A Study on the Distribution of the Foreclosure Lag, Its Expected Capital Opportunity Cost and Its Analyses

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Abstract

The goal of this paper is to present models that can help lenders and insurers calculate the length of the foreclosure period (defined as the foreclosure lag) and its expected capital opportunity cost incurred during this period. In the empirical results, we find that the banks needed on average about two years to complete the foreclosure process. The actual foreclosure lag fits well with the exponential distribution after linear transformation. Moreover, the expected capital opportunity cost per monetary unit of the outstanding mortgage balance is nearly twice the mortgage rate. The analysis results also reveal that, the economic situations (i.e., interest rate and housing return), loan characteristic (i.e., loan-to-value (LTV) ratio and the loss rate) and different state foreclosure policies significantly influence the foreclosure lag. The interest rate and housing return are positively correlated with the foreclosure lag at the date the borrower stops payments, but the correlation is negative at the date the house is sold. The LTV ratio is negatively correlated but the loss rate is positively correlated with the foreclosure lag. In addition, the lag increases 0.52 years if the state policy is judicial foreclosure and 0.14 years if it is redemption. These results can help lenders forecast their foreclosure costs and calculate their capital requirements based on the Basel Accord.

Keywords: foreclosure lag, capital opportunity cost, foreclosure policy, loan characteristics

1. Introduction

In mortgage market, lenders unavoidably face the credit risk from the mortgage loans in their portfolio. Enforcing the right of foreclosure is the most important protection and the last resort to recover the unpaid principal balance (hereafter UPB) once the mortgage defaults. It is important for lenders to analyze the issues related foreclosure, because it can help them to more effectively estimate the credit risk involved and limit the potential losses given default. The purpose of this paper is to demonstrate how to accurately estimate the length of the foreclosure period (hereafter called the “foreclosure lag”) as well as the capital opportunity cost that accrues during this period. Our results may help lenders to make cost-benefit analyses for foreclosure, and thereby avoid excessive losses from defaulted mortgages.

To minimize potential losses given default, lenders usually require the borrower’s house to be put down as collateral when the mortgage contract is created. When borrowers face irresistible reasons such as job loss, divorce, and a permanent reduction in income, they may become unable to make timely mortgage payments (Newman, 2010; Nelson, 2011). If borrowers are unable to repay their mortgage, they may choose to sell their house to avoid default and maintain a good credit rating. However, if there is a sharply housing downturn, as occurred during the subprime mortgage crisis, the house price may not be high enough to cover the mortgage principal. Borrowers may decide to choice default on the mortgage and let the lender foreclose on the property. Moreover, when the house price is low enough, borrowers may become unwilling to make their mortgage payments even if they can still make payments. This behavior, called “strategic default,” is common among borrowers who reside in areas where there has been a significant depreciation on housing market.

When a mortgage becomes delinquent, the first step for the lender is to send a ‘‘Notice of Default and Election to Sell’’ to the borrower. If the borrower does not pay off the mortgage during a period of at least two or three months after receiving notice, the lender may begin the foreclosure proceedings by forcing the sale of the house. The foreclosure process usually has one of the following three outcomes: (1) the borrower pays off the loan; (2) the borrower signs the home over to the lender by means of a document generally referred to as a Deed-in-Lieu; (3) the property is sold at a foreclosure auction (Collins, Lam and Herbert, 2011). If the property is not sold to a third party at the auction, the bank generally takes it over as Real Estate Owned (REO) and hires a real estate broker to sell the property.

In the literature concerning foreclosure, numerous empirical studies demonstrate a statistically significant negative effect of foreclosures on the prices of nearby homes (Immergluck and Smith, 2006; Rogers, 2008; Schuetz, Been and Ellen, 2008; Campbell et al., 2009; Harding, Rosenblatt and Yao, 2009; Leonard and Murdoch, 2009; Lin, Rosenblatt and Yao, 2009; Wassmer, 2010; Daneshvary, Clauretie and Kader, 2011). Some studies have found that foreclosed homes usually sell for far less than the value of nearby homes. For example, studies by Rogers (2008), Campbell, Giglio and Pathak (2009), and Clauretie and Daneshvary (2009) found that foreclosed properties sold at a 27-33% discount. The losses from REO sales are especially high for manufactured housing and older homes (Capozza and Thomson, 2005).

From the lender’s perspective, executing the right of foreclosure is the final way to limit the losses from a mortgage default. The studies on the issues related foreclosure are important for market practitioners. The recent sub-prime mortgage crisis and subsequent high foreclosure rates in all mortgage sectors have increased interest in mortgage foreclosure research by scholars. Most traditional studies have emphasized estimation of the explicit total loss the lender incurs during the foreclosure process (Russell, 1937; Ghent, 2011). In addition to the depreciation of the value of the foreclosed housing, the loss includes the fees associated with the foreclosure. Examples of the latter are legal costs, administrative fees including court fees, auctioneer fees, and title fees. Russell (1937) and Ghent (2011) have claimed that lenders incur foreclosure costs of approximately 5% of the value of the property.

