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Abstract

The role of information's processing in bank intermediation is a crucial input. The bank has access to different types of information in order to manage risk through capital allocation for Value at Risk coverage. Hard information, contained in balance sheet data and produced with credit scoring, is quantitative and verifiable. Soft information, produced within a bank relationship, is qualitative and non verifiable, therefore manipulable, but produces more precise estimation of the debtor's quality. In this article, 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 propose to implement an adequate incentive salary package which unables this manipulation. The comparison of the results from the two frameworks (information hard versus combination of hard and soft information) using simulations confirms that soft information gives an advantage to the banker but requires particular organizational modifications within the bank, as it allows to reduce capital allocation for VaR coverage.

Keywords : Hard information, Soft information, risk management, Value at Risk, moral hazard, hidden information, manipulation

JEL Classification : D82, G21, G31

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1 Introduction

Information remains a crucial input for the banking industry. Banks are confronted to information's asymmetry problems because of borrowers' informational opacity. This opacity varies borrower's type, 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, rating, scoring ...), and soft information, which is internal, via bank-borrower relationship (judgement, opinions, notes, reports ...). This also implies two lending technologies : transaction lending versus relationship banking. A recent stream of literature puts forward distinctions to be made between hard and soft information (Petersen, 2004)[1]. Taking into account soft information in risk analysis can increase estimation's precision of borrowers' quality (Lehmann, 2003; Grunert et al., 2005), but has the disadvantage of being non verifiable 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 costs of its manipulation.

Recent research on risks management in banks puts forward the importance of information's treatment. Hakenes (2004) considers the banker as a "specialist" of information's treatment and risk's monitoring. 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 (or a director of the credit risk department) and a credit officer (or a bank's agency clerk). The director allocates equity for Value at Risk coverage. He also decides on the officer's budget, as well as her wage, which are both a function of a signal, based on

[1] However, bank's role as an information's producer has already been put forward by Fama (1985).

hard information only or a combination of hard and soft information. The difference between the two types of signal lies in their nature, more precisely 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 the director, as the soft component is manipulable. 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 te moral hazard problem.

We find several interesting results. 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 officer. We then propose a wage scheme to impeach this manipulation. 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 can provide an advantage, as it effectively allows to reduce equity for VaR coverage.

The rest of this article is organized as follows. In section 2, we present elements allowing to distinguish between hard and soft information, as well as recent 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 scheme for the officer is then proposed to resolve the manipulation problem in section 6. Finally, the results from the hard and a combination of hard and soft information cases are compared, using numerical solutions, and presented in section 7. Section 8 concludes the article.

2 Hard information versus soft information and banks' organizational structure

We analyze in this section the characteristics of hard and soft information in order to define several dimensions allowing to clearly distinguish these two types of information, and to determine their respective advantages and disadvantages (Petersen, 2004).

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 also rather "backward looking" (e.g. balance sheet data) as soft information is rather "forward looking" (e.g. business plan).

- collecting method: collection of hard information is impersonal, and it doesn't depend upon the context of its production (hard information is therefore exhaustive and explicit), as collecting soft information is personal and includes its production and treatment context.

- cognitive factors[2]: subjective judgement, opinions and perception are absent in hard information, whereas they are integral components of soft information.

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

- a low cost, as hard information is reduced, its treatment technology 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 and therefore non manipulability.

The practical advantages of hard information is confirmed by empirical research by Feldman (1997a,b), as well as Berger et al. (2002a) and Frame et al. (2001), who analyse credit scoring. Scoring[3] is a hard information's

[2]Note that 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)".

[3]Following Mester (1997), credit scoring (or scoring) is a statistical method of borrower's default probability estimation.

treatment method. It is shown that scoring can reduce the cost of credit risk and increase credit risk decision's speed, as well as 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, through multiple interactions in time, gives access to private and confidential information, superior to publicly available information (Berger, 1999; Boot, 2000; Berger and Udell, 2002; Elsas, 2005). Thus, soft information has the advantage to increase the predictive capacity of hard information, but remains non verifiable. The latter makes this type of information easily manipulable by the agent responsible of its production and treatment, and therefore imposes a particular organizational structure.

Soft information's capability to increase hard information's predictive power is documented by empirical research which aims at investigating qualitative factors' impact on default risk prediction. 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[4]. The integration of qualitative factors into default risk prediction models increase 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.

