The Anatomy of Non-recourse Lending

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Lenders are frequently accused of mispricing the put option imbedded in non-recourse lending (Herring and Wachter, 1999 and 2003). In this paper we investigate the causes of market-wide mispricing and its effect on asset prices. We find two competitive equilibria – "good" and "underpricing." In the good equilibrium, lenders accurately price the put option and asset prices reflect their fundamental value. In the underpricing equilibrium,
- *Competitive pressures force all lenders to underprice the put,*
- *Asset prices rise above their fundamental level,*
- *The spread of lending over deposit rates narrows, and*
- *Lenders have negative expected profits.*

Such continuing operations result from agency frictions between bank shareholders and managers and/or because deposit insurance covers the potential losses and/or because of limited liability for shareholders and managers. We show that the transition from the good to the underpricing equilibrium is only a matter of time. This result holds even when all participants in both equity and debt markets are fully rational.

JEL Classification: G12, G13, G21

1. Introduction

Investigating the effects of the put option imbedded in non-recourse lending on the underlying asset markets is not new to finance. In his 2000 Presidential address to the American Finance Association, Franklin Allen discusses the role of financial institutions in asset pricing. More detailed studies of the subject are presented in Allen and Gale (1998 and 1999), which relate non-recourse financing to asset prices. Pavlov and Wachter (2004) extend this work to show that a single lender may rationally choose to underprice the put option imbedded in non-recourse loans. Here, we broaden this work to show the conditions under which many lenders rationally choose to underprice. We find that, under certain conditions, all lenders choose to underprice, regardless of their initial incentives or the potential future costs of underpricing. This underpricing equilibrium is characterized by the following:

- Asset prices rise above their fundamental level,
- The spread of lending over deposit rates narrows, and
- Lenders have negative expected profits.

Such continuing operations result from agency frictions between bank shareholders and managers and/or because deposit insurance covers the potential losses and/or because of limited liability for shareholders and managers.

We further analyze the mechanism that leads to the economy switching between the two equilibria and study the economic conditions that make the underpricing equilibrium more likely to occur and/or more stable. We find that:

- If the correctly pricing lenders cannot break-even in the good state, all lenders switch to the underpricing equilibrium described above.
- The probability of entering the underpricing equilibrium increases with the value of the put option and the elasticity of demand for loans, but decreases with the overall size of the debt market.
- The probability of entering the underpricing equilibrium increases with the time since the last market crash.

- Markets with longer product cycles experience a higher degree of underpricing.
- The spread between lending rates and deposit rates is negatively correlated with asset prices.
- Lenders' losses following a market crash are positively correlated with the time since the previous crash.
- Lenders' losses are larger for markets with longer cycles.

In Section 2 we put forward a model of the debt markets that ultimately shows why rational lenders underprice the put option even if they correctly estimate its value. Section 2.1 presents the model solution with no underpricing. Section 2.2 examines the managerial incentives and suggests that they are aligned with maximizing shareholder value. We present the key result that a single lender may choose to underprice in section 2.3. Sections 2.4 through 2.5 generalize this result to the case of two or more underpricing lenders. The most important result of the paper, that under certain conditions all lenders underprice regardless of their time horizon, is presented in Section 3. Section 4 analyzes the economic environment that makes the conditions for this underpricing equilibrium likely to occur. Empirical implications are presented in Section 5.

2. Debt Market

Following Pavlov and Wachter (2004), we assume banks are financial intermediaries that accept deposits and make loans to investors (borrowers) who purchase risky asset (properties) with zero equity. All agents are risk-neutral. In this setting, Pavlov and Wachter (2004) show that underpricing the put option results in inflated asset prices above their fundamental value. In what follows we investigate the circumstances under which fully rational lenders will underprice the put option *even if they correctly estimate its value.*

We use the following variables throughout the model:

