Institut National de la recherche Agronomique

Unité d'Economie et Sociologie Rurales
4 Allée Adolphe Bobierre, CS 61103
F 35011 Rennes Cedex

Tél. (33) 02 23 48 53 82/53 88 - Fax (33) 02 23 48 53 80
http://www.rennes.inra.fr/economie/index.htm

Reducing farm credit rationing: an assessment of the relative effectiveness of two government intervention schemes

Laure LATRUFFE and Rob FRASER

April 2002

Working Paper 02-02

Reducing farm credit rationing: an assessment of the relative effectiveness of two government intervention schemes

Laure LATRUFFE
INRA – ESR Rennes and University of Paris 10

Rob FRASER
Imperial College at Wye and University of Western Australia

Acknowledgements
The authors strongly thank Sofia Davidova and Chantal Le Mouël for their comments. The authors also benefited from helpful suggestions received when an earlier draft of the paper was presented in seminar in Imperial College at Wye.

Corresponding address
Laure LATRUFFE
INRA – Unité ESR
4 Allée Bobierre, CS 61103
35011 Rennes Cédex, France
Email: latruffe@roazhon.inra.fr

Abstract

The paper develops a theoretical model of a rural credit market under uncertainty with a view to evaluating the relative effectiveness of two policy measures aimed at reducing credit rationing. The optimal behaviour of both parties, farmers and lenders, is developed theoretically. A numerical application then investigates whether credit subsidies are potentially more effective than loan guarantees in terms of the number of additional applicants. However the actual effectiveness may be different due to several factors relating to population characteristics.

Keywords: farmers, credit, collateral, rationing, credit subsidies, loan guarantees

JEL classification: G2, Q14

Résumé

Un modèle théorique d'un marché de crédit rural en environnement incertain est développé, afin d'évaluer la performance relative de deux politiques d'intervention ayant pour objectif de réduire le rationnement du crédit. Le comportement optimal des deux parties, exploitants et banquiers, est analysé théoriquement. Plusieurs contrats de prêt sont proposés, qui diffèrent selon leurs termes et le type de crédit. Chaque contrat est caractérisé par un taux d'intérêt et un niveau de collatéral optimaux. La segmentation des exploitants entre les contrats est déterminée par leur aversion au risque et le collatéral qu'ils possèdent. Le rationnement du crédit considéré est celui où les termes du contrat découragent les demandeurs potentiels. Les subventions au crédit et les garanties de prêt agissent sur des contraintes d'optimisation des exploitants différentes. Cependant, la performance réelle de l'une ou l'autre intervention publique en terme de demandeurs de crédit additionnels peut être différente selon les caractéristiques de la population, en particulier selon le niveau de réservation d'utilité et la distribution du collatéral possédé. Une application numérique montre toutefois que les petits exploitants sont plus sensibles à une subvention au crédit alors que les grands exploitants répondent plus à une garantie de prêt.

Mots clé: exploitants agricoles, crédit, collatéral, rationnement, subvention au crédit, garantie de prêt

Classification JEL: G2, Q14

Reducing farm credit rationing: an assessment of the relative effectiveness of two government intervention schemes

Laure LATRUFFE and Rob FRASER

1. Introduction

Credit rationing occurs if some farmers have limited access to credit. It can affect the number of individuals who receive a loan. Another form of rationing occurs when all individuals get a loan but some are restricted in the amount they can borrow. Rural credit markets in developing and transition countries are often characterised by credit rationing (Hoff and Stiglitz, 1990). When farmers are able to apply for a loan but do not receive it, it is a case of external rationing. This is due to constraints faced by the banks, such as high transaction costs or insufficient supply of funds (Besley, 1994). Internal rationing implies that farmers do not apply for a loan although they wish to. Reasons can be that they are not able to meet the terms of the loan or they are discouraged because of high costs they would face during the application process or subsequently (Besley, 1994; Adams and Nehman, 1979). Credit rationing has been a widespread subject of investigation in the literature. Several models of credit markets have been designed in order to explain or characterise rationing. General models such as Stiglitz and Weiss' (1981) and Besanko and Thakor's (1987) explain credit rationing with asymmetric information, insufficient supply or limited collateral. Specific models for rural credit markets give as the main reasons for rationing insufficient supply, limited collateral and transaction costs. These models often focus on the consequences of rationing, in particular low productivity of small farmers and slow technological change (*e.g*. Feder, 1985; Blackman, 2001).

