan applications, while columns 3 and 4 contain only loans that are financed. Columns 1 and 3 control for residual interest rate, while column 2 controls for internal rate of return for investors based on requested loan amount, and column 4 controls for internal rate of return for investors based on loan size. Changes in Smava's fee policy are captured as dummies in columns 1 and 3, but not in columns 2 and 4, as the internal rate of return for lenders already includes fees.

	(1)		(2)		(3)		(4)	
	Supply		Supply		Supply		Supply	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
<i>Contractual characteristics</i>								
Residual interest rate	1.109***	(0.058)			0.418***	(0.106)		
Residual IRR investors			1.001***	(0.052)				
Residual IRR lenders							0.385***	(0.095)
Term (60 months=1)	-2.138***	(0.283)	-2.605***	(0.285)	0.050	(0.500)	0.132	(0.496)
<i>Risk characteristics</i>								
Schufa rating								
B	-0.560	(0.416)	-0.494	(0.413)	-1.374	(0.727)	-1.432*	(0.729)
C	-0.357	(0.492)	-0.230	(0.489)	-1.241	(0.830)	-1.330	(0.832)
D	-0.446	(0.477)	-0.352	(0.473)	1.029	(0.975)	0.934	(0.976)
E	-0.568	(0.478)	-0.437	(0.474)	-0.376	(0.901)	-0.362	(0.905)
F	-1.833***	(0.434)	-1.625***	(0.430)	-1.922*	(0.784)	-1.987*	(0.786)
G	-1.872***	(0.412)	-1.597***	(0.409)	-1.264	(0.785)	-1.318	(0.788)
H	-1.556***	(0.457)	-1.164*	(0.456)	-1.487	(0.839)	-1.539	(0.841)
KDF indicator								
2	1.920***	(0.296)	1.878***	(0.294)	1.176	(0.611)	1.197	(0.611)
3	3.675***	(0.310)	3.648***	(0.308)	2.009***	(0.609)	2.053***	(0.609)
4	4.659***	(0.353)	4.603***	(0.350)	2.106***	(0.635)	2.178***	(0.633)
<i>Socio-economic characteristics</i>								
Age	-0.102	(0.053)	-0.099	(0.053)	-0.034	(0.101)	-0.038	(0.101)
Age squared	0.001	(0.001)	0.001	(0.001)	0.000	(0.001)	0.000	(0.001)
Gender (male=1)	-0.419	(0.258)	-0.369	(0.256)	0.313	(0.441)	0.299	(0.443)
Job fixed effects	Yes		Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes		Yes	
<i>Loan-specific information</i>								
Membership, ln	-0.152	(0.103)	-0.151	(0.102)	-0.257	(0.177)	-0.233	(0.177)
Description, ln	-0.154	(0.084)	-0.135	(0.083)	-0.012	(0.158)	-0.040	(0.155)
Purpose fixed effects	Yes		Yes		Yes		Yes	
<i>Macroeconomic conditions</i>								
Banks' interest rate	-5.193***	(0.929)	-4.645***	(0.799)	-3.177	(1.643)	-3.758*	(1.464)
Month fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
Fee fixed effects	Yes		No		Yes		No	
Constant	24.214***	(6.382)	19.307***	(5.127)	16.839	(11.002)	25.369**	(9.112)
Insigma constant	1.340***	(0.025)	1.335***	(0.025)	1.325***	(0.037)	1.330***	(0.037)
p value	0.000		0.000		0.000		0.000	
Observations	5983		5983		5026		5026	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

icantly more. For example, in column 1, a one-percent higher interest rate residual increases supply by €1,109. The positive effect of the interest rate residual is weaker if we regard only those loans that are financed. In column 3, a one-percent higher interest rate residual only increases supply by €418.

For financed loans, the Schufa rating does not influence supply. Regarding loan applications, investors supply significantly less for Schufa classes F to H. Interestingly, investors are willing to supply more if the KDF indicates a higher risk. Also, a higher loan term significantly decreases supply in columns 1 and 2 but has no effect in columns 3 and 4. Socio-economic and loan-specific information does not have a significant impact on supply.