R_H	=	High payoff to the risky asset (this is 1 + return in the good state)
R_L	=	Low payoff to the risky asset (in the bad state)
i	=	Interest rate charged on the loans
P	=	Price of the risky asset today ($R_H > P > R_L$)
δ	=	Probability of high return to the risky asset
v	=	Value of the put option imbedded in the loan
d	=	Rate paid on deposits
y	=	Number of loans made by each bank. (Since all projects are of the same size, y is proportional to the dollar value of the loans).
$c(y)$	=	Total cost to the bank (i.e. payment on the deposits)
$\pi_0(i,y)$	=	Expected profit of the bank
$\pi(i,y)$	=	Profit of the bank *in the good state*.
$a–b(E(i))$	=	Industry demand for loans as a function of the expected interest rate, δi.
m	=	Number of banks (endogenously determined)

Pavlov and Wachter (2004) motivate the following cost function for all banks:

$$c(y) = y^2 + 1 + vy = d(y)y + vy , \qquad (1)$$

where $d(y)$ is the deposit rate. The interest rate charged on the loan incorporates the value of the put option:

$$i = \frac{v+d}{\delta} \qquad (2)$$

The division by δ reflects the assumption that interest is collected only in the good state. This specification arises from the assumption of risk-neutral lenders whose only marginal

cost is the deposit rate. Thus, the value of the put option becomes part of the cost of capital for the borrowers.[1]

The expected profit to the bank, π, then becomes:

$$E(\pi_0) = \delta iy - (y^2 + 1 + vy) = (v + d(y))y - d(y)y - vy = 0 \qquad (3)$$

2.1 "Good" Equilibrium

By equating the expected marginal revenue to the expected marginal cost we obtain:

$$\delta i = 2y + v \qquad (4)$$

Substituting δi into the expected profit condition (3), we determine that the profit of the bank *in the good state* is:

$$\pi = (2y + v)y - (y^2 + 1) = y^2 + vy - 1 \qquad (5)$$

This leads us to the following proposition that will be utilized in the rest of the paper:

*Proposition 1: Profits in the **good state** are an increasing function of the **optimal** output, y.*

To determine the optimal output in this base case, we aggregate supply and demand:

$$a - b(2y + v) = my$$
$$y = \frac{a - bv}{m + 2b} \qquad (6)$$

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[1] Typically, the cost of capital contains a risk premium which incorporates the risk of default and depends on the risk-aversion of the lenders. Our assumption of risk-neutral lenders simplifies the risk premium to

The number of banks, *m*, is determined by finding the maximum *m* that will allow the participating banks to break-even. In this case,

$$m = a - b(2 + v) \qquad (7)$$

and the optimal output, *y*, equals one.[2] This leads to zero expected profit. The profit in the *good state* is the value of the option, *v*. In this case, all lenders price the put option correctly and, as Pavlov and Wachter (2004) show, asset prices reflect the fundamental value.

2.2 Bank Management

Similarly to Pavlov and Wachter (2004), conditional on the bank being in business, we assume the manager's compensation to have two components: salary, *S*, and bonus *B(π)* that depends on the realized bank profits. If bank managers price the put option correctly, they receive the salary component regardless of the state of the world. In the good state the bank realizes positive profit and the managers receive the bonus, *B(π)*, which is an increasing function of the realized profits.

Pavlov and Wachter (2004) motivate the assumption that underpricing of the option is detected only in the bad state. Thus, managers receive *S* in the good state, regardless of whether they price the option correctly or not. Furthermore, if managers underprice the put option they may be able to increase profits in the good state. This results in a higher bonus in the good state. If, however, an underpricing is discovered, i.e. the manager underprices the put and the bad state occurs, the manager is fired and they receive zero thereafter.

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just the value of the put option.
[2] The optimal number of loans (=1) in the base case is a result of normalization and can be set to any number by changing the fixed cost in the cost function of the lender.

Denoting the realized profit of the bank if the manager underprices the put by π_u, we summarize the compensation to the managers:

Payoff	High	Low
Price correctly	$S+B(\pi)$	S
Underprice	$S+B(\pi_u)$	0

The above compensation scheme can arise from any one of the following two conditions:
- agency friction between bank shareholders and managers, or
- limited liability for shareholders and managers.

