The Organization of Credit Risk Management in Banks: Hard versus Soft Information ⋆

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Abstract

We investigate the impact of the information's type on credit risk management in a principal-agent framework with moral hazard with hidden information. The results show that access to soft information allows the banker to decrease the capital allocation for VaR coverage. We also show the existence of an incentive of the credit officer to manipulate the signal based on soft information that he produces. Therefore, we implement an adequate incentive salary package which prevent this manipulation. The comparison of the results from the two frameworks (hard information versus a combination of hard and soft information) using simulations confirms that soft information gives advantages to the banker but requires particular organizational modifications within the bank.

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1 Introduction

Information remains a crucial input for the banking industry. Banks face information's asymmetry problems because of borrowers' informational opacity. This opacity varies with borrower's type, the SMEs being considered as the most opaque (because of lack of public information). In order to resolve this informational asymmetry, the bank can acquire two types of information: hard information, which is external, via public information (balance sheet data, scoring ...), and soft information, which is internal, via bank-borrower relationship (judgement, opinions, notes, reports ...). The type of information also implies two lending technologies : transaction lending versus relationship banking.

A recent stream of literature puts forward the distinctions to be made between hard and soft information (Petersen, 2004). Taking into account soft information in risk analysis can increase the precision of borrowers' quality estimation (Lehmann, 2003; Grunert et al., 2005), but has the disadvantage of being non verifiable by a third party and therefore manipulable. This type of information can influence credit risk management in banks, but may also have an impact on banks' organizational structure, which should be adapted to soft information in order to avoid the consequences and the costs of its manipulation (Berger and Udell, 2002; Stein, 2002; Berger et al., 2005).

Recent research on risk management in banks puts forward the importance of information's processing. Hakenes (2004) considers the banker as a "specialist" of information's processing and the monitoring of risk. Danielsson et al. (2002) analyze bank's choice of risks management system, investigating different levels of power delegation implying more or less transmission of information. However, this stream of research doesn't distinguish hard and soft information.

Therefore, this article investigates the impact of information's type on the balance sheet structure and organization in terms of credit risk management of the bank. We propose a theoretical model of the credit decision within a principal-agent framework with a bank director and a credit officer. The director allocates equity for Value at Risk coverage. He also decides on the officer's budget, as well as his wage, which are both a function of a signal, based on hard information only or a combination of hard and soft information. The difference between the two types of signal lies in their nature - their verifiability and manipulability - as well as their level of precision. A combination of hard and soft information is more precise than hard information only, but is not verifiable by a third party because of the soft component. Soft information is therefore a source of moral hazard with hidden information. It is a potential driver of organizational modifications in the bank in order to limit the moral hazard problem.

We show that taking into account soft information in risk management can allow to economize equity for VaR coverage, under certain conditions. However, we also verify the existence of the soft information's manipulation incentive by the credit officer. We then propose a wage contract to prevent this manipulation. Thus, the influence of soft information on banks' organizational structure is modelled through a specific salary package. The comparison of solutions from the two frameworks (one with hard information only versus a combination of hard and soft information), realized with numerical simulations, confirms that the soft information's component allows to reduce equity for VaR coverage.

This article is particularly related to the field of research dealing with the relationship between the type of information produced in the banking industry for risk management purpose, the lending technology, and the organizational design of the financial institutions (Berger and Udell, 2002; Stein, 2002; Takats, 2004; Berger et al., 2005). It is also related to the literature investigating the role of wage contracts and budget allocation mechanisms in providing proper incentives to agents producing and transmitting relevant information (Bhattacharya and Pfleiderer, 1985; Bernardo et al., 2001; Ozbas, 2005). However, we additionally take explicitly into account the type of information (hard versus soft).

The rest of this article is organized as follows. In section 2, we present the elements allowing to distinguish hard from soft information, as well as recent empirical and theoretical research investigating information's type influence on banks' organizational structure. The credit risk decision model is presented in section 3. Sections 4 and 5 provides results in the hard information's case, and deduce pros and cons of soft information, in particular the existence of a manipulation incentive in presence of a soft information based signal. An incentive wage contract for the officer is then proposed to resolve the manipulation problem in section 6. Finally, the results from the comparison of the hard information and the combination of hard and soft information cases, using numerical solutions, are presented in section 7. Section 8 concludes the article.

2 Hard information versus soft information and the organizational structure of banks

Three types of dimensions can allow to distinguish hard information from soft information:

- **nature**: hard information is quantitative - "numbers" (in finance these are balance sheet data, asset returns . . .); soft information is qualitative - "words" (opinions, ideas, projects, comments . . .); hard information is rather "backward looking" (e.g. balance sheet data) as soft information is rather "forward looking" (e.g. business plan).
- **collecting method**: the collection of hard information is impersonal and independent from the context of its production (hard information is therefore exhaustive and explicit); collecting soft information is personal and includes its production and treatment context.
- **cognitive factors**[1]: subjective judgement, interpretations, opinions and perception are absent in hard information, whereas they are integral components of soft information.
- **lending technology**: hard information is produced with transaction lending technology; soft information is the output of a bank-borrower relationship technology.

These dimensions imply several advantages for each type of information. Regarding hard information, these are:

- a low cost, as the processing technology of hard information is easily automated, it implies competitive and productivity gains, as well as standardization and economies of scope and scale,
- an important duration, as hard information is easily collected, stockable and transmissible,
- an easier comparability, allowing to separate processes of collecting and using the information, and therefore an easier delegation of collection, production and treatment functions,
- verifiability by a third party.