From this literature it is clearly perceived that many small farmers have limited access to credit and it is also suggested that rationing results in less investment in agriculture and constrains agricultural growth (Yaron, 1992). However none of these models examines the relative effectiveness of possible means to alleviate the rationing problem, so that when provided, policy recommendations are only listed. But the government can intervene in improving credit access to the rationed farmers, with the justification for public intervention based on equity as well as efficiency on grounds. Indirect intervention involves taking measures to reduce transaction costs or increase the supply of funds. Direct intervention mainly takes the form of two schemes, credit subsidies and loan guarantees (Swinnen and Gow, 1999). Credit subsidies are subsidised interest rates. Loan guarantees work on the other characteristic of the loan: the collateral required by the lender to secure the contract. The measure reduces the amount of collateral provided by a farmer, as the requirement is provided by both the government and the farmer.

The objective of this paper is to examine the relative effectiveness of these two measures to reduce credit rationing. Section 2 develops a theoretical model of a rural credit market under uncertainty. The framework describes the two parties considered, farmers and lenders[1], and the simplifying assumptions. The optimal behaviour of both parties is developed. Internal credit rationing is considered, both as a consequence of limited collateral and as discouragement from applying because of a high interest rate. Government intervention in the form of a credit subsidy and a loan guarantee is then introduced. As a consequence of the algebraic complexity of the model, a numerical application is given in Section 3, where the relative effectiveness of both policy measures is compared in terms of the number of additional applicants. Section 4 concludes and discusses the potential usefulness of these measures.

2. The model

2.1. Framework

The model is based on Stiglitz and Weiss' credit market under uncertainty and asymmetric information (1981). Model development features in particular a specification of total applicant behaviour in order to investigate the effectiveness of government intervention to reduce credit rationing. Farmers apply for a loan to undertake a project i costing L and giving an uncertain return R_i at the end of the period considered. For simplicity two types of projects are assumed. A safer project might be land purchase in order to extend the farm. A riskier project might be a new technology purchased in order to modernise the farm and is called business project in what

[1] In the paper, lenders stand for formal lenders. Specific arrangements of informal lenders are not considered.

follows.[2] The difference between the two projects types lies not only in their riskiness but also in their expected return. Although business projects are riskier, they have a greater expected return. The project's uncertain return is given by:

$$R_i = f(\theta_i, \gamma_i, L)$$

where

i = land or business

L>0 with $\frac{\partial f}{\partial L} > 0$

$\gamma_i > 0$ are return coefficients with $\frac{\partial f}{\partial \gamma_i} > 0$

θ_i are risk terms with $\mathrm{Var}\theta_i > 0$

$\mathrm{Var}\theta_{business} > \mathrm{Var}\theta_{land}$ and $\gamma_{business} > \gamma_{land}$.

The farmers can be separated into two size classes: small farmers and large farmers, where the land owned by small farmers is less than by the large farmers, although within each group there is a distribution of actual land owned around some average level. All farmers are risk averse, and they can be separated into two risk aversion classes: low risk aversion farmers and high risk aversion farmers. All farmers have some reservation level U_0>0, which represents the opportunity cost of taking out a loan and below which they do not apply. On this basis, smaller farmers have lower reservation levels than larger farmers. The rural credit market is assumed to be competitive, therefore it will be analysed in terms of a representative lender, who is assumed to be risk neutral. She offers loan contracts with three characteristics: the amount of the loan L, the interest rate charged r, and the collateral requirement C. For simplicity it is assumed that the loan amount L is fixed and the same for all borrowers. Therefore the loan contracts are defined as {r,C}. The credit transaction takes place over a single period. At the end of it, if the project's return is sufficient, the farmer repays the loan with the interest, (1+r)L. In case the return is not sufficient, the lender becomes the owner of the farmer's collateral. The pledging of collateral solves the enforcement problem (Besley, 1994). It induces the borrower to repay the loan whenever she is able to do so. As it is mostly the case for farm credit, the collateral is land.

---

[2] Credit is commonly separated this way. In the literature, both types of credit are respectively called residential or housing credit (safe credit), and non-residential or corporate credit (risky credit). See for example Hendershott and Hu (1983).

The lender offers credit for both types of projects. She charges a higher interest rate for business credit than for land credit because of the greater riskiness (and therefore greater probability of default). Both the interest rate and the collateral would be specific to each borrower in the case of full information. However credit markets are typically affected by asymmetric information, where the lender does not know all the characteristics of the borrower. The screening problem arises from adverse selection, when the lender is unable to identify *ex ante* the borrower's type, defined in particular by the size of collateral she can put up. A common screening device is to offer several contracts differing in the collateral requirement and let the borrowers choose (Hoff and Stiglitz, 1990). Therefore, in what follows, in order to induce borrowers to separate according to the collateral requirement, contracts feature interest rates that are inversely related to the collateral requirement. For simplification, only two (low and high) collateral contracts are specified here, and the collateral requirements do not differ from land credit to business credit[3]. Thus the lender offers in total four possible loan contracts, depending on the project type and on the collateral required. Table 1 lists them and introduces the notation used throughout the paper. Collateral is required as a percentage of the loan amount: $C=\alpha L$ or $C=\beta L$.