An agency friction that gives rise to the proposed compensation scheme could be that bank shareholders attempt to provide performance incentives for the managers but do not observe underpricing. While plausible, this justification ultimately assumes inefficient capital markets, and is therefore questionable. None of the results of this paper require such an assumption. Pavlov and Wachter (2004) show, in a similar setting, that the above compensation scheme is consistent with maximizing bank equity value, even if shareholders perfectly observe the underpricing behavior. These findings also hold in the absence of underpricing.

We further assume that depositors cannot enforce correct pricing even in the absence of deposit insurance. Assuming otherwise would result in the unlikely implication that depositors are more informed then shareholders.

The above compensation scheme results in the following condition for underpricing:

$$\delta(B(\pi_u)+S)+\delta V(T) > S + \delta B(\pi)+V(T), \qquad (8)$$

where T denotes the time horizon of the manager, and $V(T)$ denotes the value to the manager of keeping their job. Solving for the continuation value we obtain:

$$(1-\delta)V(T) < \delta(B(\pi_u) - B(\pi)) - (1-\delta)S \qquad (9)$$

Given that V is an increasing function of T, and B is an increasing function of π, we can write the following proposition:

Proposition 2: If underpricing increases profits in the good state, $\pi_u > \pi$, there exists a time horizon T^* such that managers with time horizons shorter then T^* will underprice the put option. Furthermore, $T^*(\pi_u - \pi)$ is an increasing function of the additional profits obtained in the good state if the put option is underpriced.

The intuition behind Proposition 2 is based on the tradeoff between increased profits in the good state and discovery of underpricing in the bad state. Long-term managers have a great deal to lose if they underprice and are discovered. Thus, long-term managers would not underprice. Short-term managers, however, have relatively little to lose if their underpricing is discovered. For them the benefit of increased profits in the good state is sufficient to underprice and risk discovery.

Furthermore, the above compensation scheme is consistent with maximizing shareholder value. Thus, shareholders with limited liability may provide incentives for the managers to underprice. This possibility is strongest for shareholders who have little equity compared to the payoff from underpricing in the good state. Therefore, Proposition 2 holds even if there is no agency friction or informational asymmetry between managers and shareholders. Furthermore, we can phrase Proposition 2 in terms of shareholders' equity:

Proposition 2a: If underpricing increases profits in the good state, $\pi_u > \pi$, there exists a bank equity level, E^*, such that shareholders of banks with lower equity prefer underpricing. Furthermore, $E^*(\pi_u - \pi)$ is an increasing function of the additional profits obtained in the good state if the put option is underpriced.

To be consistent with previous research, we focus on bank management and use the first form of Proposition 2 in the remainder of this paper. This also allows us to include a friction between managers and shareholders as a possible cause for underpricing. Nonetheless, if such a friction does not exist, all of our results can be restated in terms of shareholder equity by utilizing Proposition 2a.

2.3 Incentives for a Single Lender to Underprice the Put Option

We adopt the following additional notation:

y_u = number of loans made by the bank that underprices the put option.

y_u^g = number of loans made by the banks that *do not* underprice the option (good banks), when there is one bank that underprices.

π_u = profit of the bank that underprices the put

π_u^g = profit of the banks that price correctly in the presence of a bank that underprices

We formulate the following proposition:

Proposition 3: In the good state, the bank that underprices the put receives higher profits and the other banks receive lower profits relative to the base case, i.e.,

$$\pi_u > \pi > \pi_u^g \tag{10}$$

Proof:

The marginal revenue for the bank that underprices is $2y_u$. Thus, the interest rate charged on the loans is:

$$\delta i = 2y_u^g + v = 2y_u \tag{11}$$

Equating aggregate demand and supply, we obtain the following equation for the output of the lenders:

$$a - b(2y_u) = (m-1)y_u^g + y_u \qquad (12)$$

Substituting the expression for y_u^g from equation (11) into equation (12), leads to the following expression for the optimal output of the bank that underprices:

$$y_u = \frac{a(2+v) - v(1 + b(2+v))}{2(a-bv)} \qquad (13)$$

Equation (7) implies that $a - bv = m + 2b > 1$. It is then easily verified that $y_u > 1 = y$. Invoking Proposition 1, we conclude that the profits of the underpricing bank are higher relative to the base case, i.e., $\pi_u > \pi$.

