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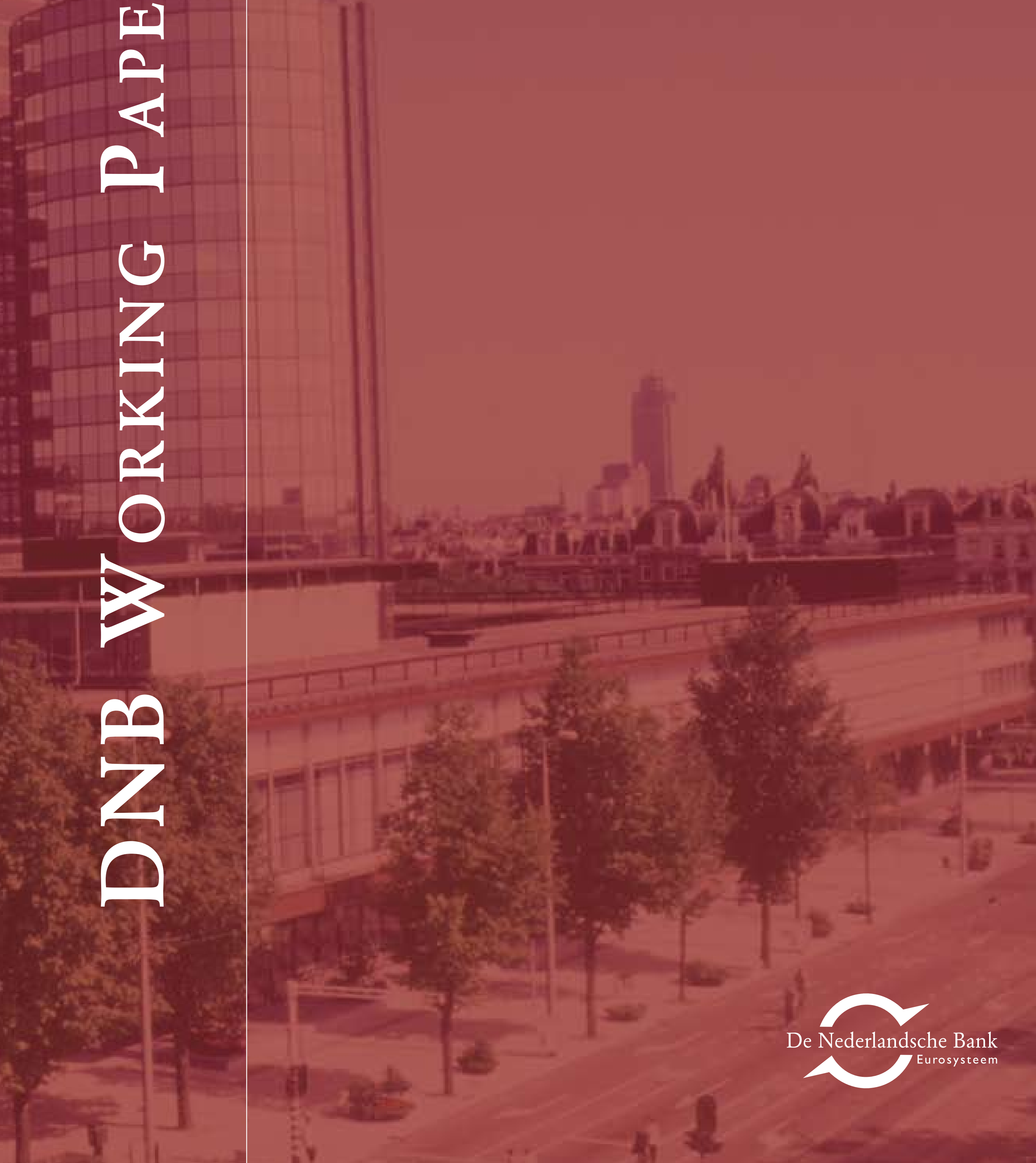

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De Nederlandsche Bank
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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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On the Possibility of Credit Rationing in the Stiglitz-Weiss Model: A Comment

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Abstract

The model of Stiglitz and Weiss (*American Economic Review*, 1981, 71(3)) is the seminal analytical work on credit rationing. However, in a recent paper, Arnold and Riley (*American Economic Review*, 2009, 99(5)) claim that the distributional assumption on which that model's main result depends cannot hold. This paper shows that Arnold and Riley's result is an outcome of their implicit assumption of a one-period Bertrand game between banks. In more realistic modes of bank competition, in which banks have some degree of monopoly power, Stiglitz and Weiss's result can hold.