The results in table 8 show that the loan applicant can only estimate  $S_i$  under uncertainty. Thus, the previous results suggest that a higher  $\tilde{r}_i$  increases the probability that loan application  $i$ 's requested amount will be financed. Moreover, the requested amount also affects this probability. I test this hypothesis by specifying the Probit model

$$Prob(S_i \geq D_i | X_i, D_i, \tilde{r}_i) = \Phi(\beta X_i + \delta f(\tilde{r}_i) + \gamma D_i + \varepsilon_i) \quad (10)$$

where  $D$  is the loan size demanded in application  $i$ . If the loan applicant accepts the granted loan, the loan business comes into effect, which occurs with probability  $Prob(accepted | S_i \geq D_i)$ .

Table 9 shows the estimation results. In columns 1 and 2, I estimate the probability that the requested amount will be fully granted, and in columns 3 and 4 I estimate the probability that the loan will be fully financed.

In all columns of table 9, estimation results are similar. Residual rate has a positive impact on the probability that the loan will be financed, while its square has a negative effect. For example, in column 3, a one-percent increase of the residual interest rate significantly increases the probability that the loan will be fully financed - specifically, by 22.2 percent - whereas its square only decreases the probability by 0.8 percent. Not surprisingly, a €1,000 larger demand decreases the probability of obtaining the requested amount by one percent and decreases the probability that the loan will be financed by 1.2 percent. A longer loan term decreases the probability of obtaining a loan by between 4.9 and 7.5 percent. However, this effect is small relative to that of the residual rate.

In all columns, loan applicants whose Schufa rating is F or riskier have a significantly lower probability of obtaining a loan. This is in contrast to the counterintuitive result that loan applicants with a riskier KDF indication actually have a higher prob-

**Table 9: Hidden information and probability of obtaining requested amount.** Probit regression with the dependent variables probability that the requested loan amount will be fully granted (in columns 1 and 2) and probability that the requested amount will be fully financed (in columns 3 and 4). All columns contain all loan applications. Columns 1 and 3 control for residual interest rate and its square, while columns 2 and 4 control for internal rate of return for investors based on the requested loan amount and its square. Changes in Smava's fee policy are captured as dummies in columns 1 and 3, but not in columns 2 and 4, as internal rate of return for lenders already includes fees.

	(1)		(2)		(3)		(4)	
	Pr(granted)		Pr(granted)		Pr(financed)		Pr(financed)	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
<i>Contractual characteristics</i>								
Residual interest rate	0.152***	(0.014)			0.222***	(0.020)		
Residual interest rate squared	-0.005***	(0.001)			-0.008***	(0.001)		
Residual IRR investors			0.123***	(0.011)			0.157***	(0.015)
Residual IRR investors squared			-0.003***	(0.000)			-0.005***	(0.001)
Demand (€1.000s)	-0.010***	(0.001)	-0.010***	(0.001)	-0.012***	(0.001)	-0.012***	(0.001)
Term (60 months=1)	-0.058***	(0.009)	-0.075***	(0.009)	-0.049***	(0.011)	-0.069***	(0.011)
<i>Risk characteristics</i>								
Schufa rating								
B	-0.034**	(0.012)	-0.033**	(0.012)	-0.027	(0.015)	-0.026	(0.015)
C	-0.028	(0.015)	-0.023	(0.015)	-0.032	(0.018)	-0.028	(0.018)
D	-0.040**	(0.014)	-0.036*	(0.014)	-0.046**	(0.018)	-0.045*	(0.018)
E	-0.031*	(0.015)	-0.025	(0.015)	-0.041*	(0.018)	-0.038*	(0.018)
F	-0.073***	(0.013)	-0.065***	(0.013)	-0.094***	(0.017)	-0.090***	(0.017)
G	-0.070***	(0.013)	-0.062***	(0.013)	-0.086***	(0.016)	-0.083***	(0.016)
H	-0.060***	(0.015)	-0.048**	(0.015)	-0.098***	(0.018)	-0.095***	(0.018)
KDF indicator								
2	0.066***	(0.010)	0.064***	(0.010)	0.119***	(0.013)	0.118***	(0.013)
3	0.113***	(0.010)	0.112***	(0.010)	0.173***	(0.013)	0.174***	(0.013)
4	0.140***	(0.011)	0.139***	(0.011)	0.202***	(0.014)	0.204***	(0.014)
<i>Socio-economic characteristics</i>								
Age	-0.002	(0.002)	-0.002	(0.002)	-0.001	(0.002)	-0.001	(0.002)
Age squared	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Gender (male=1)	-0.014	(0.008)	-0.012	(0.008)	-0.008	(0.010)	-0.007	(0.010)
Job fixed effects	Yes		Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes		Yes	
<i>Loan-specific information</i>								
Membership, ln	-0.007*	(0.003)	-0.007*	(0.003)	-0.003	(0.004)	-0.004	(0.004)
Description, ln	-0.002	(0.003)	-0.000	(0.002)	0.001	(0.003)	0.003	(0.003)
Purpose fixed effects	Yes		Yes		Yes		Yes	
<i>Macroeconomic conditions</i>								
Banks' interest rate	-0.221***	(0.029)	-0.203***	(0.024)	-0.224***	(0.038)	-0.130***	(0.028)
Month fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
Fee fixed effects	Yes		No		Yes		No	
Observations	5983		5983		5983		5983	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