However, the foreclosure costs calculated in previous studies reflect only the lender's explicit loss. It is not enough to calculate all possible foreclosure costs. Because default on the mortgage during the foreclosure lag causes lenders to use their capital inefficiently, it is important to estimate the foreclosure capital opportunity cost (defined as the maximum interest the lender must earn from the outstanding balance of the mortgage loan during the lag period). FHA data show that lending banks need on average nearly two years to complete the foreclosure process (see the summary in Table 1). In extreme cases, the foreclosure lag can nearly 12 years. Thus, the foreclosure capital opportunity cost may be very large for a foreclosed mortgage. The estimation of foreclosure capital opportunity cost is important for the lenders who want to reasonably estimate their possible costs and control their potential losses from defaulted mortgages. However, to the best of our knowledge, no previous study has addressed this need. This reason led us to conduct a study aimed at accurately calculating the foreclosure capital opportunity cost.

Lending banks can hold two types of mortgages: uninsured mortgages and mortgages insured by the FHA. Foreclosures influence these two types of mortgages in different ways. If the mortgage is uninsured, the lender incurs possible losses during the foreclosure process if the mortgage ends up in foreclosure. Lenders can charge a high auction price for the foreclosed house, but that increases the foreclosure lag, which in turn increases their total foreclosure capital opportunity costs. This presents lenders with a trade-off problem: should they sell the foreclosed property quickly or hold on to it longer, hoping to sell at a higher price. This is why it is important to model the foreclosure lag as a step in estimating the capital opportunity cost for lenders who own uninsured mortgages.

If the mortgage is insured, lenders can recover the interest lost during the foreclosure lag from the FHA. This gives them an incentive to increase the foreclosure lag, because the FHA reimbursement will then be at the mortgage contract rate. Thus, the interest during foreclosure is not a potential loss for lenders, but it is for insurers. No matter for both lenders and insurers, it is important to limit the losses given default and to more effectively manage the risk from foreclosed mortgages. This study provides a model that can help both parties accurately appraise the capital opportunity cost during a foreclosure lag.

Lenders can control the length of the foreclosure period because they can decide to sell the property quickly by asking a very low auction price. However, they may prefer not to do so because it increases their losses given default. In addition, the foreclosure process may take longer than expected for many reasons (e.g. the housing situation, the difference between the market house price and lender's listed price, the buyer's offer.) Therefore, we assume that the foreclosure lag is a random variable for a foreclosed mortgage. Because the foreclosure lag always takes a positive value, we use the gamma and exponential distributions to model the distribution for foreclosure lags. We then use a model to calculate the expected capital opportunity cost of foreclosure lag based on each of these distributions.

We also performed empirical analyses to demonstrate the effect of relevant factors on the foreclosure lag. Economic circumstances (such as the interest rate and housing return) is likely to influence the strengths of the investor's desire to buy the house and also have the effects for lender's desire to sell the collateral (i.e., house) for the defaulted mortgage. These influence the foreclosure lag. However, the effect of these economic circumstances is ambiguous, because two time points are needed to consider: the date the borrower stops monthly payments (here defined as the default date) and the date the collateral houses are sold (here defined as the selling date). At the default date, the economic circumstances only influence the decision of the lender. At the selling date, the economic circumstances influence the decisions of the lender and buyer simultaneously. Thus, we can infer that the economic circumstances at the default date and selling date should have different effects on the foreclosure lag.

The foreclosure lag may also be influenced by the characteristics of the loan, such as the loan-to-value (LTV) ratio and the loss rate. In theory, the larger the loan, the greater the foreclosure capital opportunity cost for lenders during the foreclosure period. Because the auction price lenders expect can affect how long it takes for a foreclosed house to be sold off, we conjecture that the auction price can influence the duration of the foreclosure lag. As mentioned above, lenders face the trade-off of choosing between selling the foreclosed house quickly at a deeply discounted price and waiting longer in the hope of a higher selling price. This trade-off results from lenders' desire to reduce their total losses. Thus, we can infer that both the LTV ratio and the loss rate should affect the foreclosure lag and in turn the capital opportunity cost.

The foreclosure policies for the different state may also influence the foreclosure lag. State laws have dictated the foreclosure process for banks needs to start with a court ("judicial foreclosure") or without a court ("non-judicial foreclosure"). In judicial foreclosure, the process occurs only if there is no sale clause in the loan document, and the lender sues the borrower to obtain a foreclosure decree and an order of sale. In non-judicial foreclosure, the clause of ‘‘power of sale’’ allows the lender to sell the property to recover the mortgage balance. The foreclosure lag tends to be longer in judicial foreclosure states than in non-judicial foreclosure states (Immergluck, 2010; Daneshvary, Clauretie and Kader, 2011). In some states, borrowers have the right of redemption, which allows them to redeem their property up to one year after a foreclosure for the foreclosure sale price plus foreclosure expenses. Collins, Lam and Herbert (2011) argue that the existence of such a right can chill demand for foreclosed properties, forcing lenders to endure longer foreclosure lags and accept lower sale prices. Therefore, the foreclosure lag and its capital opportunity cost are heavily influenced by state foreclosure laws.