Keywords: Credit rationing, Stiglitz-Weiss, Bank competition, Market Structure

JEL Classification: D82, G21

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For nearly three decades the model of Joseph E. Stiglitz and Andrew Weiss (1981) (henceforth SW) has been the cornerstone of analytical thinking about credit rationing. But a recent paper by Lutz G. Arnold and John G. Riley (2009) (henceforth AR) casts into doubt the usefulness of this model. AR claim to show that SW's primary result on rationing (Theorem 5, p. 397) is based on a distributional assumption that can never hold. In this paper I show that AR are wrong about this. Rather, whether SW's result can hold depends on the structure of the banking market.

In SW credit rationing arises from adverse selection. Borrowers have equal mean returns on their projects, but their projects vary in their riskiness (variance). Because of their limited liability, higher risk borrowers then have higher expected returns, and are willing to pay higher interest rates. Borrowers know the characteristics of their own projects, but they are indistinguishable to banks. Thus banks face a sorting effect when setting their interest rates. Higher rates imply that higher risk projects remain among the pool of borrowers willing to take out a loan. In equilibrium there can then be excess demand from borrowers, because banks do not want to increase rates too far, as this lowers their expected profits. Thus rationing can arise, which SW define as follows: "Among loan applicants who appear to be identical some receive a loan and others do not, and the rejected applicants would not receive a loan even if they offered to pay a higher interest rate" (SW, 394-395).

SW's primary result is based on a hump-shaped distribution of a bank's expected returns in interest rates. Initially higher rates raise expected returns. But beyond a threshold the negative sorting effect dominates and higher rates lower expected returns. AR argue that this hump-shape is untenable. They define $V(R)$ as the expected return per loan made by banks, when the gross loan rate is R. They show that $V(R)$ always reaches its global maximum when only the highest risk borrower remains on the market. The reason is that when a bank sets an interest rate equal to the expected return of this borrower, it appropriates his entire expected return. Since no loan could earn a higher expected return, $V(R)$ must have its global maximum at its right-hand endpoint. Therefore, though $V(R)$ can be non-monotonic, it cannot be globally hump-shaped. That is, a local "hump" cannot be the global maximum.

AR do not define an explicit bank maximization problem. However, implicitly they are assuming a one-period Bertrand competition game, because banks push "the lending rate R down to the level where profit [...] is zero" (p. 2015). In fact, Arnold (2007) provides a game-theoretic microfoundation for AR, in which he explicitly assumes one-period Bertrand competition. But, in fact, AR's general claim that "for the central model analyzed by SW [...] rationing with a single equilibrium loan rate is impossible" (p. 2019) depends on this very specific mode of competition. The particular feature of Bertrand competition is that setting the price marginally below that of the competitor allows a firm to capture the entire market. But Bertrand competition does not provide a realistic description of the banking market. Empirical evidence indicates that in virtually all countries - including the US - the banking market is best described by monopolistic competition (Jacob A. Bikker and Katharina Haaf (2002) and Stijn Claessens and Luc Laeven (2004)).

As for SW themselves, beyond stating that they "are not discussing a price-taking equilibrium" (p. 395), they take no stance on market structure. As soon as banks have monopoly power, AR's claim is untrue. This can be most easily highlighted using the opposite extreme of a monopolist bank. Note that this extreme can actually even be sustained as the equilibrium of a Bertrand competition game, if it is infinitely repeated instead of one-period. As is well known, with an infinitely repeated Bertrand game any equilibrium price between the one-period price and monopoly pricing is sustainable.

Consider for simplicity that bank funding is exogenous. The bank has been given $\overline{L}$ deposits, and I assume that these earn a zero interest rate. These are not key assumptions and it is straightforward to extend the argument to an elastic supply function of loanable funds. Using AR's notation, the monopolist's maximization problem can be written as:

$$\max_{R} \Pi\left(R\right) = \max_{R} \left\{ V(R) \left[\min \left\{ \int_{\theta(R)}^{1} g\left(t\right) dt, \overline{L} \right\} \right] \right\}$$

where expected profit, $\Pi\left(R\right)$, is the expected return per loan, $V(R)$, times the amount lent, $\left[\min\left\{\int_{\theta(R)}^{1} g\left(t\right)dt, \overline{L}\right\}\right]$. The amount lent equals the demand for loans $\int_{\theta(R)}^{1} g\left(t\right)dt$, if demand does not exceed maximum supply, $\overline{L}$. If there is excess demand, credit rationing takes place and the amount lent is $\overline{L}$.[1] In the expression for the demand for loans t is the borrower type, which is distributed between 0 and 1 according to distribution $g(t)$. Types are sorted such that higher t means higher risk. Moreover, $\theta(R)$ is the threshold type that is just willing to take out a loan (of size 1) at interest rate R. Here, as in SW and AR, $\frac{d\theta(R)}{dR} > 0$ because borrowers' limited liability makes them the owner of a call option, the value of which increases in volatility.