ability of obtaining a loan.<sup>32</sup>

A potential concern is that demand is correlated with other observable characteristics. As a robustness check, I ran the same regressions as in table 9 and dropped the regressor *Demand*. The significance and signs of the coefficients remained constant.

### 4.3 Time until the loan is financed

In the previous subsection, I showed that a higher residual interest rate significantly increases investors' willingness to supply. This subsection will first analyze whether a higher residual interest rate also helps loan applicants to obtain their loan faster and then will examine whether impatient loan applicants default more often.

#### 4.3.1 Bid time until requested loan amount is supplied

To examine the speed with which a loan applicant obtains a loan, I regard the bid time from the posting of loan application  $i$  to its closing. To estimate bid time  $b_i$ , I specify the Tobit model

$$b_i = \begin{cases} 0 & \text{if } b_i \leq 1 \\ b_i^* = \beta X_i + \delta f(\tilde{r}_i) + \varepsilon_i & \text{if } 1 < b_i < 20.160 \\ 20.160 & \text{if } b_i \geq 20.160. \end{cases} \quad (11)$$

I cannot observe the bid time if the loan is supplied in the first minute, as in this case investors could theoretically have preferred to supply even faster. I also cannot observe the bid time if the loan application is closed after 14 days and demand still exceeds supply (i.e.,  $S_i < D_i$ ). In this case, more time would be required for the demand to be satisfied. Thus, I can only observe the bid time if  $S_i = D_i$  occurs between the first and the 20,160th minute.<sup>33</sup>

Table 10 shows estimation results. Columns 1 and 2 include all observations, while columns 3 and 4 only include financed loans. Bid time significantly decreases with interest rate, but this effect is non-linear, as it weakens with a higher interest rate. For example, in column 3, a one percentage point higher residual interest rate significantly decreases bid time on average by 88 minutes and increases its square by 3 minutes. A 60-month loan term increases bid time in column 1 by 42, in column 2 by 50, and in columns 3 and 4 by 24 minutes, compared to a 36-month term. Moreover, in columns

<sup>32</sup>Barasinska and Schäfer's (2010) analysis of Smava finds the same result.

<sup>33</sup>14 days times 24 hours/day times 60 minutes/hour = 20,160 minutes.

1 and 2, a risky Schufa rating (F to H) significantly extends the bid time; on the other hand, surprisingly, bid time decreases with a KDF indicating a higher risk.

A potential concern of the estimation results in table 10 is that a larger demand increases bid time. To address this concern, I could simply control for *Demand*. However, if observable characteristics indicate a lower risk, investors may be willing to supply more. If observationally less risky loan applicants anticipate this, they may, on average, demand more. In turn, investors may supply loans faster even though demand is greater. To prevent this problem, I focus on investors' bid speed instead of bid time. As a proxy for bid speed, I use the average bid size per minute, denoted by  $B_i \equiv D_i/b_i$ . To estimate  $B_i$ , I specify the Tobit model

$$B_i = \begin{cases} 0 & \text{if } B_i \leq 0 \\ B_i^* = \beta X_i + \delta f(\tilde{r}_i) + \varepsilon_i & \text{if } 0 < B_i < D_i \\ D_i & \text{if } B_i \geq D_i. \end{cases} \quad (12)$$

I cannot observe  $B_i$  if investors do not supply anything during the 14-day bid period (i.e. if  $B_i = 0$ ). If, in contrast, a loan request is granted immediately in the first minute, this results in  $B_i = D_i$ ; in this case, I cannot observe whether investors would have preferred to supply more. Thus, I can only observe  $B^*$  if  $0 < B_i < D_i$ .