Using equation (11) we obtain an expression for the output of the banks that do not underprice in the presence of one underpricer:

$$y_u^g = 1 - \frac{v}{2(a-bv)} \qquad (14)$$

Thus, the optimal output of the correctly pricing banks is below the output in the base case, $y_u^g < 1 = y$. Invoking Proposition 1, we conclude that the profits of the correctly pricing banks are lowered by the presence of an underpricer, i.e., $\pi > \pi_u^g$.
Q.E.D.

Combining Propositions 2 and 3 directly yield the following result:

Result 1: There exists a time horizon T_1^* such that a manager with shorter time horizon, $T<T_1^*$, chooses to underprice the put option. Such a choice leads to

- *negative expected profit for the underpricing bank,*
- *higher profits for the underpricing bank in the good state,*
- *maximum expected management compensation for the underpricing manager,*
- *lower profits in the good state for the banks that price the put option correctly (they still have zero expected profits over all states),*
- *lower compensation for the managers of the banks that price correctly, and*
- *lower lending rates.*

The most important implication of Result 1 is that the presence of an underpricing manager leads to lower lending rates. Interest rates no longer fully reflect the value of the put option imbedded in the loans. We will come back to this point below.

2.4 Incentives for Two Lenders to Underprice the Put Option

Conditional on one lender underpricing the put option, we now examine the incentives for a second lender to underprice. We introduce the following additional notation:

y_{uu} = number of loans made by each of the two banks that underprice the put option.

y_{uu}^g = number of loans made by the banks that *do not* underprice the option (good banks), when there are two banks that underprice.

π_{uu} = profit of the banks that underprice the put

π_{uu}^g = profit of the banks that price correctly in the presence of two banks that underprice

We formulate the following proposition:

Proposition 4: In the presence of one underpricer, a bank can increase the good state profits by underpricing. Furthermore, the other banks who price correctly in the presence of two underpricers receive lower profits relative to the case of one underpricer, i.e.,

$$\pi_u > \pi_{uu} > \pi_u^g > \pi_{uu}^g \tag{15}$$

Proof:

Analogously to the proof of Proposition 3, we equate the demand and supply:

$$a - b(2y_{uu}) = (m-2)y_{uu}^g + 2y_{uu} \tag{16}$$

This leads to the following expression for the optimal output of a bank that underprices:

$$y_{uu} = \frac{a(2+v) - v(2 + b(2+v))}{2(a - bv)} \tag{17}$$

Comparing expression (17) to (13) shows that $y_{uu} < y_u$ which verifies the first part of Proposition 4.

Comparing expression (17) with that for y_u^g given by (14), verifies that $y_{uu} > y_u^g$, which proves the second inequality of Proposition 4. Equating the marginal costs of the underpricing and correctly pricing banks, we obtain that

$$y_{uu}^g = y_{uu} - \frac{v}{2} \tag{18}$$

It is easily verified that $y_{uu}^g < y_u^g$ which proves the third inequality of Proposition 4.
Q.E.D.

Combining Propositions 2 and 4 we obtain the following result:

Result 2: In the presence of one underpricer, there exists a time horizon T_2^* such that a manager with shorter time horizon, $T<T_2^*$, chooses to switch from pricing correctly to underpricing. Such a choice leads to

- *negative expected profit for both underpricing banks,*
- *lower profits for the underpricing banks in the good state,*
- *lower profits in the good state for the banks that price the put option correctly (they still have zero expected profits over all states),*
- *lower compensation for the managers of the banks that price correctly, and*
- *lower interest rates.*

2.5 Incentives for *K* Lenders to Underprice the Put Option

We now examine the case when K lenders underprice the put option. The central question is whether there is still incentive for yet another lender to start underpricing. We adopt the following notation:

y_k =   number of loans made by each of the banks that underprice the put option.

y_k^g =   number of loans made by the banks that DO NOT underprice the option (good banks), when there are K banks that underprice.