(Table 1)

Further assumptions include no monitoring costs for the lender (that is to say there is no moral hazard problem; Besley, 1994) and no transaction costs for the farmers. The opportunity cost of land is zero and the land market is perfectly functioning. It is also assumed that all applicants get a loan (*i.e.* no external rationing).

2.2. Optimisation behaviour

Borrowers

Farmers may choose one of the four contracts offered, depending on the characteristics of the contracts, and those of the farmer. The choice of the contract for farmers is influenced by two constraints. They apply for a type of credit (land or business) only if the expected utility is greater than their reservation level, and the type of collateral contract (low collateral or high collateral) chosen depends on the level of collateral they

[3] This assumption is made to keep the model simple. In reality banks require higher collateral for business credit.

own. To do this they maximise their expected utility (EU). Based on the mean-variance form their optimisation problem is:

$$\text{Max } EU_{ij} = U\{EY_{ij}\} + \frac{1}{2}U''\{EY_{ij}\}\text{Var}Y_{ij}$$

on $\{r_{ij},j\}$

$$\text{subject to } \begin{cases} EU_{ij} \geq U_0 \\ \text{collateral owned} \geq jL \end{cases}$$

where

i = 1 or 2 (project) and j = α or β (collateral)

U is the increasing and concave utility function

U_0 is the farmer's reservation level

EY_{ij} and $VarY_{ij}$ are respectively the farmers' expected income and the variance of the income Y_{ij}. They are functions of the project's return and riskiness, the interest rate and the collateral requirement. The mathematical expressions are derived from the Winsorisation of the project's return. They are given in the Appendix.

Based on this specification of farmer behaviour and the details of lender behaviour contained in Table 1, it is clear that in the absence of the collateral constraint all farmers prefer the contracts with a lower interest rate. What separates the farmers is the constraint of their collateral. Small farmers are forced to consider only the low collateral contract, while large farmers can apply for the high collateral contract. Farmers are also segmented for the choice of type of projects, in this case according to their risk aversion. The risk aversion index determines if the expected utility for each contract $\{r_{ij},j\}$ is greater than the farmer's reservation level. High risk aversion farmers prefer credit for land purchase, while low risk aversion farmers prefer credit for business purchase. The consequent segmentation of farmers is summarised in Table 2.

(Table 2)

For each contract, N_{ij} is the number of farmers applying for the contract $\{r_{ij},j\}$. It is a decreasing function of the collateral required and of the interest rate because of the distribution of farmers within each size category, and because a farmer's expected utility relative to the reservation utility is a decreasing function of the interest rate charged:

$$N_{ij} = g(r_{ij}, j)$$

with $\frac{\partial g}{\partial r_{ij}} < 0$ and $\frac{\partial g}{\partial j} < 0$

where i = 1 or 2 (project) and j = α or β (collateral).

Note that some small farmers cannot meet even the low collateral requirement and thus cannot apply, while some large farmers cannot satisfy the high collateral requirement. However, given their higher reservation utility specified previously, it is assumed that they do not apply for the low collateral loan. The number of borrowers decreases when the interest rate increases, because farmers' expected utility decreases, and if it drops below their reservation level they do not apply. But given the segmentation, it is assumed that they do not choose to apply for another contract and prefer to not apply at all.

Lender

When designing the four contracts, the lender sets the collateral requirements and interest rates that maximise her total expected profit from all the loans, $E\pi_{TOT}$. Her optimisation problem is:

$$\text{Max } E\pi_{TOT} = \sum_{i,j} N_{ij} E\pi_{ij}$$

on r_i and j, where i = 1 or 2 (project) and j = α or β (collateral)

subject to $\alpha<\beta$, $r_{2\alpha}>r_{1\alpha}$, $r_{2\beta}>r_{1\beta}$

where

N_{ij} is the number of farmers applying for the contract $\{r_{ij},j\}$

$E\pi_{ij}$ is the lender's expected profit per loan contract $\{r_{ij},j\}$, defined as

$$E\pi_{ij} = (1-p_{ij})(1+r_{ij})L + p_{ij}jL$$

where p_{ij} is the borrowers' probability of default in repaying the loan.