Table 11 shows estimation results. Columns 1 and 2 include all observations, while columns 3 and 4 include only financed loans. In the first two columns, residual interest rate non-linearly increases bid size per minute, while in the last two columns it has only a linear effect.<sup>34</sup> For example, in column 1, a one percentage point higher residual interest rate increases the bid size per minute by €2.631, but its square only decreases the bid size by €80 per minute. In column 3, a one percentage point higher residual interest rate increases the bid size per minute by €180 per minute. In fact, in all columns, riskier Schufa classes have a significantly negative impact on bid speed. In contrast, investors have a higher bid speed if KDF indicates a higher risk as well as if the term of the loan is longer.

#### 4.3.2 Instant loan

In the previous subsection, I showed that a higher interest rate induces investors to provide a loan faster or with a higher probability. However, a loan applicant may

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<sup>34</sup>I ran robustness checks controlling for residual interest rate linearly and non-linearly and compared the AIC and the BIC. The regressions with the lowest values are shown in table 11.

Table 10: **Hidden information and bid time.** Tobit regression with lower limit of one and upper limit of 20,160 as the dependent variable bid time (minutes) is censored. Columns 1 and 2 contain all loan applications, while columns 3 and 4 contain only financed loans. Columns 1 and 3 control for residual interest rate as well as for fee dummies, column 2 controls for internal rate of return for investors based on requested loan amount, and column 4 controls for internal rate of return for investors based on loan size.

	(1)		(2)		(3)		(4)	
	Bid time		Bid time		Bid time		Bid time	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Residual interest rate	-55.777***	(3.974)			-87.767***	(7.873)		
Residual interest rate squared	1.541***	(0.165)			3.026***	(0.299)		
Residual IRR investors(lenders)			-53.387***	(3.531)			-59.185***	(5.601)
Residual IRR inv.(lend.) squ.			1.420***	(0.137)			2.264***	(0.242)
Term (60 months=1)	42.333***	(3.024)	50.053***	(3.012)	24.839***	(2.807)	23.558***	(2.784)
<i>Risk characteristics</i>								
Schufa rating								
B	0.841	(4.319)	0.269	(4.321)	-1.207	(3.858)	-1.091	(3.869)
C	-5.091	(5.166)	-6.569	(5.167)	-6.467	(4.613)	-6.244	(4.626)
D	1.784	(5.127)	0.124	(5.130)	-3.929	(4.631)	-3.871	(4.644)
E	0.915	(5.131)	-2.070	(5.139)	-4.203	(4.666)	-4.135	(4.681)
F	21.337***	(5.026)	17.704***	(5.033)	12.530**	(4.620)	12.393**	(4.636)
G	21.032***	(4.772)	17.561***	(4.774)	9.283*	(4.428)	9.371*	(4.444)
H	14.023**	(5.414)	8.861	(5.420)	-0.148	(5.102)	0.360	(5.124)
KDF indicator								
2	-27.423***	(4.246)	-27.251***	(4.247)	7.270	(4.344)	6.731	(4.355)
3	-37.636***	(4.098)	-37.853***	(4.096)	8.204	(4.200)	7.510	(4.209)
4	-49.071***	(4.448)	-49.645***	(4.441)	5.157	(4.478)	4.413	(4.486)
<i>Socio-economic characteristics</i>								
Age	1.398*	(0.626)	1.412*	(0.626)	0.546	(0.582)	0.622	(0.583)
Age squared	-0.009	(0.007)	-0.009	(0.007)	-0.002	(0.006)	-0.003	(0.006)
Gender (male=1)	7.144*	(2.908)	6.819*	(2.909)	3.228	(2.653)	3.019	(2.661)
Job fixed effects	Yes		Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes		Yes	
<i>Loan-specific information</i>								
Membership, ln	1.541	(1.086)	1.510	(1.085)	0.271	(0.970)	0.250	(0.970)
Description, ln	5.040***	(0.829)	4.634***	(0.821)	4.251***	(0.754)	4.508***	(0.749)
Purpose fixed effects	Yes		Yes		Yes		Yes	
<i>Macroeconomic conditions</i>								
Banks' interest rate	107.903***	(11.946)	110.794***	(8.485)	67.934***	(11.184)	92.465***	(7.929)
Month fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
Fee fixed effects	Yes		No		Yes		No	
Constant	-113.788	(87.770)	-75.543	(61.304)	318.676***	(94.769)	-101.011	(61.764)
sigma constant	98.184***	(0.898)	98.253***	(0.898)	82.463***	(0.822)	82.719***	(0.825)
Pseudo R sq	0.037		0.036		0.019		0.018	
p value	0.000		0.000		0.000		0.000	
Observations	5983		5983		5026		5026	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