The practical advantages of hard information is confirmed by empirical research by Berger et al. (2002) and Frame et al. (2001), who analyse credit scoring[2]. It is shown that scoring can reduce the cost of credit risk and increase credit risk decision's speed, and increase the amount of loans and implement risk adjusted pricing, with a decrease in credit rationing.

Regarding soft information, its most particular characteristic is to be tightly linked to the environment and context where it was produced. In the banking framework, this environment is the bank-borrower relationship, which,

[1] Kirschenheiter (2002) proposes to define hard and soft information in an accounting framework as follows:

> "Hard information (. . .) is when everyone agrees on its meaning. (. . .) Honest disagreements arise when two people perfectly observe information yet interpret this information differently (*i.e.* soft information)".

[2] In these articles, credit scoring is based on hard information only.

through multiple interactions in time, gives access to private and confidential information, superior to publicly available information (Boot, 2000; Berger et al., 2004; Elsas, 2005).

Soft information's capacity to increase hard information's predictive power is documented by empirical research which aims at investigating the impact of qualitative factors on default risk prediction [3]. The integration of qualitative factors into default risk prediction models increases their discrimination and reclassification performance, and therefore default prediction accuracy (Lehmann, 2003; Grunert et al., 2005). Also, qualitative factors appear to be less dispersed and more stable.

Thus, soft information has the advantage to increase the predictive capacity of hard information, but remains non verifiable by a third party. Effectively, in case of disagreement upon soft information between two agents, it is impossible for a third party to settle who is right. Therefore, this type of information is easily manipulable by the agent responsible of its production and treatment, and therefore implies a particular organizational structure.

The adaptation of the organizational structure to the type of information used in banking has received a first theoretical evidence by Stein (2002), who investigates the influence of banks' organizational structure on their optimal funds allocation's decision. He supposes that in a large bank, processes of collecting and treating information, needed for credit decision, are separated. Thus, the information must be easily transmissible to superior hierarchical levels. It should also be easily interpretable in an uniform manner, independently of the production's context and the agent's in charge of its treatment. In his model, Stein (2002) shows the existence of an adequacy between organizational structure and information type, allowing optimal funds' allocation, through better incentives. Soft information is associated with decentralized and less hierarchical organizations, because they provide the agent with more power and authority [4]. In such a framework, he has better incentives to make efficient use of his information in the funds' allocation process. Hard information is associated with centralized and more hierarchical organizations, because it facilitates its transmission to superior hierarchical levels where funds' allocation

[3] These studies use in particular bank's internal ratings which are integrated into default risk prediction models, along with hard balance sheet and financial factors. A strong part of these internal rating are based on qualitative factors, and therefore soft information, as management quality or business perspectives of the borrower. For example, following results of Günther and Grüning (2000), 70 out of 145 German banks surveyed on their risk management process answered that their internal ratings are strongly based on such qualitative factors.

[4] Let's note that in an world of incomplete contracts, the incentives of agents depend on their control of allocated assets (Hart and Moore, 1990; Hart, 1995; Harris and Raviv, 1996, 1998).

decision is made. In summary, the type of information implies a more or less important level of authority and power delegation toward the agent in charge of information's treatment.

Several empirical studies confirm this theoretical evidence (Berger et al., 2001; Berger et al., 2002; Berger and Udell, 2002; Berger et al., 2005; Liberti and Mia, 2006). In a bank-borrower relationship framework, the production and treatment of information is delegated to a credit officer, who therefore receives strong authority and power, because of possible manipulation of soft information. In this context, the officer has a crucial position within the bank. Small, less hierarchical and decentralized organizations are more suitable for relationship banking. Therefore, small banks are considered to have a superior capacity in processing soft information in the framework of bank-borrower long term relationships (DeYoung et al., 2004; Scott, 2004; Berger, 2006; Uchida et al., 2006). When SMEs face external finance choice, they usually prefer small banks, in order to reduce credit rationing.

Stein (2002) focuses on a specific feature of soft information: its non credible transmission to upper hierarchical levels, where the decision upon budget allocation is made. The solution he proposes to this problem relies on a different organizational structure of the bank, with less hierarchy and centralization of the credit decision. However, the non credible transmission of soft information is a consequence of its non verifiability by a third party. Thus, we focus on this particular feature of soft information which implies its manipulability. The solution we propose to this problem relies on a different wage contract, which provides the right incentives to the agent in charge of producing soft information and make its transmission credible, while keeping the hierarchical organization of the bank intact.

3 The credit risk decision model

The following model allows us to investigate the role of information's type in bank's credit risk management and organizational structure. The credit decision is modelled within a principal-agent framework with a bank director or a banker (the principal) and a credit officer (the agent) over one time period.

The banker is supposed to take his decisions regarding the composition of the balance sheet and risk management, using the information provided by the agent. The banker's utility is defined on bank's profit. The bank's balance sheet is composed of risky assets A, deposits D and equity E:

Balance sheet

A	E
	D

The risky assets' random return is $\tilde{r}_A$. The deposits cost r_D is exogenous and strictly positive. The credit officer wage is w, eventually function of assets' return $\tilde{r}_A$, so that $w = w(\tilde{r}_A)$.

The bank's profit $\tilde{\Pi}$ is:

$$\tilde{\Pi} = \tilde{r}_A A - r_D D - w(\tilde{r}_A) - c, \tag{1}$$

with c being an unemployment insurance cost for the credit officer, which we normalize to 0.