This probability is given by Winsorising the project's return (Fraser, 1988), as shown in the Appendix. $E\pi_{ij}$ is expected to be positively influenced by the interest rate and the collateral requirement, but N_{ij} is negatively influenced by both of them. $E\pi_{ij}$ is positively related to the project's expected return, but negatively related to the project's riskiness.

The derivative of total expected profit with respect to one collateral requirement, for example the low collateral (α), is given by the following:

$$\frac{dE\pi_{TOT}}{d\alpha} = \left[\frac{\partial E\pi_{1\alpha}}{\partial\alpha}N_{1\alpha} + \frac{\partial E\pi_{2\alpha}}{\partial\alpha}N_{2\alpha}\right] + \left[\frac{\partial N_{1\alpha}}{\partial\alpha}E\pi_{1\alpha} + \frac{\partial N_{2\alpha}}{\partial\alpha}E\pi_{2\alpha}\right] \tag{1}$$

with $\frac{\partial E\pi_{1\alpha}}{\partial\alpha} = p_{1\alpha}L$ and $\frac{\partial E\pi_{2\alpha}}{\partial\alpha} = p_{2\alpha}L$

$\frac{\partial N_{1\alpha}}{\partial\alpha} = \frac{\partial N_{2\alpha}}{\partial\alpha} = \frac{\partial g}{\partial\alpha}$[4].

The first term into brackets in (1) is positive and the second term is negative. Therefore the sign of the derivative is ambiguous. However, increasing the collateral requirement firstly increases the lender's total expected profit since it increases her compensation in case of default. But at some point, a large number of borrowers have dropped out of the market. The lender's total expected profit with respect to the low collateral has thus the shape depicted on Graph 1. The same reasoning applies for the high collateral requirement.

The derivative of the total expected profit with respect to one interest rate, for example $r_{\alpha 1}$ (low collateral, land project), is given by the following:

$$\frac{dE\pi_{TOT}}{dr_{1\alpha}} = \frac{\partial E\pi_{1\alpha}}{\partial r_{1\alpha}}N_{1\alpha} + \frac{\partial N_{1\alpha}}{\partial r_{1\alpha}}E\pi_{1\alpha} \tag{2}$$

with $\frac{\partial E\pi_{1\alpha}}{\partial r_{1\alpha}} = (1 - p_{1\alpha})L + \frac{\partial p_{1\alpha}}{\partial r_{1\alpha}}L[\alpha - (1 + r_{1\alpha})]$

$\frac{\partial N_{1\alpha}}{\partial r_{1\alpha}} = \frac{\partial g}{\partial r_{1\alpha}}$.

The first term of the right hand side of (2) is expected to be positive and the second term is negative. Therefore the sign of the derivative is ambiguous. However increasing the interest rate firstly increases the lender's total expected profit because it increases the repayment. But at some point, a large number of borrowers have dropped out of the market. The lender's total expected profit with respect to $r_{\alpha 1}$ has thus the shape depicted on Graph 2. The same reasoning applies for the other three interest rates. The relationships depicted on Graphs 1 and 2 are consistent with the conclusions of several authors, including Stiglitz and Weiss (1981).

(Graph 1) (Graph 2)

[4] This implies an identical distribution of small and large farmers by collateral within each risk aversion group.

The optimal collateral requirements, represented by the coefficients j*, and the optimal interest rates r_{ij}^{*} are given by the first order conditions of the lender's optimisation problem, where $\frac{dE\pi_{TOT}}{d\alpha}$ is given by (1), $\frac{dE\pi_{TOT}}{dr_{1\alpha}}$ is given by (2), and the other first order conditions take similar forms.

2.3. Credit rationing and government intervention

The model specified previously focuses on internal rationing. Farmers do not apply for a loan either because they cannot provide enough collateral, or the high interest rate makes their expected utility from applying less than their reservation level. Credit subsidies and loan guarantees may act for farmers to remove a constraint that was previously binding. Credit subsidies may raise a farmer's expected utility above her reservation level so that more high risk averse farmers are able to apply for land credit (*i.e.* $N_{1\alpha}$ and $N_{1\beta}$ increase) and more low averse farmers are able to apply for business credit (*i.e.* $N_{2\alpha}$ and $N_{2\beta}$ increase). Loan guarantees mean that more small farmers satisfy the requirement for low collateral contracts (*i.e.* $N_{1\alpha}$ and $N_{2\alpha}$ increase), and that more large farmers satisfy the requirement for high collateral contracts (*i.e.* $N_{1\beta}$ and $N_{2\beta}$ increase). These intervention measures can be included in the function representing the number of applicants:

$$N_{ij} = g(\mu_r r_{ij}, \mu_C j)$$
$$\text{with } 0 \leq \mu_r \text{ and } \mu_C \leq 1$$

where the impact of μ_r is to reduce the interest rate paid by the farmer, and the impact of μ_C is to share with the farmer the collateral requirement.

