Robbing the Bank:

Non-recourse Lending and Asset Prices

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We investigate the market prices of assets in fixed supply whose purchase is typically financed through non-recourse loans. The largest and most common asset in this category is real estate. We demonstrate that within these markets, lenders' underpricing of the put option contained in non-recourse loans leads to inflated asset prices within efficient markets, and that lenders with short-term horizons have incentives to underprice the put option. This persistent underpricing of the put option is one of the reasons for the cycles experienced in real estate markets. These results hold when participants in both equity and debt markets are rational. The model also allows for management compensation that is aligned with maximizing bank shareholders' value. Using real estate transaction data we find empirical evidence consistent with the predictions of the model.

1. Introduction

As is well known, when a bank makes a non-recourse loan the bank provides a put option on the underlying asset. If the value of the asset declines, the borrower has the right, but not the obligation, to "put" the asset back to the bank (i.e., walk away from the property). In other words, the borrower can "sell" the asset to the bank for the outstanding loan balance. This "right to sell" limits the losses of the borrower and is a put option, written by the bank, with a strike price equal to the outstanding loan balance. [3]

If the put option is priced correctly and the price is passed on to the borrower in the form of higher interest rate, the lending has no impact on asset prices (e.g., property values). We show in this paper that if the put option imbedded in a loan is underpriced, that is the interest rate charged is too low relative to the deposit rate, then investors incorporate this mistake into their demand price for the asset. Thus, lending without proper valuation of the put option results in an inflated price of the asset within efficient equity markets.

Managers' incorrect valuation of the put option can directly result in the underpricing of the loan leading to inflated asset prices. Moreover, even if managers know the correct value of the put option, certain conditions can induce them to underprice. Managers have an incentive to underprice the put option in order to increase their lending volume and profits in good states. However, if they underprice, they are discovered only in bad states. Short-term managers have 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. This result holds even if managers act in the best interest of shareholders, i.e. absent any agency conflicts. While this outcome has been widely surmised to occur, we formally show the circumstances which lead to it.

Furthermore, we show that the underpricing behavior leads to lower lending rates and to increased lending activity. The increased lending needs to be financed through higher

[3] This is similar to the Black and Scholes' (1973) proposition that the equity in a levered firm can be thought of as a call option, or alternatively a portfolio of the firm assets and a put option.

deposit rates. These outcomes can be used to evaluate whether market data are consistent with the model's predictions.

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. The asset-pricing model incorporated in this paper shares several common characteristics with the above studies. However, their model relies on asymmetric information problems between borrowers and lenders. Our main point of departure is to demonstrate, even without information asymmetry, how rational lenders may choose to underprice the put option imbedded in non-recourse loans and to show how this leads to inflated asset prices even within efficient markets and with rational lenders.

Cauley and Pavlov (2002a,b) also study the effects of non-recourse financing on the liquidity in residential and commercial real estate markets. While in their model all options are priced correctly at origination, ex-post changes in their values have substantial impact on the market liquidity for the underlying asset contributing to asset market instability.

A number of studies argue that lenders may be unable to price the put option correctly. Under the best of circumstances, it is difficult for lenders to estimate the present value of a real estate project. Appraisals are based on past sales and, as such, are backward-looking and susceptible to disaster myopia, defined in Herring and Wachter (1999), as the extrapolation of past positive price trends given the low-frequency and non-observation of negative events. Hendershott and Kane (1995) present econometric evidence of appraisal bias of over 50 percent in the late 1980's U.S. commercial office market. The current paper also relies on the underpricing of the put option, not because of these difficulties, but rather because of incentives for lenders to underprice. We justify our assumption that underpricing is not discovered in the good state due to the lack of market data.

In Section 2, which follows, we show the effect of underpricing of the put option on asset prices assuming efficient markets. Section 3 puts forward a model of the debt market that ultimately shows the circumstances under which rational lenders underprice the put option even if they correctly estimate its value. Section 3.1 presents the model solution with no underpricing. Sections 3.2 and 3.3 examine managerial and shareholder incentives and suggest that they are aligned. Here we also present the key result that rational managers may choose to underprice. Section 4 revisits asset pricing in view of the findings of Section 3. Some important empirical implications and results are presented in Section 5 and Section 6 concludes.