Table 11: **Hidden information and bid speed.** Tobit regression with lower limit zero and variable upper limit demand  $D_i$  as the dependent variable bid speed (bid size per minute) is censored.  $D_i$  can vary for every loan application  $i$ . Columns 1 and 2 contain all loan applications, while columns 3 and 4 contain only financed loans. Columns 1 and 3 control for residual interest rate as well as for fee dummies, column 2 controls for internal rate of return for investors based on requested loan amount, and column 4 controls for internal rate of return for investors based on loan size.

	(1)		(2)		(3)		(4)	
	Size/min		Size/min		Size/min		Size/min	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
<i>Contractual characteristics</i>								
Residual interest rate	2.631***	(0.306)			0.180***	(0.052)		
Residual interest rate squared	-0.080***	(0.012)						
Residual IRR investors			1.972***	(0.247)				
Residual IRR investors squared			-0.051***	(0.009)				
Residual IRR lenders							0.149**	(0.047)
Term (60 months=1)	1.852***	(0.176)	1.534***	(0.176)	2.558***	(0.185)	2.592***	(0.183)
<i>Risk characteristics</i>								
Schufa rating								
B	-0.884***	(0.247)	-0.863***	(0.246)	-0.776**	(0.251)	-0.775**	(0.251)
C	-0.972***	(0.295)	-0.930**	(0.295)	-1.108***	(0.300)	-1.111***	(0.300)
D	-1.399***	(0.295)	-1.345***	(0.294)	-1.355***	(0.303)	-1.345***	(0.302)
E	-1.404***	(0.297)	-1.313***	(0.297)	-1.438***	(0.306)	-1.438***	(0.306)
F	-1.757***	(0.289)	-1.645***	(0.289)	-1.606***	(0.302)	-1.598***	(0.302)
G	-2.042***	(0.274)	-1.946***	(0.273)	-1.811***	(0.286)	-1.815***	(0.286)
H	-2.900***	(0.312)	-2.776***	(0.311)	-2.865***	(0.326)	-2.872***	(0.326)
KDF indicator								
2	1.919***	(0.247)	1.928***	(0.246)	1.207***	(0.286)	1.220***	(0.285)
3	3.027***	(0.238)	3.041***	(0.237)	1.927***	(0.275)	1.940***	(0.275)
4	2.988***	(0.256)	3.010***	(0.255)	1.577***	(0.292)	1.587***	(0.292)
<i>Socio-economic characteristics</i>								
Age	-0.039	(0.036)	-0.039	(0.036)	-0.002	(0.038)	-0.004	(0.038)
Age squared	0.001	(0.000)	0.001	(0.000)	0.000	(0.000)	0.000	(0.000)
Gender (male=1)	0.082	(0.167)	0.101	(0.167)	0.248	(0.173)	0.253	(0.173)
Job fixed effects	Yes		Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes		Yes	
<i>Loan-specific information</i>								
Membership, ln	-0.390***	(0.062)	-0.393***	(0.062)	-0.412***	(0.063)	-0.412***	(0.063)
Description, ln	-0.016	(0.048)	-0.004	(0.047)	0.053	(0.049)	0.050	(0.049)
Purpose fixed effects	Yes		Yes		Yes		Yes	
<i>Macroeconomic conditions</i>								
Banks' interest rate	-1.289	(0.676)	-1.454**	(0.483)	0.535	(0.715)	-0.216	(0.511)
Month fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
Fee fixed effects	Yes		No		Yes		No	
Constant	-7.625	(5.166)	-5.433	(3.634)	-1.950	(5.052)	3.296	(3.432)
lnsigma constant	1.667***	(0.010)	1.665***	(0.010)	1.625***	(0.011)	1.625***	(0.011)
p value	0.000		0.000		0.000		0.000	
Observations	5983		5983		5026		5026	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

not offer a higher interest rate for that purpose; instead, he may have other reasons which I cannot observe. If this is the case, then impatience may not be the reason that observationally identical but unobservably riskier borrowers are willing to pay a higher interest rate.