The principal and the agent have both CARA utility functions.

Banker's utility is defined as:

$$U_B = -\exp^{-\beta(\tilde{\Pi})}. \tag{2}$$

Credit officer's utility is supposed to be increasing with the amount and the development of his budget, which is allocated by the banker, and with his wage $w(\tilde{r}_A)$. The allocated budget corresponds to the assets A. Officer's utility is thus defined as:

$$U_C = -\exp^{-\gamma(\tilde{r}_A A + w(\tilde{r}_A))}. \tag{3}$$

The information collected, treated and produced by the credit officer is provided to the banker through a signal on the risky assets' return $\tilde{r}_A$. This signal, noted $\tilde{\mu}$, informs about the distribution of assets return. We suppose that this signal follows a normal distribution $N(\bar{\mu}, \upsilon^2)$. It is correlated with the return as follows:

$$\tilde{r}_A = \tilde{\mu} + \tilde{\varepsilon}, \tag{4}$$

where $\tilde{\varepsilon}$ has a normal distribution $N(0, \sigma^2)$. $\tilde{\mu}$ and $\tilde{\varepsilon}$ are supposed to be uncorrelated. The *a posteriori* distribution of $\tilde{r}_A$ conditional on the realization of $\tilde{\mu}$ is therefore $(\tilde{r}_A \mid \mu) \sim N(\mu, \sigma^2)$.

Two types of information are available to the credit officer: hard or soft information. Hard information is supposed to be verifiable by a third party, but using exclusively this type of information provides less precise predictions concerning borrower's quality, compared to a combination of hard and soft information, the latter being non verifiable by a third party. The difference in the level of precision between these two types of information is modelled through the error term $\tilde{\varepsilon}$ from equation (4). A signal based on hard information has an error term with standard deviation σ_H, whereas a signal based on a combination of hard and soft information has an error term with standard deviation σ_S, with $\sigma_S < \sigma_H$ [5].

The information concerning the return on risky assets is used for risk management purpose. The banker covers credit portfolio risk, measured as the Value at Risk [6], with equity E. VaR corresponds to the minimum level of equity E so that the accepted bank's default probability equals α (e.g. 1%). It is denoted VaR_α. Bank's default occurs when the value of its assets is lower than the value of its deposits [7]:

$$prob\,[A(1+\tilde{r}_A) - D(1+r_D) < 0] = \alpha. \tag{5}$$

Taking into account the balance sheet's constraint $(K + D - A = 0)$, we can infer the VaR per unit of risky assets at the accepted level of losses α, denoted r_α (see appendix for details) [8]:

$$r_\alpha = \frac{r_D - \mu - u_\alpha \sigma}{1 + r_D}, \tag{6}$$

and

$$VaR_\alpha = r_\alpha A, \tag{7}$$

with u_α corresponding to the α level fractile of a normal distribution $N(0,1)$ [9].

[5] In the rest of this article, we will take into account subscripts H and S only if it is strictly necessary.
[6] See Jorion (2000) for an extensive presentation and discussion of the Value at Risk.
[7] In case of default, the credit officer's wage is guaranteed by the unemployment insurance.
[8] See also Broll and Wahl (2003).
[9] We suppose that the accepted bank's default probabilities α is lower than 50% so

It is important to notice that the VaR per unit of risky assets r_α depends on the signal, particularly the information's type, as it is demonstrated by the presence of the mean μ and the standard-deviation σ of the *a posteriori* distribution of $\tilde{r}_A$ in equation (6). Therefore, the type of information used for credit risk management purposes will have an impact on equity allocation for VaR coverage.

We state $r_\alpha > 0$, which means that for every risky assets unit, the banker allocates a positive unit of equity to cover default risk. This also implies that $\mu < r_D - u_\alpha \sigma$. We remark that r_α increases with σ. The more the signal on the distribution of return is precise, i.e. low σ, corresponding to a signal based on a combination of hard and soft information, the more the VaR per unit of risky assets r_α is lower, allowing economies of equity for the banker.

4 The hard information's case

In this section we suppose that the credit officer uses hard information only (e.g. a scoring system). The error term's ε standard deviation is equal to σ_H [10].

In a first step, the banker decides on the credit officer's wage contract, knowing that the latter will provide the signal $\tilde{\mu}$. In a second step, the banker takes his decisions concerning equity E, risky assets A and deposits D, as functions of the transmitted signal. The latter is supposed to be verifiable and not manipulable. Therefore, the information provided by the credit officer to the banker is considered as credible.

We suppose that the credit officer's wage contract includes a fixed part only, w_0, so that

$$E_{\tilde{r}_A}(w) = w(\tilde{r}_A) = w_0. \tag{8}$$

The banker's decision concerning the wage contract is therefore focused only on its fixed part, which should be adjusted in order to assure that the wage contract is acceptable by the credit officer.

that the fractile u_α is negative.

[10] In what follows, we drop the subscript H in the notations.