The adaptation of the organizational structure to the type of information used in banking has also received theoretical and empirical evidence. Stein (2002) investigates the influence of banks' organizational structure on their optimal funds allocation's decision. 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. Also, it should also be easily interpretable in an uniform manner and independent of the production's context and the agent's in charge of its treatment. These are the main characteristics of hard information. In an world of incomplete contracts, agents' incentives depend on their control on allocated assets (Hart and Moore, 1990; Hart, 1995; Harris and Raviv, 1996, 1998). In his model, Stein (2002) confronts two types of information (hard versus soft), and two types of organizational structure (hierarchical and centralized

[4]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.

versus non-hierarchical and decentralized). He then 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 organizations, because they provide the agent more power and authority. In such a framework, she has better incentives to make efficient use of her information in the funds' allocation process. Hard information is associated with centralized organizations, because it facilitates its transmission to superior hierarchical levels where funds' allocation 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 and Udell, 2002; Berger et al., 2001; Berger et al., 2002a; Berger et al., 2005). In a bank-borrower relationship framework, information's production and treatment is delegated to a credit officer, who therefore receives strong authority and power, because of possible soft information's manipulation. In this context, the officer has a crucial position within the bank. Small, less hierarchical and decentralized organizations are more suitable for relationship banking. Small banks are considered to have a superior capacity in processing soft information in the framework of bank-borrower long term relationships (Berger, 2004; DeYoung et al., 2004; Scott, 2004). When SMEs face external finance choice, they usually prefer small banks, in order to reduce credit rationing .

Another strand of literature investigates wages' structure and budgets' allocation role in driving proper incentives of credit officers in charge of information's treatment. Bernardo et al. (2001) consider a risk-neutral firm with an investment project for which optimal fund allocation depends on uncertain project's quality. A manager can be hired in order to produce information about this quality. She enjoys private benefits from controlling the allocated budget and reports project's non verifiable quality to the firm's director. The latter allocates funds depending on reported project. The manager may then exergue costly and non verifiable effort allowing to increase project's return. Manager's utility is affected both by allocated budget and wage's scheme proposed by the director, composed of a fixed and a variable term. Bernardo et al. (2001) show the existence of three cases of wage and budget's optimal combinations: a low reported project's quality implies no budget, an average quality implies a budget but no variable term in the wage scheme and a high quality implies a budget and a variable term in the wage scheme.

Another model considers several agents within the same firm (Ozbas, 2005). This author studies information asymmetries' problems in a model of internal competition for resources between managers in a firm. These managers have access to information qualified as specific knowledge. The model focus on the concept of strategic communication between a principal - firm's director - and the agents - firm's managers. These have an utility define on budget, thus inciting them to exacerbate return's predictions in order to increase the probability to obtain more funds. However, non realization of their predictions reduce manager's reputation. Strategic communication's quality between the principal and the agents deteriorates with organizational integration. Two types of agents (good and bad) and two types of projects (high and low return) exist. Bad managers' projects have low return with certainty, as good managers's projects can have low or high return, with probability p and $1-p$ respectively. Ozbas (2005) investigates several types of organization (with different degrees of integration) and finds that rigid rules in budget allocation can increase communication's quality and efficiency, and reduce managers' internal competition. Centralization can increase work-group, but only if communication is efficient. A higher level of integration implies communication's deterioration, which remains a crucial element for efficient funds' allocation.

A study of information's role in financial markets is provided by Ozerturk (2004). This author investigates the influence of wage scheme on funds manager incentives to acquire precise information. The wage scheme includes fees and is also indexed on managed fund's returns. The fund manager - the agent - exergues costly effort in order to observe assets' return for the benefit of a investor - the principal. Her effort influence information's precision, which is modelled through a signal. Precision and effort are not observable by the principal, as well as the signal's realization. A linear wage contract in the portfolio return incites the agent to acquire more information when market's participants have rational anticipations. As assets' prices depend on demand, they influence manager's incentives to acquire more precise information.

In what follows, we aim at linking these two separate strands of literature, one dealing with the relationship between the type of information and organizational structure, and the other dealing with optimal wage in a principal-agent framework with hidden information (**?**), focusing on the process of bank risk management organization.

3 The model

The following model allows us to investigate the role of information's type in bank's credit risk management and organizational structure. Credit decision is modelled within a principal-agent framework with a bank director (or banker) and a credit officer over one period[5].