To address this potential concern, I examine Smava’s instant loan service as an applicant must access it before posting his loan request. This service helps impatient applicants to obtain their loan within a few minutes or hours. In practice, Smava proposes a sufficiently high interest rate through this service to enable a loan applicant to get his loan financed instantly. Thus, by choosing the proposed interest rate for an instant loan, a loan applicant unambiguously pays a higher interest rate because he is impatient.

However, I cannot observe whether a peer has used the instant loan service before posting his current loan application, as Smava does not publish this information. Hence, I use a proxy to indicate an instant loan; following Smava’s definition of an ‘instant’ loan as a loan financed within a few minutes or hours, I specify a loan as instant if its bid time does not exceed a certain number of minutes. As a robustness check, I vary this number of minutes.

Table 12 shows the results of the estimation of the hazard rate using the Cox proportional hazard rate model. In columns 1, 2 and 3, I define a loan as instant if its bid time does not exceed 4, 120 or 1,000 minutes respectively. In column 4, I control for the bid time nonlinearly as a proxy for the expected bid time, in order to analyze its effect on default risk.

Columns 1 to 3 show that borrowers who choose an instant loan have significantly higher default risk. In column 1, borrowers who raise an instant loan have a 78.2 percent higher hazard risk than borrowers who raise loans more slowly. If the bid time exceeds four minutes, the probability that some of the loans I define as ‘instant’ are in actuality *not* instant increases. In these cases, borrowers obtain their loans quickly because they offer a higher interest rate for other purposes or simply due to luck, rather than because they have used Smava’s instant loan service or wanted to have the loan financed instantly. Results in columns 2 and 3 indicate that borrowers who wait longer for their loans default significantly less often. While in column 2 borrowers with an instant loan have a 47.7 percent higher risk than other borrowers, this percentage decreases to 42.2 percent in column 3. However, a shorter bid time does not always mean a higher default risk; column 4 shows a non-linear relationship between bid time and default risk.



Although the dummy for an instant loan has a strong impact on default risk, a higher residual interest rate still has a significant non-linear impact on default risk. For example, in column 1, a one percent higher residual interest rate increases the hazard ratio by 20 percent, but its square only decreases the ratio by 0.6 percent. This result is remarkable, as a higher interest rate could also capture the effect of the dummy that indicates an instant loan. This could make my indicator for an instant loan insignificant and works against me. The fact that the residual interest rate still has a significant and positive effect indicates a strong link between impatience and default risk which cannot be justified merely by the effect of a higher residual interest rate.

In a robustness check, I control for residual interest rate instead of for residual internal rate of return for investors. In this case, residual interest rate has a significant effect on default risk but does not have a non-linear effect.

## 5 Disclosure of information through starting interest rate

The main result of this chapter is that observationally identical but unobservably riskier applicants pay a higher interest rate because they are more impatient to obtain a loan. Up to this point, I have only analyzed the role of the final interest rate that is paid in the event of a legally valid loan business. However, this is not the only information about interest rate contained in my sample.

With the initial posting of the loan application, applicants offer a starting interest rate. During the bid period, they have the opportunity to raise this starting rate. If they do so, their final interest rate will be higher than their starting interest rate. Previous results suggest that the starting interest rate contains some private information about default risk for two reasons. First, less risky but observationally identical applicants are more sensitive to the interest rate and may be more likely to prefer to start with a lower interest rate. Second, more patient applicants are willing to wait longer in exchange for a lower interest rate. Both of these reasons give them an incentive to start with a lower interest rate than the final rate.

To test this, I run a Cox proportional hazard rate estimation, as shown in table 13. In column 1, I additionally include a dummy that is equal to one if the starting interest rate is lower than the final interest rate and is equal to zero otherwise; in column 2, I control for the difference between final and starting interest rate.

Table 12: **Instant loans and default risk.** Cox proportional hazard regression with dependent variable hazard ratio, which is the exponentiated hazard rate. Columns 1, 2 and 3 include a dummy for all loans that are granted until the 4th, 120th and 1,000th bid minute, respectively. Column 4 controls for bid time and its square in days.