Quite obviously, $\Pi(R)$ goes to zero as R increases to the maximum, because the demand for loans vanishes. Thus, where $V(R)$ achieves its global maximum, the term $\left[\min\left\{\int_{\theta(R)}^{1} g(t)\,dt, \overline{L}\right\}\right]$ equals zero as does $\Pi(R)$. As in AR's analysis, define R_1 and R_2 such that $V'(R)|_{R<R_1} > 0$, $V'(R)|_{R\in(R_1,R_2)} < 0$ and $V'(R)|_{R>R_2} > 0$. That is, consider the case of a non-monotonic $V(R)$. Also define $\widetilde{R}$ as the $R : \int_{\theta(R)}^{1} g(t)\,dt = \overline{L}$. Then, whenever $\widetilde{R} > R_1$ there is a local maximum of $\Pi(R)$ at R_1. This follows from the derivative

$$\frac{d\Pi(R)}{dR} = V'(R)\left[\min\left\{\int_{\theta(R)}^{1} g(t)\,dt, \overline{L}\right\}\right] + V(R)\frac{d}{dR}\left[\min\left\{\int_{\theta(R)}^{1} g(t)\,dt, \overline{L}\right\}\right]$$

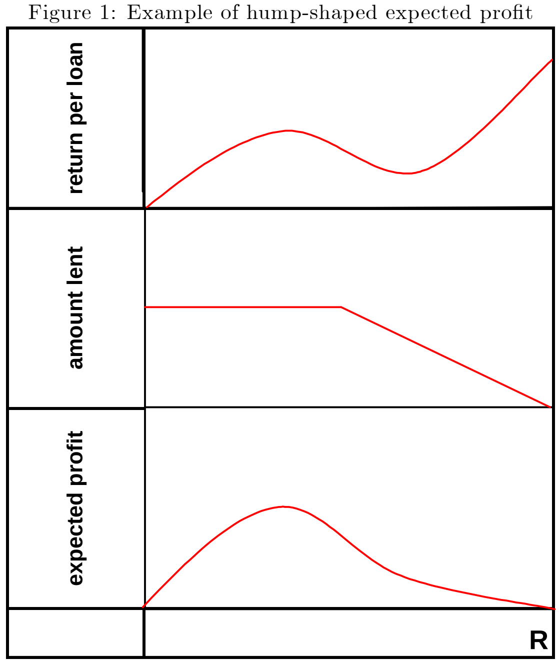
where $\frac{d}{dR}\left[\min\left\{\int_{\theta(R)}^{1} g(t)\,dt, \overline{L}\right\}\right] = 0$ up to $\widetilde{R}$ while the first part of the derivative has a local maximum at R_1 by the non-monotonicity of $V(R)$. Moreover, there can be no global maximum at the bottom or top end of R, as either the expected return per loan or the demand for loans is zero. Thus, the maximum at R_1 can be global, where by $\widetilde{R} > R_1$ rationing takes place. Rationing with a single equilibrium loan rate is possible, therefore.

An example of the intuition is represented by figure 1. As in AR's figure 1 the expected return per loan, $V(R)$, is assumed to be non-monotonic. As they argue, it reaches its global maximum at the highest R. This is seen in the first graph in the figure. The second graph in the figure depicts the amount lent as a function of R. For low R demand for loans exceeds supply and the line is flat, while for high R the amount lent follows demand. Finally, the third

[1] Obviously for a sufficiently high $\overline{L}$ no rationing takes place. This is consistent with SW's Corrolary 1. Rationing only arises because the supply of funds is limited (less than perfectly elastic).

graph depicts the expected profit of the bank.

Figure 1: Example of hump-shaped expected profit



If, as in the example in figure 1, $V(R)$ has its local maximum ("hump") at a point where there is excess demand for loans, then $\Pi(R)$ can only have one of two shapes. Firstly, as in the lowest graph, it can be globally hump-shaped. Or, if $V'(R)$ is sufficiently positive after R_2, it could have a double hump. If there is one hump, or if there is a double hump but profit at the second hump is lower than at the first, there will be credit rationing.

Clearly, the case of a monopolist is extreme. However, the principle is clear. As long as banks have monopoly power over part of demand, they do not just consider the expected return per loan. Rather, in their maximization they also consider the amount they lend. When this is the case, AR's finding on the impossibility of rationing with a single equilibrium loan rate no longer holds. This paper's discussion with AR's thus highlights the importance of market structure for the analysis of credit rationing. In more competitive banking markets, with less monopoly power, credit rationing to borrowers may be less likely to come about.

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