The banker's optimization program is the following:

$$
\max_{w_0,E,A,D} EU_B,
$$
$$
\begin{cases}
EU_C \geq \bar{U}, \\
E, A, D \in \arg\max_{\hat{E},\hat{A},\hat{D}} EU_B \\
\begin{cases}
\hat{E} + \hat{D} - \hat{A} = 0, \\
\hat{E} - VaR_\alpha \geq 0, \\
VaR_\alpha = r_\alpha \hat{A} = \frac{r_D - \mu - u_\alpha \sigma}{1 + r_D} \hat{A}.
\end{cases}
\end{cases}
\tag{9}
$$

with

$$
EU_B = \int_{-\infty}^{+\infty} - \exp^{[-\beta(\tilde{r}_A A - r_D D - w_0)]} \eta(\tilde{r}_A|\mu) dr_A,
$$

$$
EU_C = \int_{-\infty}^{+\infty} - \exp^{[-\gamma(\tilde{r}_A A + w_0)]} \eta(\tilde{r}_A|\mu) dr_A,
$$

and

$$
\bar{U} = - \exp^{-\gamma v}.
$$

In the program (9), the first constraint corresponds to the credit officer's participation constraint, where $\bar{U}$ is his reservation utility's level (with v being his reservation's value), and the next three constraints from the sub-optimization program affect the banker's choice of the balance sheet's variables, and correspond respectively to the balance sheet's constraint, the VaR constraint and the VaR expression.

Solving the program (9) gives the following solutions.

The credit officer's mean optimal wage is

$$
Ew^* = w_0^* = v + \frac{(\mu - r_D(1 + u_\alpha \sigma))(\gamma(\mu - r_D(1 + u_\alpha \sigma)) - 2\beta\mu(1 + r_D))}{2\beta^2\sigma^2(1 + r_D)^2}.
\tag{10}
$$

Optimal assets and therefore credit officer's budget is

$$A^* = \frac{(\mu - r_D(1 + u_\alpha \sigma))}{\beta \sigma^2 (1 + r_D)}. \tag{11}$$

Under the hypothesis of a positive net interest margin, $\mu > r_D$, we have $\mu > r_D + u_\alpha \sigma$ (as $u_\alpha < 0$) and the optimal assets' level is positive, i.e. $A^* > 0$. A sufficient margin's level, i.e. $\frac{\mu - r_D(1+u_\alpha\sigma)}{\mu} > \frac{2\beta(1+r_D)}{\gamma}$, gives a positive fixed wage, i.e. $w_0^* > 0$.

The optimal level of equity is

$$E^* = r_\alpha A^* = \left(\frac{r_D - \mu - u_\alpha \sigma}{1 + r_D}\right) \left(\frac{\mu - r_D(1 + u_\alpha \sigma)}{\beta \sigma^2 (1 + r_D)}\right). \tag{12}$$

The VaR constraint is binding at the optimum, therefore the optimal equity level E^* is equal to the bank's VaR. A^* and r_α being positive, we obtain $E^* > 0$.

Knowing that $D^* = A^* - E^* = A^*(1 - r_\alpha)$, a strictly positive value of deposits D implies r_α strictly inferior to 1, which means that the banker doesn't cover 100% of the risky assets unit with equity, as the accepted bank's default probability is positive.

The banker's optimal expected utility is therefore

$$EU_B^* = -\exp^{\left(\frac{(\mu - r_D(1+u_\alpha\sigma))(\beta(r_D(1+u_\alpha\sigma) - \mu(3+2r_D)) + \gamma(\mu - r_D(1+u_\alpha\sigma)))}{2\beta\sigma^2(1+r_D)^2} + \beta v\right)}. \tag{13}$$

The credit officer's optimal expected utility corresponds to his reservation level

$$EU_C^* = \bar{U} = -\exp^{-\gamma v}. \tag{14}$$

5 Gains and losses associated with soft information

Following the results obtained above in the hard information case, we investigate in this section the positive and negative implications of additional use of soft information in the risk management process. The integration of soft information gives a more precise signal, but can be manipulated, as this type of information is not verifiable by a third party.

Increased prediction's precision corresponds to a lower error term's standard deviation σ. The equity is influenced by signal's precision (see equation 12). The derivative of E^* respect to σ is positive if and only if:

$$(\mu - r_D) > \frac{u_\alpha \sigma}{2}(r_D - 1).$$

This condition assures that the higher precision of the signal, thanks to the soft information's component, reduces equity level allocation. Therefore, a more precise signal, based on a combination of hard and soft information, should reduce VaR as long as the margin remains superior to a certain level, corresponding to the above inequality's right term.

However, soft information can be manipulated. The credit officer can transmit to the banker a signal's value μ, although he observes a different signal's value $\mu + f$, with $f > 0$ or $f < 0$, for a downgrading or upgrading manipulation respectively. The budget and the wage of the credit officer are established by the banker upon the transmitted signal μ so that his expected utility is at the reservation's level (see equation 14), for a return's *a posteriori* distribution $N(\mu, \sigma^2)$ which is consistent with the transmitted signal's value. However, regarding the transmitted signal's value by the credit officer, the return's *a posteriori* distribution is in fact $N(\mu + f, \sigma^2)$, and the agent gets an expected utility in presence of manipulation, denoted EU_C^M, equal to

$$EU_C^M = -\exp^{-\gamma v} \exp^{\left(-\frac{f\gamma(\mu - r_D(1+u_\alpha \sigma))}{\beta \sigma^2 (1+r_D)}\right)}. \tag{15}$$

As we suppose a positive margin, EU_C^M is higher than the reservation level for any downgrading manipulation, i.e. $f > 0$. The credit officer has an incentive to transmit to the banker a signal μ although he observes a signal $\mu + f$, with $f > 0$. As the banker guarantees his reservation level for any signal's value, the only possibility for the credit officer to extract some benefits and to get a higher utility level is to induce the banker in error, so that the latter under-estimates what he actually allocates to the agent. It is the case when the agent transmits a lower signal's value and he can expect a higher utility level through his budget's development, thanks to a mean return which is higher than expected by the principal.