2. Asset Pricing

Without loss of generality, we assume banks are financial intermediaries that accept deposits and make loans to investors (borrowers) who purchase risky assets (properties) with zero equity.[4] All agents are risk neutral.

We use the following variables throughout the model:

R_H	=	Price of high payoff to the risky asset (this is 1 + return in the good state)
R_L	=	Price of 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

Under a full equity investment, the price of the asset, P, is simply:

[4] The zero equity purchase is a simplifying assumption that has no impact on the conclusions.

$$P_f = \frac{\delta R_H + (1-\delta)R_L}{1+d} \tag{1}$$

We call this the “fundamental” price.

Since the loans are non-recourse and the investment requires zero equity, the zero-profit condition for investors, who are also borrowers, simply states that the return in the high-payoff state equals the interest rate:

$$\frac{R_H}{P} = 1 + i \tag{2}$$

When the payoff is low, investors walk away, lose the asset to the bank, and pay no interest.

The value of the put option satisfies the following no-arbitrage condition:

$$v + (1-\delta)\left(\frac{R_L}{P} - 1\right) = 0 \tag{3}$$

The writer of the option (bank) receives the value, *v*, plus zero in the high-payoff state and $(R_L/P)-1$ in the low-payoff state. This yields the following value of the put option:

$$v = \frac{(1-\delta)(P-R_L)}{P} \tag{4}$$

Due to the equilibrium condition (2) which reflects the fact that, in the high payoff state, borrowers always make their principal and interest payment, the value of the put option is not a function of the interest rate.[5]

The interest rate charged on the loan must incorporate the value of the put option and equals:

$$i = \frac{v + d}{\delta} \tag{5}$$

The division by δ reflects the fact that the value of the option is part of the interest rate on the loan, which is collected only in the good state with probability δ.[6] An important interpretation of Equation (5) is that the expected return to the lender, δi, equals the deposit rate plus the value of the put option. If the lender collects both interest and principal in all states of the world, then the value of the put would be zero.

Substituting the interest rate into the zero-profit condition for investors shows that the price of the asset is the same as the fundamental price, P_f (under full equity investment).

Let us now examine the implications of underpricing the put option (i.e., below fair market interest rate). The new expression for the value of the option, *v*, is:

$$v = \frac{(1-\delta)(P - R_L)}{P} - \varepsilon \tag{6}$$

where ε is the amount of underpricing.

Substituting the new, underpriced, option value into the interest rate charged yields the following:

[5] If the payoffs to the risky asset follow a continuous distribution (or discrete distribution with many states), a higher interest rate would make it more difficult to meet the loan obligation in some states and increase the probability of default. Thus, the interest rate would affect the value of the put option.

$$P = \frac{\delta R_H + (1-\delta)R_L}{1+d-\delta\varepsilon} \tag{7}$$

Any underpricing of the put option imbedded in the loan results in an inflated asset price, i.e., a price above the fundamental value under full equity investment. The larger the underpricing, the larger the price inflation of the asset.

3. Debt Market

In what follows we investigate the circumstances under which rational lenders underprice the put option even though they correctly estimate the value.

We utilize the following variables:

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)

Assume all banks have the same standard cost function:

$$c(y) = y^2 + 1 + vy = d(y)y + vy\ , \tag{8}$$

where vy represents the cost of providing the put option and $d(y)$ is the deposit rate, assumed to be of the form

$$d(y) = y + 1/y \tag{9}$$

[6] In the bad state, the borrower defaults, and no interest (and therefore option price) is collected.