However, a consequence of the ambiguity of impacts identified in Section 2.2 is that an algebraic investigation of the relative effectiveness of these two policy measures gives additional ambiguous findings. Therefore, in order to evaluate further this policy effectiveness, a numerical application is undertaken in the following section.

3. The numerical application

In order to undertake a numerical analysis of the model developed in the previous section it is necessary to specify the functional forms and the base case parameter values of the model. In what follows the probability distribution of uncertain returns is specified to be normal and the functional form of the project's uncertain return is multiplicative as indicated in the Appendix. In addition, the function representing the impact of changes in the interest rate and collateral requirement on the number of loan applicants for each type of contract is given by:

$$N_{ij} = 300 - 10^{a_r}\left(\mu_r r_{ij}\right)^{x_r} - 10^{a_j}\left(\mu_C jL\right)^{x_C}$$

where

i = 1 or 2 (project) and j = α or β (collateral)

the parameters a and x characterise the function's "slope" and "curvature"

$\mu_r = \mu_C = 1$ in the case of no intervention

$\mu_r = 0.7$ and $\mu_C = 1$ in the case of a credit subsidy only

$\mu_r = 1$ and $\mu_C = 0.3$ in the case of a loan guarantee only.

This function is designed to capture how changes in the interest rates and collateral requirements affect the extent to which the reservation utility and own collateral constraints are binding across the population of borrowers. This impact will depend on the population characteristics embodied in the assumed values of the parameters a and x. Therefore, these values will be subjected to a sensitivity analysis in what follows. The levels of intervention are such that farmers pay 70% of the interest rate in the credit subsidy case, and that they provide 30% of the collateral in the loan guarantee case[5]. Table 3 gives the numerical values of other parameters. The numerical values chosen for the projects give a coefficient of variation of 10% for land projects and 23% for business projects[6]. In addition, business projects have a 20% greater expected return.

(Table 3)

The parameter values are chosen such that the optimal interest rates and collateral requirements calculated in the base case could reflect reality. These are given in Table 4. The numbers of applicants for the base case (no intervention, credit subsidy only, loan guarantee only) are given in Table 5.

[5] These values are typical of government intervention in developing and transition countries (*e.g.* Swinnen and Gow, 1999). Unreported numerical analysis shows that the pattern of results that follows is independent of these values.

[6] The coefficient of variation measures the relative dispersion around the mean. It is defined by the return's standard deviation over its mean. A greater coefficient of variation means a riskier project. High riskiness is characterised by a coefficient of variation between 20% and 30%. See for example Hazell *et al.* (1990).

(Table 4)

(Table 5)

As can be seen from the results in Table 5, the parameter values of the base case have been chosen in order to indicate the two policy measures as being equally effective in stimulating loan applications overall. There are, however, clear differences within the loan categories, with credit subsidies being more effective in stimulating applications from small farmers, and loan guarantees being more effective with large farmers. The explanation for this result lies in the specification of the policies as proportional changes in interest rates or collateral requirements. As a consequence, for those (small) farmers facing higher interest rates, the larger absolute reduction in their interest rate has a greater impact than for the (large) farmers facing a lower interest rate. The same reasoning applies for the loan guarantee regarding the larger absolute contribution for those (large) farmers facing higher collateral requirements.

Moreover, the overall effectiveness of the policy measures also depends on the population characteristics of borrowers. For example, if farmers are more tightly distributed in terms of own collateral, but are below the relevant requirement, a small reduction in this requirement via a loan guarantee can make this policy relatively more effective than a credit subsidy. This situation is depicted in Table 6, where the "slopes" (the a parameters) of the application functions have been changed to make them more "responsive" to changes in the collateral requirement[7].

(Table 6)

Alternatively, there may be a substantial number of farmers whose expected utility from the relevant loan is just below their reservation level, in which case a small reduction in their interest rate could reverse this ranking and therefore could be very effective in stimulating loan applications. This situation is depicted in Table 7 where the "slopes" of the application functions have again been changed, this time to make them more "responsive" to changes in interest rates.

(Table 7)

---

[7] Changes in the x parameters can be used to generate similar findings.