In order to benefit from the economies of equity thanks to soft information without supporting its costs, consequence of signal's manipulation by the credit officer, the banker must implement an adapted organizational structure of the bank. It can be done through the modification of the wage contract, in order to implement proper incentives for the agent and avoid his signal's manipulation.

6 The soft information's case

The banker is now supposed to work with a credit officer who has access to hard and soft information, the latter being obtained through a bank-borrower relationship. The soft information's component allows to produce a more precise signal. The error term's ε standard deviation equals to σ_S [11].

As in the previous case, the banker decides in a first step on the credit officer's wage contract, knowing that the credit officer transmits later to the banker the signal $\tilde{\mu}$, and that his decisions concerning equity E, risky assets A and deposits D are based in a second step on the transmitted signal. The latter is based on a combination of hard and soft information. The soft component is not verifiable by a third party and thus potentially manipulable by the credit officer. Thus, the banker takes into account the fact that the credit officer can transmit a signal's value which may be different from the signal's value that he actually observes. The former is m, whereas the latter is μ. This also implies modifications in the banker's optimization program.

When the banker decides on the wage contract, the risk of manipulation of soft information is taken into account. Therefore, the wage contract he proposes must not only be acceptable by the agent but also implement proper incentives to avoid manipulation and incite the credit officer to transmit the signal he actually observes. This implies an additional incentive constraint into the banker's optimization program. It also implies a different wage contract, as the additional incentive constraint makes the optimization problem over-determined. The new wage contract still includes a fixed part w_0, but also includes now a variable part which is contingent on the assets' return through a variable term w_1. The assets' return is taken into account in terms of a spread. The latter is a difference between the return on assets and its supposed expected mean, with respect to the credit officer's transmitted signal m. Hence, his wage contract is now defined as:

$$w(\tilde{r}_A) = w_0 + w_1(\tilde{r}_A - bm), \tag{16}$$

with b being a weighting factor of the transmitted message concerning the mean return. This message, corresponding to a return's prediction, serves as a basis for a target bm to attain by the credit officer, which is associated to a bonus $w_1(\tilde{r}_A - bm) > 0$ in case of out-performance, when $b > 0$. b can be considered as a level of conservativeness in the assignment of targets by the banker to the credit officer. For $b = 0$, the variable part of the wage contract is only contingent upon the return on assets.

[11] In what follows, we neglect the subscript S in the notations.

The banker's new optimization program in the hard and soft information's case is the following

$$\max_{w_0,w_1,E,A,D} EU_B(\mu),$$
$$\begin{cases} EU_C(\mu) \geq \bar{U}, \\ \mu \in \arg\max_m EU_C(m), \\ E, A, D \in \arg\max_{\hat{K},\hat{A},\hat{D}} EU_B(m), \\ \begin{cases} \hat{E} + \hat{D} - \hat{A} = 0, \\ \hat{E} - VaR_\alpha \geq 0, \\ VaR_\alpha = r_\alpha \hat{A} = \frac{r_D - m - u_\alpha \sigma}{1+r_D} \hat{A}. \end{cases} \end{cases} \tag{17}$$

with

$$EU_B(m) = \int_{-\infty}^{+\infty} -\exp^{[-\beta(\tilde{r}_A A - r_D D - (w_0 + w_1(\tilde{r}_A - bm)))]} \eta(\tilde{r}_A|m) dr_A,$$

and

$$EU_B(\mu) = \int_{-\infty}^{+\infty} -\exp^{[-\beta(\tilde{r}_A A - r_D D - (w_0 + w_1(\tilde{r}_A - b\mu)))]} \eta(\tilde{r}_A|\mu) dr_A,$$

as well as

$$EU_C(m) = \int_{-\infty}^{+\infty} -\exp^{[-\gamma(\tilde{r}_A A + (w_0 + w_1(\tilde{r}_A - bm)))]} \eta(\tilde{r}_A|\mu) dr_A,$$

and

$$EU_C(\mu) = \int_{-\infty}^{+\infty} -\exp^{[-\gamma(\tilde{r}_A A + (w_0 + w_1(\tilde{r}_A - b\mu)))]} \eta(\tilde{r}_A|\mu) dr_A.$$

In the program (17), the first constraint corresponds to the agent's participation constraint, and the second one corresponds to the incentive constraint. The next three constraints in the sub-optimization program correspond to the balance sheet, the VaR and the VaR's expression constraints respectively. It is worth noticing that banker's choice of the balance sheet's structure are made upon the transmitted signal m.

Solving the program (17) gives the following solutions.

The credit officer's mean optimal wage is

$$Ew^{**} = v - \frac{2\mu\gamma^2(\mu - r_D(1+u_\alpha\sigma))}{\beta\sigma^2(1+r_D)(b\beta+2\gamma)^2} + b(\mu - r_D(1+u_\alpha\sigma))\Phi, \qquad (18)$$

with

$$\Phi = \frac{b\gamma(\mu - r_D(1+u_\alpha\sigma)) - 2\mu(1+r_D)(\beta(b+\mu(1+r_D))+\gamma)}{2\sigma^2(1+r_D)^2(b\beta+2\gamma)^2}.$$

We remark that for a null weighting factor $b = 0$, which implies a wage contract contingent only on the return on assets, the mean optimal wage is positive only for strictly positive reservation values v. Therefore, the wage contract is adapted to any kind of agents if $b \neq 0$. Thus, soft information effectively implies all of the proposed organizational modifications.