π_k =   profit of the banks that underprice the put

π_k^g =   profits of the banks that price correctly in the presence of K banks that underprice

Equating demand and supply with K underpricers, we obtain the following equilibrium condition:

$$a - b(2y_k) = (m-K)y_k^g + Ky_k \tag{19}$$

Analogously to Propositions 3 and 4, this leads to the following expressions for y_k and y_k^g:

$$y_k = \frac{a(2+v) - v(K + b(2+v))}{2(a - bv)} \tag{20}$$

and

$$y_k^g = 1 - \frac{Kv}{2(a - bv)} \tag{21}$$

To determine the underpicing incentive we compare the output of K underpricers with the output of a good bank in the presence of K-1 underpricers:

$$y_k - y_{k-1}^g = \frac{v}{2}\left(1 - \frac{1}{(a - bv)}\right) > 0 \tag{22}$$

Combined with Propositions 1 and 2, this leads to the following result:

Result 3: In the presence of K underpricers, there exists a time horizon T_k* such that a manager with a shorter time horizon, $T<T_k*$, chooses to switch from pricing correctly to underpricing. Such a switch leads to

- *negative expected profits for all underpricing banks,*
- *lower profits for all underpricing banks in the good state,*
- *lower profits in the good state for the banks that price the put option correctly (they still have zero expected profits over all states),*
- *lower compensation for the managers of the banks that price correctly, and*
- *lower interest rates.*

The essence of Result 3 is that regardless of the number of underpricers on the market, there is always a potential incentive for a "good" manager, i.e., manager who prices correctly, to begin underpricing.

3. Underpricing Equilibrium

The management compensation scheme described above assumes that the bank is in business. A necessary condition for staying in business is that the bank makes positive profits at least in the good state:

$$\pi_k^g = (y_k^g)^2 + v y_k^g - 1 > 0 \tag{23}$$

In other words,

$$y_k^g = \frac{-v + \sqrt{4 + v^2}}{2} > 0. \tag{24}$$

Substituting (21) into (24) results in the following condition for K:

$$K < K_{max} = \frac{(a - bv)(2 + v - \sqrt{4 + v^2}}{v} \tag{25}$$

where K_{max} denotes the maximum number of underpricers that will allow for the good banks to make positive profit in the good state. This maximum will be binding only if K_{max} exceeds the total number of banks, m. Using expression (7) for m, we obtain the following condition for $K_{max} < m$:

$$a > \frac{bv\sqrt{4 + v^2}}{\sqrt{4 + v^2} - 2} \tag{26}$$

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which simply states that the total debt market has to be large relative to the value of the put option.

If a bank cannot turn positive profit even in the good state, i.e. $K>K_{max}$, the manager faces certain dismissal. If, however, the manager underprices the put, the manager receives salary plus bonus in the good state and only looses his or her job if the bad state occurs. It is thus clear that all remaining managers will underprice the put *regardless of their time horizon*.

This allows us to formulate the following result:

*Result 4: For a sufficiently large market (condition (26)), if the number of underpricing banks exceeds K_{max} all remaining managers will switch to underpricing **regardless of their time horizon**. The new equilibrium has the following characteristics:*

1. *The interest rate on the loans reflects only the deposit rate and does not include the put option at all*
2. *The new interest rate is lower relative to the base case*
3. *All banks make the same number of loans*
4. *All banks make positive profit in the good state although this profit is negligible in a large market*
5. *All banks have negative expected profit*
6. *The deposit rate is higher relative to the base case, although this difference is negligible in a large market*
7. *More loans are made relative to the base case, although this increase is negligible in a large market*

Proof:
Let y^* denote the optimal number of loans when all banks underprice. The marginal cost to the bank only reflects the cost of obtaining new deposits, $2y^*$, and does not include the put option. Equating aggregate supply and demand provides the following equation for the optimal output:

$$a - 2by = my \qquad (27)$$

Substituting (7) into (27) provides the following expression for the optimal output:

$$y^* = \frac{a}{a - bv} \qquad (28)$$

This is greater then the optimal output in the base case (=1). For a large debt market, i.e., $a \gg bv$, y^* approaches the output in the base case.