As a consequence, it can be seen that neither policy can be argued as being more effective in stimulating loan applications without additional information regarding the characteristics of the population of borrowers. However, it is also clear that a proportion-based policy approach will be more effective in stimulating loans to large farmers if it is targeted at the loan collateral requirement, and more effective in stimulating loans to small farmers if it is targeted at the interest rate payable on loans.

4. Conclusion

The aim of this paper has been to assess the relative effectiveness of two government intervention schemes, a credit subsidy and a loan guarantee, in reducing credit rationing among farmers. Only credit rationing of the "internal" form, whereby potential applicants are discouraged from applying by features of the loan contract, has been considered. In Section 2 a framework of a credit market operating under uncertainty was developed, including a modelling of the optimal behaviour of borrowers and lenders, and of the operation of the two intervention schemes. This model was then subjected to a numerical analysis of relative policy effectiveness in Section 3.

It was shown that no unambiguous ranking of the overall effectiveness of the two schemes in stimulating loan applications is possible. This is because of the important role of characteristics of the population of borrowers in determining this effectiveness. In particular, the responsiveness of the demand for loans among the population of borrowers was shown to depend both on the distribution of own collateral and on the reservation utility levels among this population. Nevertheless, it was shown that the impact of each scheme manifests itself differently within the population of borrowers, with loans to small farmers being more responsive to the interest rate scheme, and loans to large farmers being more responsive to a collateral guarantee.

It may be concluded that, if the aim of the intervention is simply to increase overall lending, then the effectiveness of the intervention will benefit from gathering information about the population of borrowers as indicated. In particular, since the distribution of own land can be easily determined, the studies should therefore concentrate on determining utility reservation levels. Whereas if the aim of the intervention is targeted within the population of borrowers, then the results of this analysis provide clear direction for how to proceed.

References

Adams, D. and Nehman, G. (1979). Borrowing costs and the demand for rural credit. *Journal of Development Studies*, 15(2): 165-176.

Besanko, D. and Thakor, A. (1987). Collateral and rationing: sorting equilibria in monopolistic and competitive credit markets. *International Economic Review*, 28(3): 671-689.

Besley, T. (1994). How do market failures justify interventions on rural credit markets. *World Bank Research Observer*, 9(1): 27-47.

Blackman, A. (2001). Why don't lenders finance high-return technological change in developing-country agriculture. *American Journal of Agricultural Economics*, 83(4): 1024-1035.

Feder, G. (1985). The relationship between farm size and farm productivity: The role of family labor, supervision and credit constraints. *Journal of Development Economics*, 18: 297-313.

Fraser, R. (1988). A method for evaluating supply response to price underwriting. *Australian Journal of Agricultural Economics*, 32(1): 22-36.

Hazell, P., Jaramillo, M. and Williamson, A. (1990). The relationship between world price instability and the prices farmers receive in developing countries. *Journal of Agricultural Economics*, 41(2): 227-241.

Hendershott, P. and Hu, S. (1983). The allocation of capital between residential and nonresidential uses: Taxes, inflation and capital market constraints. *The Journal of Finance*, 38(3): 795-812.

Hoff, K. and Stiglitz, J. (1990). Introduction: Imperfect information and rural credit markets – Puzzles and policy perspectives. *World Bank Economic Review*, 4(3): 235-250.

Stiglitz, J. and Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review*, 71(3): 393-409.

Swinnen, J. and Gow, A. (1999). Agricultural credit problems and policies during the transition to a market economy in Central and Eastern Europe. *Food Policy*, 24(1): 21-47.

Yaron, J. (1992). *Rural Finance in developing Countries*. Working Paper Series 875, World Bank, Washington D.C. 25 p.

Appendix

The project's uncertain return is specified as follows:

$$R_i = \theta_i \gamma_i L^z$$

where $z>1$.

The borrower defaults in repaying the loan when her income is strictly negative, that is to say when the project's return is smaller than the repayment due: $R_i < (1+r_{ij})L$. In this case the income is –C. Thus there is a threshold $R^*_{ij} = (1+r_{ij})L$ under which the income is not anymore random as a function of the variable return R_i, but is equal to the fixed value –C. The probability of default in repaying the loan p_{ij} is equal to $F\{R_i < (1+r_{ij})L\} = F\{R_i < R^*_{ij}\}$. F is the cumulative density function of R_i. Calculating p_{ij} involves Winsorising the distribution of the return R_i, as shown on Graph 3. Assuming that R_i has a normal distribution, Winsorising is equivalent to mixing two distributions in the proportion $F\{R^*_{ij}\}$ and $1 - F\{R^*_{ij}\}$. $R^*_{ij} = (1+r_{ij})L$ is the point of Winsorisation and $F\{R^*_{ij}\}$ is the cumulative probability of $R_i < R^*_{ij}$. The distribution is a combination of a lower distribution (l) and an upper distribution (u), the latter one being a truncated normal distribution of R_i:

for $R_i < R^*_{ij}$, $\quad ER^l_{ij} = -C \quad$ $VarR^l_{ij} = 0$

for $R_i > R^*_{ij}$, $\quad ER^u_{ij} = ER_{ij} \big| R_i > R^*_{ij} \quad$ $VarR^u_{ij} = VarR_{ij} \big| R_i > R^*_{ij}$.