	(1)		(2)		(3)		(4)	
	Hazard ratio		Hazard ratio		Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>								
Residual IRR borrower	1.200***	(0.054)	1.186***	(0.054)	1.187***	(0.054)	1.199***	(0.055)
Residual IRR borrower squared	0.994**	(0.002)	0.995*	(0.002)	0.995*	(0.002)	0.995*	(0.002)
Instant loan (=1 if $\leq$ 4th min)	1.782***	(0.069)						
Instant loan (=1 if $\leq$ 120th min)			1.477***	(0.050)				
Instant loan (=1 if $\leq$ 1000th min)					1.422***	(0.045)		
Bid time (days)							0.912***	(0.011)
Bid time (days) squared							1.005***	(0.001)
Size (€1,000s)	1.063***	(0.008)	1.064***	(0.008)	1.064***	(0.008)	1.065***	(0.008)
Size squared(€1,000s)	0.999***	(0.000)	0.998***	(0.000)	0.998***	(0.000)	0.998***	(0.000)
Term (60 months=1)	1.173***	(0.038)	1.174***	(0.038)	1.170***	(0.038)	1.161***	(0.038)
<i>Risk characteristics</i>								
Schufa rating								
B	1.430***	(0.082)	1.424***	(0.082)	1.449***	(0.083)	1.474***	(0.085)
C	1.756***	(0.109)	1.721***	(0.107)	1.755***	(0.109)	1.782***	(0.110)
D	1.289***	(0.089)	1.282***	(0.088)	1.292***	(0.089)	1.283***	(0.088)
E	3.493***	(0.195)	3.479***	(0.195)	3.496***	(0.196)	3.536***	(0.198)
F	2.679***	(0.154)	2.692***	(0.155)	2.738***	(0.157)	2.717***	(0.156)
G	3.714***	(0.202)	3.717***	(0.202)	3.739***	(0.204)	3.724***	(0.203)
H	6.194***	(0.348)	6.230***	(0.350)	6.343***	(0.357)	6.427***	(0.363)
KDF indicator								
2	1.973***	(0.142)	1.955***	(0.141)	1.977***	(0.142)	2.025***	(0.146)
3	2.766***	(0.192)	2.747***	(0.190)	2.758***	(0.191)	2.811***	(0.195)
4	3.304***	(0.229)	3.281***	(0.228)	3.288***	(0.228)	3.352***	(0.232)
<i>Socio-economic characteristics</i>								
Age	0.931***	(0.005)	0.929***	(0.005)	0.930***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.930*	(0.027)	0.931*	(0.027)	0.925**	(0.026)	0.927**	(0.026)
Job fixed effects	Yes		Yes		Yes		Yes	
Residence fixed effects	Yes		Yes		Yes		Yes	
<i>Loan-specific information</i>								
Membership, ln	1.107***	(0.012)	1.109***	(0.012)	1.104***	(0.012)	1.099***	(0.012)
Description, ln	0.927***	(0.009)	0.922***	(0.009)	0.920***	(0.009)	0.920***	(0.009)
Purpose fixed effects	Yes		Yes		Yes		Yes	
<i>Macroeconomic conditions</i>								
Banks' interest rate	2.274***	(0.199)	2.180***	(0.191)	2.081***	(0.180)	2.012***	(0.173)
Month fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
Pseudo R sq	0.038		0.038		0.038		0.038	
AIC	143266.124		143345.851		143355.320		143369.800	
BIC	143976.771		144056.499		144065.967		144090.182	
p value	0.000		0.000		0.000		0.000	
Observations	124853		124853		124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

Table 13: **Starting interest rate and default risk.** Cox proportional hazard regression with dependent variable hazard ratio, which is the exponentiated hazard rate. Column 1 includes a dummy that is equal to one if the starting interest rate is lower than the final interest rate and is equal to zero otherwise; column 2 includes the difference between final and starting interest rate.