In fact, following equation (16), any spread between the message on the assets' mean return and the realized return implies for the credit officer a variable part which might be positive, and adds to the fixed part, but can also be negative and reduces the fixed part. Finally, in order to limit any deviations, the credit officer prefers to transmit a signal m which actually corresponds to the observes signal μ, and thus avoids any manipulation. The credit officer's predictions being taken into account in his wage contract and the spreads between his predictions and the return's realizations being penalizing, the agent provides the truth predictions to the principal, by transmitting the effectively observed signal's value.

The optimal level of assets and hence credit officer's budget is now

$$A^{**} = \frac{(\mu - r_D(1+u_\alpha\sigma))(\gamma+b\beta) + \beta\mu(1+r_D)}{\beta\sigma^2(1+r_D)(2\gamma+b\beta)}, \qquad (19)$$

which is, the margin being positive, strictly positive as long as

$$b > -\left(\frac{\gamma}{\beta} + \frac{\mu(1+r_D)}{\mu - r_D(1+u_\alpha\sigma)}\right).$$

Thus, it is possible to restrain the weighting factor to a positive value $b > 0$.

The optimal level of equity becomes

$$E^{**} = r_\alpha A^{**} = \left(\frac{r_D - \mu - u_\alpha \sigma}{1 + r_D}\right) \left(\frac{(\mu - r_D(1 + u_\alpha \sigma))(\gamma + b\beta) + \beta\mu(1 + r_D)}{\beta\sigma^2(b\beta + 2\gamma)}\right), \tag{20}$$

with

$$\frac{\partial A^{**}}{\partial b} = \frac{\gamma(\mu - r_D(1 + u_\alpha \sigma)) - \beta\mu(1 + r_D)}{\sigma^2(1 + r_D)(b\beta + 2\gamma)^2}.$$

Hence, as the variable term w_1^{**} is defined as

$$w_1^{**} = -\frac{\gamma(\mu - r_D(1 + u_\alpha \sigma)) - \beta\mu(1 + r_D)}{\beta\sigma^2(1 + r_D)(b\beta + 2\gamma)}, \tag{21}$$

it is possible to verify that the positivity of w_1^{**} implies a negative effect of b on the credit officer's budget A^{**}, the optimal level of equity E^{**}, and the variable term w_1^{**}.

7 Comparison of results

Solving (9) and (17) gives us solutions in the hard information's case and the combination of hard and soft information's case. These solutions differ in term of the standard deviation σ of the *a posteriori* distribution of return, which, although noted similarly, differs from both cases. Indeed, the signal based on the combination of hard and soft information is more precise, i.e. $\sigma_S < \sigma_H$. In order to compare these solutions, we suppose in what follows that $\sigma_H = \sigma_S + \lambda$, with λ being the signal's imprecision level based on hard information only.

Due to complex analytical solutions, we use numerical simulations to compare both cases. In particular, we compare expected values of wage Ew, equity E, assets A, and banker's expected utility $E(U_B)$.

We compute the following differences (* and ** correspond to the solutions from program 9 with hard information only and from program 17 with a combination of hard and soft information, respectively) :

- $dEw = Ew^* - Ew^{**}$,
- $dK = K^* - K^{**}$,
- $dA = A^* - A^{**}$,

- $dE(U_B) = E(U_B)^* - E(U_B)^{**}$,

which expressions are simulated fixing all parameters, except μ.

Taking into account different conditions which assure the positivity of balance sheet's elements previously stated, fixed parameters value are the following:

interest rate on deposits $r_D = 0.025$, reservation value $v = 0$, normal distribution's fractile corresponding to accepted bank's default probability of $\alpha = 1\%$, $u_{\alpha=0.01} = -2.3263$, risk aversion coefficients of the principal and the agent $\beta = \gamma = 1$, return's *a posteriori* distribution's standard deviation $\sigma = 0.2$ with soft information, hard information's based signal level of imprecision $\lambda = 0.1$, and weighting factor $b = 2$. We simulate signal's value μ within the interval $[0.03; 0.75]$.

The curves representing the differences dEw, dK, dA and $dE(U_B)$ are presented in figures 1, 2, 3 and 4 respectively.

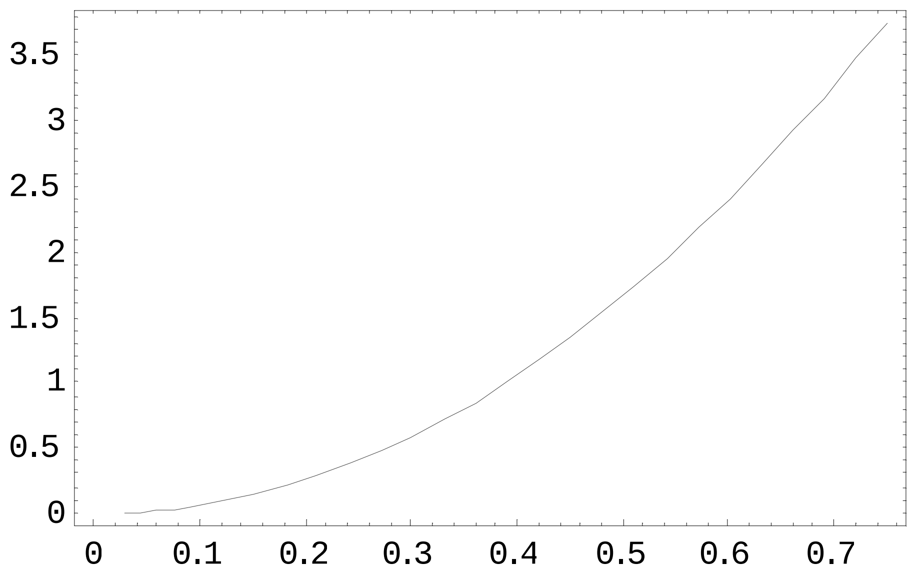

Figure 1. $dEw = Ew^* - Ew^{**}$ curve function of μ.