The expected income EY_{ij} and the income variance $VarY_{ij}$ are respectively (after Fraser, 1988):

$$EY_{ij} = F\{R^*_{ij}\}[-C] + \left[1 - F\{R^*_{ij}\}\right]\left[ER_i + \sqrt{VarR_i}\left(\frac{Z\{R^*_{ij}\}}{1 - F\{R^*_{ij}\}}\right) - (1+r_{ij})L\right]$$

$$\mathrm{Var}Y_{ij} = \left[1 - F\{R_{ij}^*\}\right]\mathrm{Var}R_i\left[1 - \left(\frac{Z\{R_{ij}^*\}}{1 - F\{R_{ij}^*\}}\right)^2 + \left(\frac{R_{ij}^* - ER_i}{\sqrt{\mathrm{Var}R_i}}\right)\left(\frac{Z\{R_{ij}^*\}}{1 - F\{R_{ij}^*\}}\right)\right] + F\{R_{ij}^*\}\left[-C - EY_{ij}\right]^2$$

$$+ \left[1 - F\{R_{ij}^*\}\right]\left[ER_i + \sqrt{\mathrm{Var}R_i}\left(\frac{Z\{R_{ij}^*\}}{1 - F\{R_{ij}^*\}}\right) - EY_{ij}\right]^2$$

with

$R_{ij}^* = (1 + r_{ij})L$ and C=jL

$F\{R_{ij}^*\}$ is the cumulative probability of $R_i < R_{ij}^*$

$$Z\{R_{ij}^*\} = \frac{1}{\sqrt{2\pi}}\exp\left\{-0.5\left[\frac{(R_{ij}^* - ER)}{\sqrt{\mathrm{Var}R}}\right]^2\right\}$$

$ER_i = \gamma_i L^z$ and $\mathrm{Var}R_i = \mathrm{Var}\theta_i L^z$

i = 1 or 2 (project) and j = α or β (collateral).

(Graph 3)

Table 1: Four loan contracts offered by the lender

	Low collateral required (α)	High collateral required (β)
Land projects (1)	contract $\{r_{1\alpha}, \alpha\}$	contract $\{r_{1\beta}, \beta\}$
Business projects (2)	contract $\{r_{2\alpha}, \alpha\}$	contract $\{r_{2\beta}, \beta\}$

$\alpha,\beta>0$

$0<r_{1\alpha},r_{1\beta},r_{2\alpha},r_{2\beta}<1$

$\alpha<\beta$

$r_{1\alpha} > r_{1\beta}$, $r_{2\alpha} > r_{2\beta}$, $r_{2\alpha} > r_{1\alpha}$, $r_{2\beta} > r_{1\beta}$

Table 2: Segmentation of farmers between the four loan contracts

	Small farmers		Large farmers	
High risk averse farmers	*Low* collateral *Land* credit	$\{r_{1\alpha},\alpha\}$	*High* collateral *Land* credit	$\{r_{1\beta},\beta\}$
Low risk averse farmers	*Low* collateral *Business* credit	$\{r_{2\alpha},\alpha\}$	*High* collateral *Business* credit	$\{r_{2\beta},\beta\}$

Table 3: Numerical values of parameters used in the model

Projects' parameters		Other parameters
$Var\theta_{land} = 0.01$	$Var\theta_{business} = 0.055$	loan amount L = 10
$\gamma_{land} = 1$	$\gamma_{business} = 1.2$	multiplicative coefficient z = 1.1

Applicant function parameters		
$x_r = 7$	$a_r = +11$	
$x_C = 7.6$	$a_\alpha = +1$	$a_\beta = -1$

Table 4: Optimal interest rates and collateral requirements

	Low collateral	High collateral
Land credit	$r_{1\alpha} = 4.94\%$	$r_{1\beta} = 3.94\%$
Business credit	$r_{2\alpha} = 5.35\%$	$r_{2\beta} = 4.35\%$
	$\alpha = 11\%$	$\beta = 24\%$