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

Balance sheet	
A	E
	D

Risky assets' random return is $\tilde{r}_A$. Deposits cost is exogenous, $r_D > 0$. Credit officer wage is w, eventually function of assets' return $\tilde{r}_A$, so that $w = w(\tilde{r}_A)$. 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 benefit of the credit officer, which we normalize to 0.

Banker's utility is defined as:

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

where $\beta > 0$ is the principal's constant risk aversion coefficient.

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

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

where $\gamma > 0$ is the agent's constant risk aversion coefficient.

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

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

[5] We may also consider the principal as being a director of a risk monitoring department and the agent as a customer relationship's officer.

where $\tilde{\varepsilon}$ follows 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: hard or soft information. Hard information is supposed to be verifiable by the banker, 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 the banker. Difference in precision's level between these two types of information is modelled through the error term $\tilde{\varepsilon}$. 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 $\sigma_S < \sigma_H$[6].

Information concerning risky assets' return is used for risk management purpose. The banker wants to cover portfolio risk, measured as the Value at Risk, 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 assets' value is lower than deposits' value:

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

In case of default, credit officer's wage is guaranteed by the unemployment insurance. Taking into account balance sheet's constraint $(K + D - A = 0)$, we can infer VaR per unit of risky assets at the accepted losses' level α, denoted r_α (see appendix for details)[7]:

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

and

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

with u_α corresponding to the α level fractile of a normal distribution law $N(0,1)$[8].

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*

[6] In the rest of this article, we will take into account subscripts H and S only if strictly necessary.

[7] See also Broll and Wahl (2003).

[8] We suppose that the fractile is negative, $u_\alpha < 0$, for accepted bank's default probabilities α lower than 50%, which is the case here.

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 return's distribution 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, which covers VaR.

Before moving to a deeper analysis of gains and losses associated with accessing to additional soft information, we present the results obtained in a principal-agent framework with hard information only.

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

In a first step, the banker is supposed to decide on credit officer's wage scheme, 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 scheme includes a fixed part only, w_0, so that

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

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

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 her reservation utility's level (with v being her reservation's value), and the next three constraints from the sub-optimization program affect banker's choice of balance sheet's variables, and correspond respectively to the balance sheet's constraint, the VaR constraint and the VaR expression.

Solving (9) gives the following solutions.

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

Optimal equity's level 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^* equals 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 volume 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.

Banker's optimal expected utility is therefore

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

Whereas credit officer's optimal expected utility corresponds to her reservation level

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

5 Gains and losses associated to soft information

Following the results obtained 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.

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. As the banker doesn't have access to information, credit officer's budget and wage are established by the banker upon the transmitted signal μ so that her 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, equals 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 her reservation level for any signal's value, the only possibility for the credit officer to extracts 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 she can expect a higher utility level through her budget's development or the wage, thanks to a higher mean return 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, through the wage scheme's modification, in order to implement proper incentives for the agent and avoid her signal's manipulation. We investigate this issue in the next section.

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, but we neglect the subscript S in the notations.

As in the previous case, the banker decides in a first step upon credit officer's wage scheme, knowing that the agent transmits him later 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 signal based on a combination of hard and soft information is not verifiable by the banker and thus potentially manipulable by the credit officer. Thus, he takes into account the fact that the agent can transmit a signal's value which may be different from signal's value that she actually observes. The former is m, whereas the latter is μ. This implies also modifications in the banker's optimization program.

When the banker decides on the wage scheme, he takes into account the fact that the credit officer have incentives to manipulate the signal. 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 she actually observes. This implies including an additional incentive constraint into the banker's optimization program. It also implies a different wage scheme, as the additional incentive constraint makes the optimization problem over-determined. The new wage scheme 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. Assets' return is taken into account in terms of a spread between the latter and its supposed mean expected return, following the credit officer's transmitted signal m. Hence, her wage scheme 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 to attain, bm, by the credit officer, which is associated to a bonus $w_1(\tilde{r}_A - bm) > 0$ in case of out-performance, when $b > 0$. For $b = 0$, the variable part of the wage scheme is only contingent upon assets' return.

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

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

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, in order to incite the credit officer to transmit the effectively observed signal's value. 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 (17) gives the following results.

The credit officer's mean optimal wage is

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

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 scheme only contingent on assets' return, the mean optimal wage is positive only for strictly positive reservation values' v. Therefore, the wage scheme 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 her wage scheme and the spreads between her 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

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

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 $b > 0$.