Such a cost function can be motivated in a number of ways. For example, this form captures the stylized observation that when a bank is very small, it needs to pay a higher rate on deposits to attract customers. As the bank grows, it is perceived as more stable and the deposit rate drops. Beyond a certain size, a bank needs to increase the deposit rates again to attract “remote” customers, i.e. customers who would choose a different bank (or a different investment all together) due to physical proximity, convenience, service, or a number of other frictions. In other words, we assume there are initially economies of scale to a lender and then diseconomies of scale beyond a certain size. Note that any other cost function can be used in what follows, as long as it captures the *U*-shape between size and deposit rates.

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

$$E(\pi_0) = \delta iy - (y^2 + 1 + vy) = (v + d(y))y - d(y)y - vy = 0 \tag{10}$$

3.1 Base Case

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

$$\delta i = 2y + v \tag{11}$$

Substituting δi into the zero profit condition (10), we determine that the profit of the bank *in the good* state is:

$$\pi = (2y + v)y - (y^2 + 1) = y^2 + vy - 1 \tag{12}$$

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

$$a - b(2y + v) = my$$
$$y = \frac{a - bv}{m + 2b} \tag{13}$$

The number of banks, *m*, is determined by finding the maximum *m* that will allow the participating banks to break-even. To find this number, we substitute the expression for *y* from Equation (13) into Equations (11) and (10). This results in the following equation for *m*:

$$\left(2\frac{a - bv}{m + 2b} + v\right)\frac{a - bv}{m + 2b} - \left(\frac{a - bv}{m + 2b}\right)^2 - 1 - v\frac{a - bv}{m + 2b} = 0 \tag{14}$$

Solving for *m*, we find that the number of banks is given by:

$$m = a - b(2 + v) \tag{15}$$

and the optimal output, *y*, equals one.[7] This leads to zero expected profit. The profit in the *good state* is the value of the option, *v*.

3.2 Bank Management

We adopt the following additional notation:

y_u = number of loans made by the banks that underprice the put option

y_u^g = number of loans made by the banks that price the option correctly (good banks) in the presence of underpricers

π_u = profit in the good state of the banks that underprice the put

π_u^g = profit in the good state of the banks that price correctly in the presence of banks that underprice

[7] 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.

Conditional on the bank being in business, manager's compensation is assumed to have two components: salary, *S*, and bonus $B(\pi)$ that depends on the realized bank profits. If bank managers price the put option correctly, managers 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, $B(\pi)$, which is an increasing function of the realized profits.

Due to informational disadvantages, outsiders are unable to monitor the pricing directly. The key outsider group, the shareholders, may have little or no incentives to monitor, as shown below. Any 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 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.

We summarize the compensation to the managers in the following table:

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

The condition for underpricing is:

$$\delta(B(\pi_u)+S)+\delta V(T) > S+\delta B(\pi)+V(T)\,, \tag{16}$$

where *T* denotes the time horizon of the manager, and $V(T)$ denotes the continuation value, i.e., the value to managers of keeping their job. Notice that if the probability of the high payoff, δ, is high, managers face a lower probability of discovery and are more likely to underprice.

While our model is static, we can get a sense of what would happen in a full dynamic setting by introducing the exogenous function, *V(T)*. We assume it is monotonic and increasing in the time horizon, *T*. This continuation value allows us to distinguish between short-term and long-term players. In particular, long-term players would have a high continuation value because they expect to receive their income over a long horizon. The continuation value would be very small for short-term players, as they do not expect to receive their income for a long time in the future even they price the put option correctly. This reasoning justifies our assumption that *V(T)* is an increasing function of the time horizon.

The left hand size of Condition (16) shows the expected payoff in case of underpricing. This payoff is received only if the good state occurs and is given by the immediate salary and bonus, $(B(\pi_u) + S)$, and the continuation value of the manager keeping their job, $V(T)$. Both of these quantities are multiplied by δ to denote that the manager receives them only in the good state. The right hand side of Condition (16) contains the payoff to the manager if the option is properly priced. In this case, the manager receives salary, *S*, with certainty, bonus, $B(\pi)$, in the good state, and the continuation value, *V(T)*, with certainty.