We first remark that the expected wage difference dEw is a convex curve and increasing with μ, located in the positive area of the graphic (see figure 1). The expected wage of the credit officer is therefore more important in the case of hard information only.

The equity difference dK is increasing with μ and located in the positive area of the graphic (see figure 2). The value of equity is therefore more important in the case of hard information only. The precision's contribution of a signal based on a combination of hard and soft information allows to reduce equity for VaR coverage.

The difference of assets, and therefore loans, (which correspond to the credit

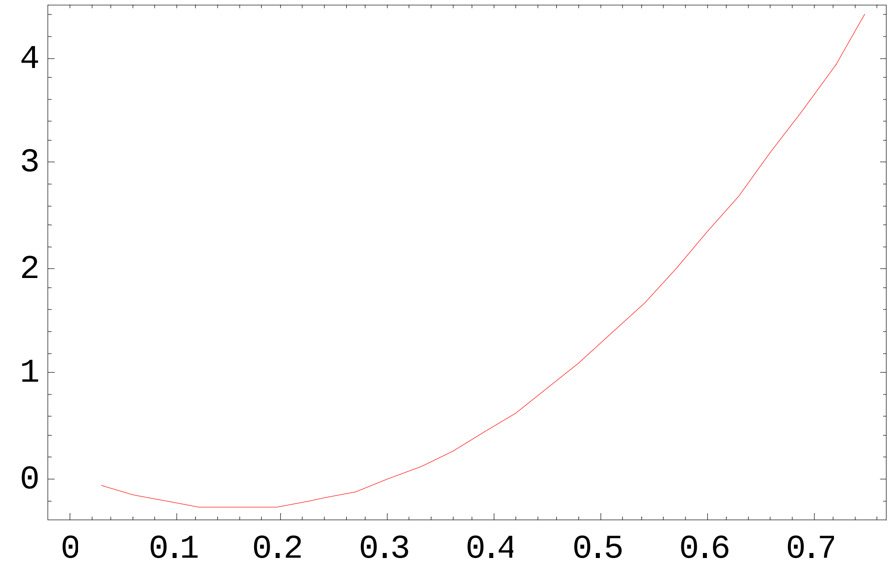

Figure 2. $dK = K^* - K^{**}$ curve function of μ.

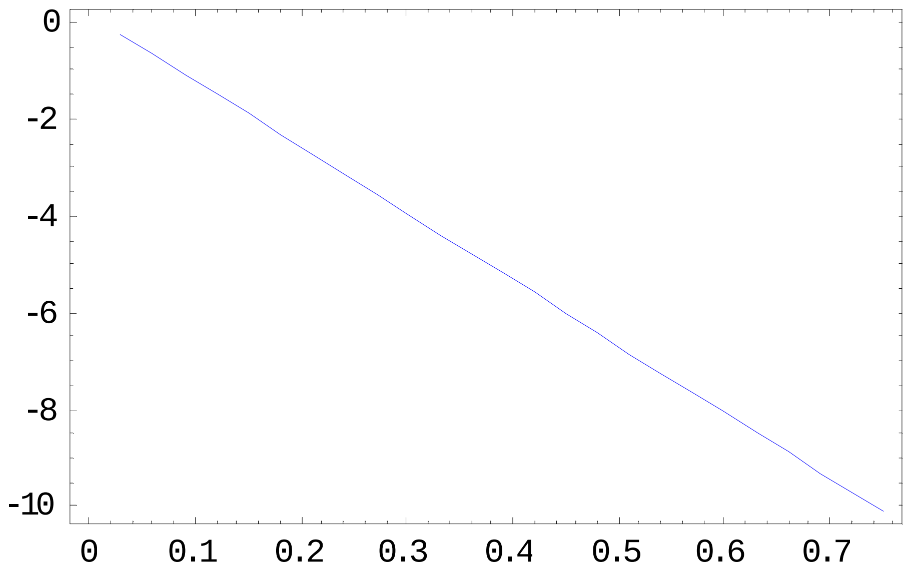

Figure 3. $dA = A^* - A^{**}$ curve function of μ.

officer's budget) dA is located in the negative area of the graphic (see figure 3). Loans' allocation (and credit officer's budget) is therefore more important when the banker has access to a combination of hard and soft information, and it is increasing with μ.

Finally, the curve representing the banker's expected utility difference $dE(U_B)$ (see figure 4) is located in the negative area of the graphic. Banker's expected utility is therefore more important when he can access soft information, although he needs to implement a specific wage contract in order to avoid signal's manipulation by the agent.