	(1)		(2)	
	Hazard ratio		Hazard ratio	
	exp(Coef.)	Std. err.	exp(Coef.)	Std. err.
<i>Contractual characteristics</i>				
Residual IRR borrower	1.247***	(0.057)	1.263***	(0.057)
Residual IRR borrower squared	0.993**	(0.002)	0.993***	(0.002)
Interest rate raised	0.796***	(0.025)		
Final - start rate			0.966***	(0.009)
Size (€1,000s)	1.050***	(0.007)	1.046***	(0.007)
Size squared(€1,000s)	0.999***	(0.000)	0.999***	(0.000)
Term (60 months=1)	1.150***	(0.037)	1.141***	(0.037)
<i>Risk characteristics</i>				
Schufa rating				
B	1.455***	(0.083)	1.446***	(0.083)
C	1.778***	(0.110)	1.769***	(0.110)
D	1.309***	(0.090)	1.301***	(0.090)
E	3.540***	(0.198)	3.548***	(0.199)
F	2.655***	(0.153)	2.651***	(0.152)
G	3.705***	(0.202)	3.678***	(0.200)
H	6.244***	(0.352)	6.234***	(0.352)
KDF indicator				
2	1.985***	(0.143)	1.983***	(0.143)
3	2.754***	(0.191)	2.754***	(0.191)
4	3.309***	(0.230)	3.288***	(0.228)
<i>Socio-economic characteristics</i>				
Age	0.930***	(0.005)	0.931***	(0.005)
Age squared	1.001***	(0.000)	1.001***	(0.000)
Gender (male=1)	0.913**	(0.026)	0.913**	(0.026)
Job fixed effects	Yes		Yes	
Residence fixed effects	Yes		Yes	
<i>Loan-specific information</i>				
Membership, ln	1.099***	(0.012)	1.093***	(0.012)
Description, ln	0.915***	(0.009)	0.911***	(0.009)
Purpose fixed effects	Yes		Yes	
<i>Macroeconomic conditions</i>				
Banks' interest rate	1.770***	(0.150)	1.675***	(0.141)
Month fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Pseudo R sq	0.037		0.037	
p value	0.000		0.000	
Observations	124853		124853	

Notes: \*, \*\* and \*\*\* denote significance on the 5%, 1% and 0.1% levels respectively.

The starting interest rate is a significant signal for a loan applicant's privately known default risk. In particular, with a starting interest rate smaller than the final interest rate is an important signal, as it decreases the hazard ratio by 20.4%. Conversely, a final interest rate one percentage point higher than the starting interest rate significantly decreases the hazard ratio by 3.4%.

## 6 Conclusions

This chapter uses data from the unique German online lending platform Smava to develop a new empirical strategy to identify hidden information about default risk. It shows that borrowers signal hidden information about their default risk as a result of their impatience. Observationally identical but unobservably riskier borrowers offer a significantly higher residual interest rate, which induces investors to supply more and thus to grant the loan faster and with a higher probability. On average, very impatient borrowers who use Smava's instant loan service to obtain a loan within a few minutes or hours are riskier than less impatient other borrowers.

These insights contribute to a better understanding of which contractual instruments are effective in screening borrowers' privately known riskiness. Nonetheless, this study leaves several questions open for future research. Although it describes how impatience helps to screen borrowers' riskiness, it does not disentangle different types of impatience (e.g. the speed or the probability of obtaining the loan). Moreover, it identifies borrowers' impatience solely via their contract choice. This raises the question of how to identify impatience that is related to default risk. This could be especially important for credit rating agencies as it helps them to mitigate asymmetric information.

## Appendix

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Table 14: Variable definitions

<i>Contractual characteristics</i>	
Interest rate	Final nominal annual interest rate
IRR	Internal rate of return
Size (€1,000s)	Actual size of the loan
Term (60 months=1)	Dummy variable that takes a value of one if duration of the loan is 60 months and zero if duration is 36 months
Demand (€1,000s)	Requested loan amount
Supply (€1,000s)	Aggregated supply of a loan application
Instant loan	Dummy variable that takes a value of one if the loan is granted until the 4th, 120th or 1,000th bid minute and zero otherwise
Interest rate raised	Dummy variable that takes a value of one if loan applicant has raised interest rate during bid period
Final - start rate	Final minus starting nominal annual interest rate
<i>Risk characteristics</i>	
Schufa rating	8 dummy variables A (lowest risk) to H (highest risk)
KDF indicator	4 dummy variables 1 (the lowest) to 4 (the highest financial burden)
<i>Socio-economic characteristics</i>	
Age	Age of loan applicant at date of application
Gender (male=1)	Dummy variable that takes a value of one if male and zero if female
Job fixed effects	3 dummy variables that indicate whether loan applicant is blue/white-collar employee, public officer or pensioner
Residence fixed effects	16 dummy variables that indicate state of the loan applicant's residence in Germany
<i>Loan-specific information</i>	
Membership, ln	Logarithm of time between date of becoming a peer and date of applying for the loan
Description, ln	Logarithm of the number of characters in the description provided with the loan application
Purpose fixed effects	17 dummy variables that indicate purpose of loan
<i>Macroeconomic conditions</i>	
Bank's interest rate	Average loan rate in a month that banks charge on the consumer loan market
Fee fixed effects	3 dummy variables that indicate Smava's fee policy at the date of the loan application