Solving for the continuation value we obtain:

$$(1-\delta)V(T) < \delta(B(\pi_u) - B(\pi)) - (1-\delta)S \qquad (17)$$

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

Proposition 1: 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 1 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. This choice leads to negative expected profit for the underpricing bank.

In a similar setting of Pavlov and Wachter (2002), we show that the banks that underprice the put option receive higher profits in the good state relative to the base case, i.e., $\pi_u > \pi$. We also show that the optimal output of the underpricing bank is greater than the optimal output of the correctly pricing banks. Together with Proposition 1, this leads to 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*

- *higher profits for the underpricing bank in the good state,*
- *maximum expected management compensation for the underpricing manager,*
- *lower lending rates.*

The most important implication of Result 1 is that the presence of underpricers leads to lower lending rates. In our case the total supply of loans is increased above the equilibrium level. This is formulated in the following proposition:

Proposition 2: The total supply of loans in the presence of an underpricing bank is increased relative to the base case,

$$(m-1)y_u^g + y_u > my \tag{18}$$

Proof: Substituting the optimal output, *y*, in Equation (18) provides:

$$(m-1)y_u^g + y_u = m\left(1-\frac{v}{2(a-bv)}\right)+\frac{v}{2} > m \tag{19}$$

Equation (15) implies that $a – bv = m + 2b > 1$. Since $a – bv > 1$, the required result holds.

The result of Proposition 2 is intuitive because a lender who underprices the put option imbedded in the loans will find it profitable to lend as much as possible. This increase is limited by our assumption that this lender will have to pay higher deposit rates to finance their lending activity. The increase of the lending supply by the underpricer exceeds the reduction of lending activity by remaining banks and, on balance, increases the overall supply of loans.

Proposition 2, together with Result 1, especially its lower interest rates implication, leads to the following result:

Result 2: The value of the put option imbedded in loans is no longer reflected in interest rates.

3.3 Bank Shareholders

Because of the increased profits, due to increased market share (Proposition 2), the value of the shareholder's stake can be modeled similarly to the compensation of the managers. We use the following change in variables:

- Salary is zero, $S = 0$,
- Bonus is the entire profit, $B(\pi) = \pi$,
- Continuation value equals the equity in the bank, $V = Equity$.

Thus, if the bank prices the put option correctly, the owners receive $B(\pi) = \pi$ plus they keep their equity. If the bank underprices, the shareholders receive $B(\pi_u) = \pi_u > \pi$ and keep their equity with probability δ, and loose their equity with probability $(1 – \delta)$. Thus, the bank management model described above also represents the bank shareholders with appropriate parameterization.

Under the shareholder parameterization, the analog of Equation (17) for the shareholders is:

$$(1-\delta)Equity < \delta(\pi_u - \pi) \tag{20}$$

In other words, if the expected increase in profits exceeds the expected loss shareholders will choose to underprice.

Furthermore, the management compensation given by the salary, *S*, and bonus, $B(\pi)$, can be defined to be consistent with maximizing shareholders' wealth. In particular, we can set the management condition (17) to equal the shareholders' condition (20):

$$(1-\delta)V(T) - \delta(B(\pi_u) - B(\pi)) + (1-\delta)S = (1-\delta)Equity - \delta(\pi_u - \pi) \tag{21}$$

This results in the following expression for the salary, *S*:

$$S = \frac{(1-\delta)Equity - \delta(\pi_u - \pi) - (1-\delta)V(T) + \delta(B(\pi_u) - B(\pi))}{(1-\delta)} \tag{22}$$

The salary, *S*, given by Equation (22) guarantees that for any compensation scheme $B(\pi)$ the management incentives are in line with the shareholders' objective. Notice that Equation (22) depends on the good state profits both in the case of pricing correctly and in underpricing.