In summary, soft information allows the banker to reduce equity's allocation

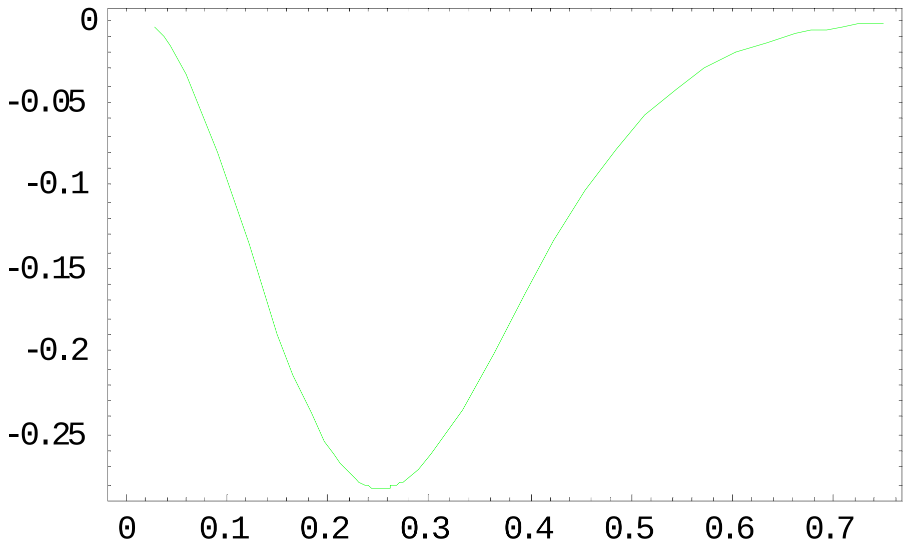

Figure 4. $dE(U_B) = E(U_B^*) - E(U_B^{**})$ curve function of μ.

for VaR coverage thanks to soft information's based signal higher precision, without implying additional costly wage contract in order to avoid manipulation, as it also allows the banker to allocate more loans and a bigger budget for the credit officer, which increases his utility.

8 Conclusion

The quality of information, produced by the bank, determines its risk taking characteristics. Recent literature treats this problem with a distinction of hard and soft information (Petersen, 2004). Acquiring this information can be performed through two technologies: transaction lending or relationship lending. The former can use statistical methods of hard information's treatment. This type of information presents several advantages, as low cost and economies of scale. On the opposite, relationship lending gives also access to soft information, which increases the precision of borrower's quality prediction estimation, but implies manipulation's problem, as this type of information is not verifiable by a third party.

In this article, we have focused on the role of information's type in credit risk management in banks. In a principal-agent model with moral hazard with hidden information where a banker requires information on assets' return in order to manage credit risk through equity allocation for VaR coverage, we show that using additional soft information allows to economize equity, thanks to soft information's higher precision. However, this type of information being not verifiable, it requires to implement a particular wage contract in order to avoid manipulation by the credit officer.

These results provide theoretical evidence on soft information's advantage in credit risk management, as we show that VaR can be reduced, which allows to economize equity, even if the bank must implement a specific organizational structure and an adequate wage contract.

The further research perspectives related to this work are both theoretical and empirical. The former concern taking into account errors in the processing of soft information (e.g. collusion between the credit officer and the debtor), introducing soft information's treatment cost (e.g. in terms of effort) and investigating the role of trust as a driver for credible transmission of soft information between the banker and the credit officer (following Chami and Fullenkamp, 2002). It would be also interesting to study the impact of different types of information produced using different lending technologies for risk management purpose on bank competition (following Berger, 2006). The empirical strategy could focus on syndicated loans, for which the decision is based on hard and soft information (Dennis and Mullineux, 2000), and to evaluate their impact on the characteristics of the debt contract.

Appendix

We infer the expression of VaR per risky assets unit (6) from the bank's default probability expression (5). Using balance sheet's constraint $E + D - A = 0$, we have

$$prob\,[A(1+\tilde{r}_A) - D(1+r_D) < 0] = \alpha,$$

which is equivalent to

$$prob\,[A\tilde{r} + E < 0] = \alpha,$$

with $\tilde{r} = \frac{1+\tilde{r}_A}{1+r_D} - 1$,

and we get

$$prob\,[-A\tilde{r} > E] = \alpha.$$

Thus, by the definition of the VaR, $VaR_\alpha = E$ and $r_\alpha = \frac{E}{A}$, we get

$$prob\,[-\tilde{r} > r_\alpha] = \alpha,$$

or

$$prob\,[\tilde{r} \geq -r_\alpha] = 1 - \alpha.$$

We can write

$$prob\,[\tilde{r} \geq \mu_{\tilde{r}} + u_\alpha \sigma_{\tilde{r}}] = 1 - \alpha,$$

using **corollary 1** :

Corollary 1 *Knowing that* $\tilde{x} \sim N(\mu_x, \sigma_x^2)$*, the fractile of level* α *from a* $N(.)$ *distribution is* $p\,(\tilde{x} \geq x_\alpha) = 1 - \alpha$*, with* $x_\alpha = \mu_x + u_\alpha \sigma_x$*,* u_α *being the fractile of level* α *of a* $N(0,1)$ *distribution.*

We can deduce the expression of the VaR per risky assets unit:

$$\begin{aligned} r_\alpha &= -(\mu_{\tilde{r}} + u_\alpha \sigma_{\tilde{r}}), \\ &= -\left(\frac{1+\mu}{1+r_D} - 1 + u_\alpha \frac{\sigma}{1+r_D}\right), \\ &= \frac{r_D - \mu - u_\alpha \sigma}{1+r_D}, \end{aligned}$$

which corresponds to equation (6), knowing that $(\tilde{r}_A|\mu) \sim N(\mu, \sigma^2)$ and therefore
$\tilde{r} \sim N\left(\frac{1+\mu}{1+r_D} - 1, \left(\frac{\sigma}{1+r_D}\right)^2\right)$.

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