The profit in the good state is given by:

$$\pi = y^{*2} - 1 = \left(\frac{a}{a - bv} \right)^2 - 1 \qquad (29)$$

Expression (29) is greater then zero, but approaches zero for a large debt market. In other words, the profits in the good state are small and approach zero, while the losses in the bad state remain unchanged. This leads to negative expected profits for the lenders.

Using Equation (1), we obtain the following expression for the deposit rate in the new equilibrium:

$$d(y^*) = \frac{a}{a - bv} + \frac{a - bv}{a} \qquad (30)$$

Since $a - bv = m + 2b > 1$, a is greater than 1, and it is easily verified that $d(y^*)$ is greater than 2, which is the deposit rate in the base case. Expression (30) also suggests that for a large market, i.e. $a \gg bv$, $d(y^*)$ approaches the deposit rate in the base case.

Finally, we compare the interest rates charged on loans in the base case and the underpricing equilibrium. The base case interest rate is given by (4), while the new interest rate, i^*, is

$$i^* = \frac{2a}{a - bv}. \tag{31}$$

It is easily verified that the new interest rate is lower then the interest rate in the base case, $i^* < i$.

Q.E.D.

4. Determinants of K_{max}

In what follows we examine the influence of the economic environment on the critical number of underpricing banks, K_{max}. We summarize the results in the following statement:

Result 5: The following relationships hold:

$$\frac{\partial K_{max}}{\partial v} < 0, \ \ \frac{\partial K_{max}}{\partial a} > 0, \ \ \text{and} \ \ \frac{\partial K_{max}}{\partial b} < 0$$

Proof:
Based on equation (25), we compute the following derivatives:

$$\frac{\partial K^*}{\partial v} = \frac{a\left(\dfrac{4}{\sqrt{4+v^2}} - 1\right) + bv\left(\dfrac{v}{\sqrt{4+v^2}} - 1\right)}{v^2} < 0$$

$$\frac{\partial K_{max}}{\partial a} = \frac{2 + v - \sqrt{4+v^2}}{v} > 0 \tag{32}$$

$$\frac{\partial K_{max}}{\partial b} = -(2 + v - \sqrt{4+v^2}) < 0$$

Q.E.D.

The most important claim of Result 5 is that the larger the option value, the smaller the critical number of underpricers. In other words, highly volatile markets are substantially more likely to enter the equilibrium in which all lenders completely ignore the put option in the loans they are providing.

Following a low realization all underpricing managers are discovered and replaced. Let $G_0(T)$ denote the cumulative distribution function of the time horizons of the managers following a low realization. Notice that $G_0(T_1) = 0$, i.e., there are no managers with time horizons shorter then T_1, defined in Result 1 as the cutoff point for a single manager to underprice. Each time period, the time horizon for all managers goes down by one. Thus, the cumulative distribution function t intervals after the last low realization, G_t, can be expressed as follows:

$$G_t(T) = G_{t-1}(T+1) = G_0(T+t).$$
(33)

The number of underpricing managers, K_t, at time t is the solution to the following equation:

$$K_t = mG_t(T(K_t)) = mG_0(T(K_t)+t).$$
(34)

Proposition 5: The number of underpricing managers, K_t, is an increasing function of time since the last low realization.