4. Asset Pricing Revisited

If banks price the put option correctly as in the base case, the asset price, *P*, equals the fundamental price, P_f, as given by Equation (1):

$$P_f = \frac{\delta R_H + (1-\delta) R_L}{1+d} \qquad (1)$$

If the interest rate does not reflect the full value of the put option, as described by Result 2, Equation (7) shows that the market price exceeds the fundamental price, $P > P_f$. Furthermore, the market price is given by Equation (2):

$$P = \frac{R_H}{1+i} \qquad (2)$$

Our lending market analysis above suggests that the presence of an underpricer decreases the lending rate, i, and increases the deposit rate, d. Therefore, there are two effects working together to increase the difference between the market and the fundamental price. First, the lending rate no longer contains an appropriate spread over the deposit rate to compensate lenders for the put option they are writing. Second, higher lending activity needs to be financed through increased deposit rates. Increased deposit rates reduce the fundamental price. Note that deposit rates have no effect on the market price since it only depends on the lending rates. We summarize this reasoning in the following important result:

Result 3: The underpricing equilibrium results in asset prices above their fundamental level. The two forces driving the divergence between market and fundamental prices are:

- *Lower lending rates that do not reflect the value of the put option*
- *Higher discount rates that reduce the fundamental value.*

The immediate empirical implication of Result 3 is that underpricing of the put option results in inflated asset prices. This is clearly 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 rise enough capital to support this increased lending activity they increase the 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 4: The spread between lending rates and deposit rates is negatively correlated with asset prices. Deposit rates are positively correlated with asset prices.

5. Data and Empirical Results

The asset class used in the empirical investigation below is a multi-family apartment sector in the Los Angeles County for the period October, 1989 to July, 2001. To calculate asset values over time we estimate appreciation rates for the per unit price of LA County apartments. We use the following semi-log hedonic value model to estimate this series:

$$\ln(Value_{it}) = Constant + \sum_{t=2}^{T} \beta_t S_t + \alpha' C_i, + \varepsilon \qquad (23)$$

where $Value_{it}$ is the price paid for property *i* sold at time *t*, C_i is a vector of physical characteristics that describe the building, S_t is a matrix of indicator variables for the time of sale, and β_t is the marginal time effect (i.e., monthly). *T* is the total number of months in the sample and ε is an error term with zero expectation.[8] Thus β_t is an estimate of the

[8] The β_t are estimated as follows. If a transaction occurred during January 1989 (i.e., t=1), all time indicator variables are assigned a value of zero. If a transaction occurred during the second month, the first time indicator variable is assigned a value of one and all other time indicator variables are set to zero. If a

rate of appreciation for time period *t*. The mean of the vector β provides an estimate of the expected monthly rate of apartment appreciation.

To implement the empirical estimation we use transaction data from CoStar COMPS. The firm produces transactions data for a wide range of income producing property. The firm has provided data for all transactions in Los Angeles County apartment buildings that occurred between October 1989 and July 2001 for a total of 18,168 observations.[9] Table 1 provides summary statistics describing the transactions that occurred during the period. The mean and median per unit price during this period were a little more than $50,000 per unit. As can be seen from the table the typical LA County apartment building is relatively small and the distribution of building size is positively skewed, with a median of 10 and a mean of 17 units.

Table 1: Descriptive statistics for transactions 1/1988-9/2000.

	Price per unit	Cap Rate	Age	Parking Spaces	Number of Units
Mean	$56,896	.09	29	21	17
Median	$52,500	.09	32	12	10
Standard Deviation	$28,076	.03	20	31	20

Tables 2 and 3 report the parameter estimates and implied appreciation rates obtained by estimating Equation (23). The parameter estimates presented in Table 2 have the expected signs and are consistent with those obtained from previous research. From Table 3 we can see that our model estimates an average monthly appreciation rate of nearly zero with a standard deviation of more than six percent.

transaction occurred during the third month, the first two indicators are set to one and all others are set to zero.

[9] The transaction data were screened for outliers and influential observations.