Equity's optimal level 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, among other elements, in term of the return *a posteriori* distribution's standard deviation σ, which, although noted similarly, differs from both cases, as 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.

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). Expected wage is therefore more important in the hard information's only case.

The equity difference dK is increasing with μ and located in the positive area of the graphic (see figure 2). Equity's value is therefore more important

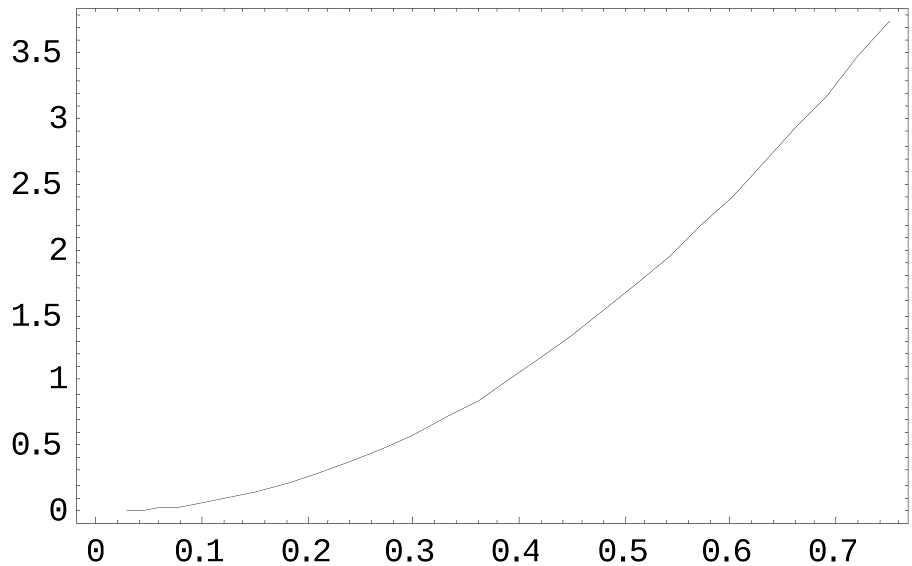

Figure 1: $dEw = Ew^* - Ew^{**}$ curve function of μ.

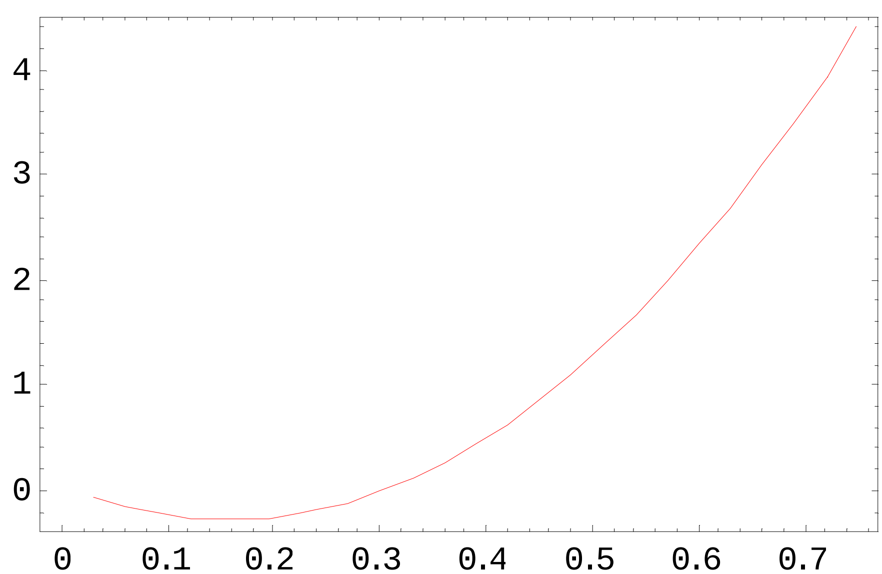

Figure 2: $dK = K^* - K^{**}$ curve function of μ.

in the hard information's only case. The precision's contribution of a signal based on a combination of hard and soft information allows to reduce equity for VaR coverage.