Table 5: Numbers of applicants with and without government intervention – Base case

	No intervention		Credit subsidy		Loan guarantee	
	Low C	High C	Low C	High C	Low C	High C
Land	100	101	*+66*	*+13*	*+27*	*+84*
Business	47	86	*+115*	*+27*	*+27*	*+84*
Total	*334*		*+221*		*+222*	

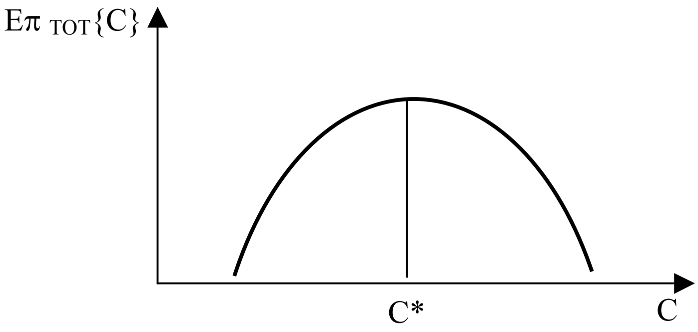
Table 6: Numbers of applicants with and without government intervention – Increase of a_α and a_β of 0.1

	No intervention		Credit subsidy		Loan guarantee	
	Low C	High C	Low C	High C	Low C	High C
Land	93	79	*+66*	*+13*	*+34*	*+106*
Business	40	64	*+114*	*+27*	*+34*	*+106*
Total	*276*		*+220*		*+280*	

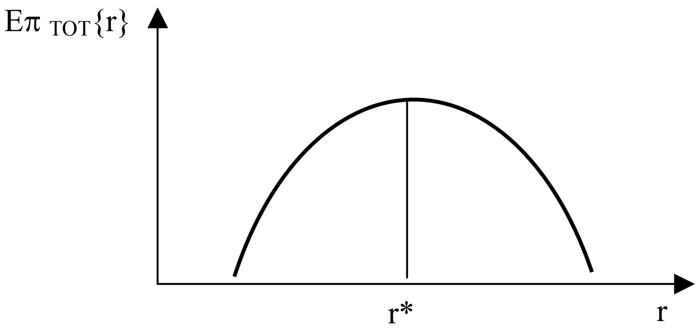
Table 7: Numbers of applicants with and without government intervention – Increase of a_r of 0.1

	No intervention		Credit subsidy		Loan guarantee	
	Low C	High C	Low C	High C	Low C	High C
Land	81	97	*+83*	*+17*	*+28*	*+84*
Business	14	78	*+145*	*+34*	*+28*	*+86*
Total	*270*		*+279*		*+225*	

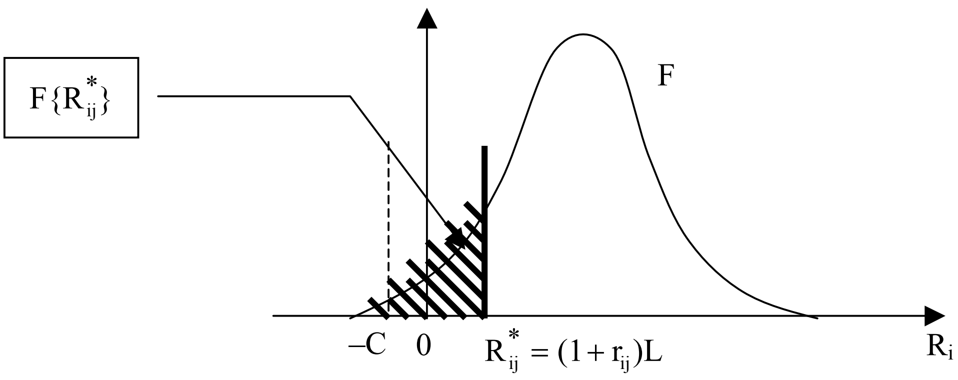
Graph 1: Lender's total expected profit with respect to one collateral requirement



Graph 2: Lender's total expected profit with respect to one interest rate



Graph 3: Winsorisation of the project's return R_i



Source: after Fraser, 1988

Working Papers INRA – Unité ESR Rennes

02-01 Tariff protection elimination and Common Agricultural Policy reform: Implications of changes in methods of import demand modelling. Alexandre GOHIN, Hervé GUYOMARD and Chantal LE MOUËL (March 2002)

02-02 Reducing farm credit rationing: An assessment of the relative effectiveness of two government intervention schemes. Laure LATRUFFE and Rob FRASER (April 2002)