Table 2: Parameter Estimates

N=18830 R^2 = .44	Age	Age Squared	# of parking spots per unit	# of parking spots per unit squared	# of units	# of units squared
Estimate	-.006	4x10E-5	.22	-.005	-.011	6x10E-4
St. Error	.0004	6x10E-6	.006	.0003	.0003	1x10E-6

Table 3: Implied monthly rates of price appreciation

Average Appreciation Rate	Standard Deviation of the Appreciation Rate	Median Appreciation Rate	Skewness of the Appreciation Rate
≈ 0	.0616	-.001	-.06

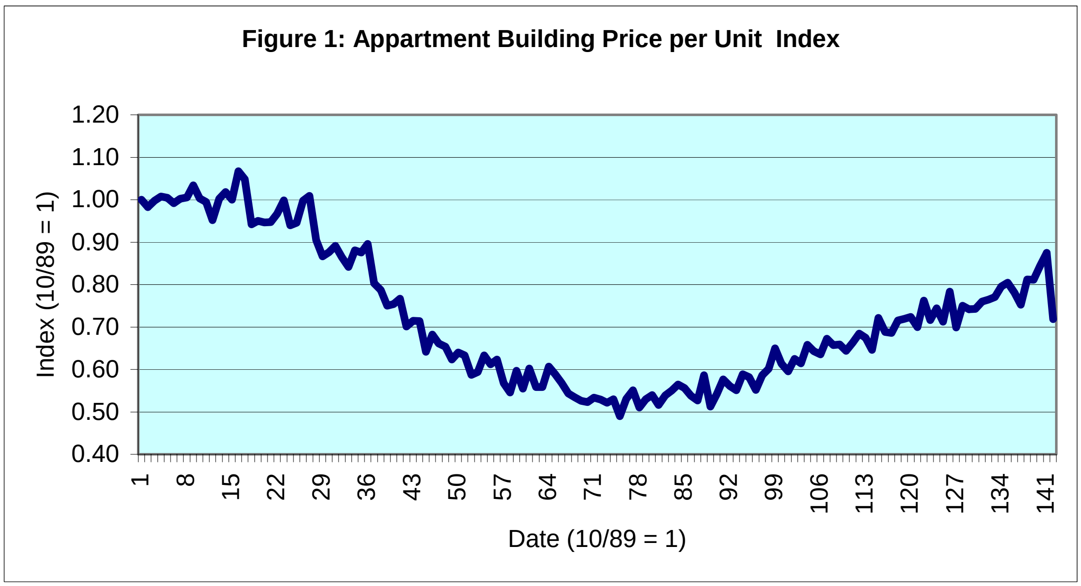

Figure 1 depicts the time series of estimates of the value (October, 1989=100) of a typical apartment building implied by the parameter estimates of Equation (23). As can be seen from this figure, the late 1980s and 1990s were a boom/bust period for Southern California property values. Between 1988 and the end of 1989 the per unit price of Los Angeles County apartment building increased by approximately 16 percent. Between the 1989 peak and November 1995 trough per unit prices fell by more than 48 percent. By the beginning of 2000 per unit prices are more than 40 percent above their low.

We use the above time series for the value of the asset to test the empirical implications of Result 4. The Federal Reserve Bank of St. Louis provides interest rate data. The first prediction of Result 4 is that the spread between lending and borrowing rates is negatively correlated with asset prices. We compute the spread as the difference between prime lending rates and 1-month certificate of deposit rates. The correlation between this spread and the asset price described above is – 67%. This negative correlation is consistent with Result 4 of the model.

The second prediction of Result 4 is that asset prices are positively correlated with deposit rates. Using 1-month certificate of deposit rates and the asset price described above, we obtain a positive correlation of 37%. We summarize these findings in the following table:

Table 4: Correlation between Asset Prices and Interest Rates

Correlation Coefficient	Asset Price	
	Model Prediction	Empirical Finding
Spread of Lending over Deposit Rates	Negative	– 67%
Deposit Rates	Positive	37%

While Table 4 is not designed to test the model, it is illustrative and consistent with the model's predictions.

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 will choose to underprice this put option. In particular, we show that the presence of short-term players in the debt market induces underpricing of the put option. The proposed model provides for some auxiliary empirical implications that are consistent with interest rates, market deposit rates, and property value data.

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