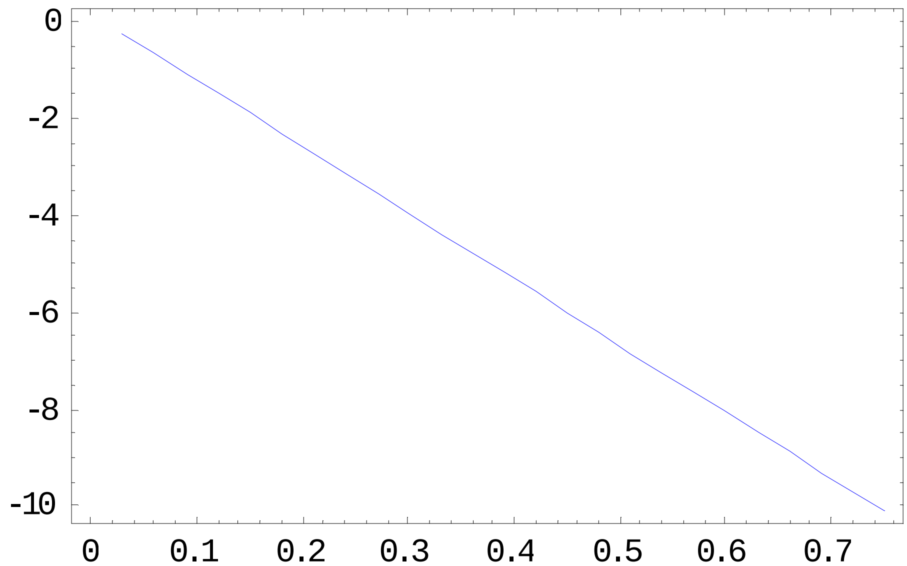

Figure 3: $dA = A^{*} - A^{**}$ curve function of μ.

The difference of assets, and therefore loans, (which correspond to the credit 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 scheme in order to avoid signal's manipulation by the agent.

In summary, soft information allows the banker to reduce equity's allocation for VaR coverage thanks to soft information's based signal higher precision, without implying additional costly wage scheme 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 her utility.

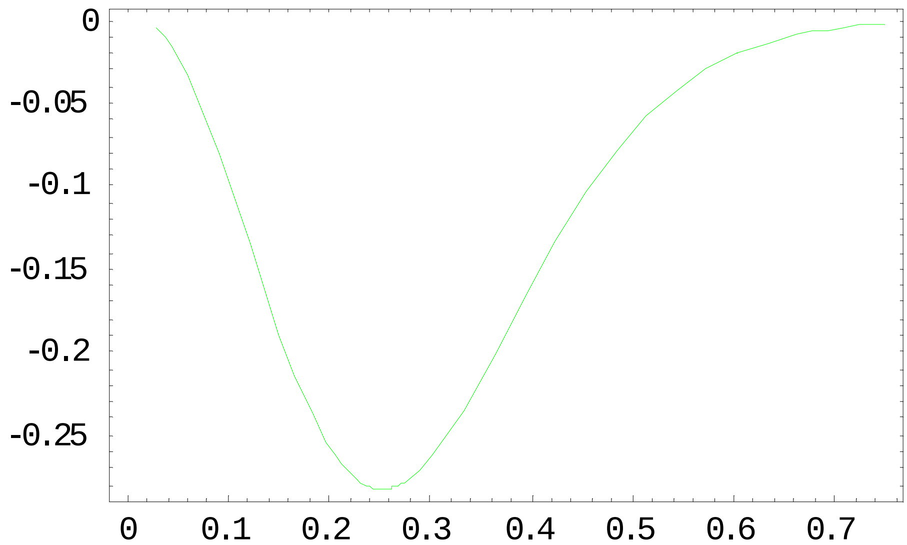

Figure 4: $dE(U_B) = E(U_B^*) - E(U_B^{**})$ curve function of μ.

8 Conclusion

Information's quality, produced by the bank, determines its risk taking characteristics. Existing literature treats this problem with a distinction of hard and soft information (Petersen, 2004). Acquiring this information can be done through two methods: 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, economies of scale and the possibility to measure Value at Risk within credit risk models. On the opposite, relationship lending gives also access to soft information, which increases he precision of borrower's quality prediction estimation, but implies manipulation's problem, as this type of information is not verifiable.

In this article, we have focused on information's type role 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 scheme 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 scheme.

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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

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

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
$\tilde{r} \sim N\left(\frac{1+\mu}{1+r_D} - 1, \left(\frac{\sigma}{1+r_D}\right)^2\right)$.