Proof:
Notice that the critical time horizon that induces underpricing, $T(K_t)$, is a function of the number of underpricing managers, K_t. Let $\Delta\pi_k = \pi_k - \pi_{k-1}^g$ denote the change in the good state profits and $\Delta y_k = y_k - y_{k-1}^g$ denote the change in optimal output for a bank that begins to underprice in the presence of *K-1* underpricers. Equation (22) shows that Δy_k is independent of K. Since the profit is a quadratic function of the optimal output (Equation (5)), the change in profits is an increasing function of the optimal output:

$$\Delta \pi_k = \Delta y_k^2 + (2 y_{k-1}^g + v) \Delta y_k \tag{35}$$

Equation (21) shows that y_{k-1}^g is a decreasing function of K. Since Δy_k is independent of K, $\Delta \pi_k$ is a decreasing function of K. Invoking Proposition 2, we find that

$$\frac{\partial T}{\partial K} < 0. \tag{36}$$

Differentiating equation (34) with respect to time gives:

$$\frac{\partial K}{\partial t} = mg(T(K_t + t)) \left(\frac{\partial T}{\partial K} \frac{\partial K}{\partial t} + 1 \right), \tag{37}$$

where g denotes the probability density function of T. Rearranging (37) we obtain:

$$\left(1 - mg(T(K_t + t)) \frac{\partial T}{\partial K} \right) \frac{\partial K}{\partial t} = mg(T(K_t + t)) \tag{38}$$

The right hand side of Equation (38) is positive. Equation (36) suggests that

$$\left(1 - mg(T(K_t + t)) \frac{\partial T}{\partial K} \right) > 0 \tag{39}$$

Therefore,

$$\frac{\partial K}{\partial t} > 0 \tag{40}$$

Q.E.D.

Since the number of underpricing managers is an increasing function of time since the last low realization, it is only a matter of time until K_t reaches the critical point K_{max} at which all managers switch to underpricing regardless of their time horizon. We summarize the above reasoning in the following result:

Result 6: The number of underpricing managers increases with time since the last market crash (i.e. low realization). Given enough time without a crash, the critical level of underpricing, K_{max}, is achieved and all managers switch to underpricing.

Result 6 immediately leads to the following important conclusion:

Result 7: Asset Markets with longer cycles suffer, on average, a higher degree of underpricing.

5. Empirical Implications

The immediate empirical implication of Result 4 is that underpricing of the put option results in inflated asset prices. This is not directly testable because outsiders do not observe the value of the put option or the fundamental price of the asset. We use the spread of the loan rate over the deposit rate as a proxy for the underpricing.

This spread compensates the lenders for providing the put option imbedded in their loans. During periods of widespread underpricing, lenders require little or no compensation for the put option, and the spread of lending over deposit rates is reduced. As shown above, this is reflected in higher market price of the underlying asset.

Furthermore, periods of widespread underpricing are associated with increased lending activity. In order for lenders to raise enough capital to support this increased lending activity they increase deposit rates. This leads to the testable implication that deposit rates are positively correlated with asset prices. We summarize the above reasoning in the following empirical prediction:

Result 8: The spread between lending rates and deposit rates is negatively correlated with asset prices. Deposit rates are positively correlated with asset prices.

Results 7 and 8 also suggest the following empirical implication:

Result 9: Lenders' losses following a market crash are positively correlated with the time since the previous crash. Furthermore, lenders' losses are larger for markets with longer cycles.

Note that all empirical implications of our model relate one or more symptoms of underpricing to observed asset prices. Therefore, none of them imply causality nor is the mechanism we propose the only one that can generate such conclusions.

6. Conclusion

We put forward a model of efficient asset markets that demonstrates how underpricing of the put option imbedded in non-recourse loans results in inflated prices for assets in fixed supply. Furthermore, we examine the conditions under which fully rational lenders choose to underprice this put option. In particular, the presence of short-term players in the debt market creates competitive pressures that force all lenders to underprice the option regardless of their time horizon. Once this happens, returning to pricing the put option correctly can only happen after a market crash.

Since the value of the put option is unobservable by outsiders, the above conclusions cannot be tested directly. The proposed model provides for some auxiliary empirical implications.

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