Based on previous descriptions, the foreclosure lag may be influenced by the economic situations (interest rate and housing return), the loan characteristics (LTV and the loss rate), and the state foreclosure laws. We use linear regression models to estimate the influence effects on these factors. The results will help lenders to understand the analyses of these influence factors on the foreclosure lag.

The rest of the paper is organized as follows. Section 2 illustrates the empirical models (including those using the exponential and gamma distributions) for estimating the foreclosure lag and its capital opportunity cost. We also show the linear model for examining whether the factors of economic situations, the loan characteristics, the state foreclosure laws influence the foreclosure lag. In Section 3, we use data provided from the FHA databank to conduct empirical analyses based on the models presented in Section 2 for constructing distributions for the foreclosure lag and estimate its expected capital opportunity cost. The final section summarizes our conclusions from the research.

2. Models for the foreclosure lag and its opportunity cost

In this section, we introduce the models and the methods for investigating the foreclosure lag and its capital opportunity cost for defaulted mortgages. In Subsection 2.1, we describe two models, based on the exponential and gamma distributions respectively, that provide estimates for the length of the foreclosure lag. Afterwards, we describe the methods for calculating the capital opportunity cost based on these two distributions. In Subsection 2.2 we use linear regression models to examine the influences of economic situations, the loan characteristics and the state foreclosure laws on the foreclosure lag.

2.1 Estimating the foreclosure lag and calculating the expected capital opportunity cost

In applied mathematics, the gamma and exponential distributions give useful representations of many physical situations associated with random processes in time (e.g. Johnson, Kotz and Balakrishnan 1994). Furthermore, the gamma distribution can be adjusted to create an exponential distribution, which is usually used to represent a random lifetime. The fact that the foreclosure lag is a random variable in time is why we use the gamma and exponential distributions to model it.

Let X be a random variable to denote the foreclosure lag. The two-parameter gamma distribution can be described as follows:

$$f^{G}(x)=\frac{x^{\alpha-1}\exp(-\frac{x}{\beta})}{\beta^{\alpha}\Gamma(\alpha)}\text{, for } x>0,\ \alpha>0 \text{ and } \beta>0, \qquad (1)$$

where $f^{G}(x)$ is the probability density function for the gamma distribution, x is the foreclosure lag, α is the shape parameter, β is the scale parameter, and $\Gamma(\cdot)$ is the gamma function, we have $\Gamma(\alpha)=\int_{0}^{\infty}t^{\alpha-1}e^{-t}dt$.

If $\alpha=1$, we have an exponential distribution, in which case its probability density function, $f^{E}(x)$, can be described as follows:

$$f^{E}(x)=\frac{1}{\beta}\exp(-\frac{x}{\beta}), \qquad (2)$$

After obtaining the distribution for the foreclosure lag, we can calculate the capital opportunity cost of foreclosure lag. Let the mortgage rate be r_C. As we know, if the borrower does not default and continues to make monthly payments, the lender will continuously receive the interest from UPB of mortgage. We let this interest is equivalent to the capital opportunity cost for foreclosure lag. The formula for this interest is

$M(t)(\exp(\frac{r_C}{D}X)-1)$, where $M(t)$ is the UPB of the mortgage, and D is the days for one year (360 in the present application), and $\frac{r_c}{D}$ is therefore denoted as the daily mortgage rate. Next we let Φ denote the capital opportunity cost per monetary unit of the UPB, which is expressed as:

$$\Phi = (\exp(\frac{r_C}{D}X)-1). \tag{3}$$

Then we define Ξ as the expected value of Φ. If X follows the gamma distribution, the expected capital opportunity cost for the foreclosure lag (denoted as Ξ^G) is:

$$\Xi^G = E[\Phi] = (1-\beta\frac{r_C}{D})^{-\alpha} - 1, \tag{4}$$

where $E[\cdot]$ is the expected operation. If X follows the exponential distribution, the expected capital opportunity cost (denoted as Ξ^E) is:

$$\Xi^E = E[\Phi] = (1-\beta\frac{r_C}{D})^{-1} - 1. \tag{5}$$

According to the foregoing expressions, the expected capital opportunity cost depends mainly on the daily mortgage rate and the estimated parameters of the gamma and exponential distributions. In Section 3, we use the maximum likelihood method to estimate the parameters for these distributions. The total expected capital opportunity cost is then calculated based on the outstanding balance of the mortgage and the daily mortgage rate.

2.2 Analyzing the influences of the economic situations, loan characteristics and state foreclosure policies on the foreclosure lag

To help the reader understand how the economic situations, loan characteristics and state policies affect the foreclosure lag, we present the following four linear models:

Model 1: $x_i = a_0 + a_1 r_i^d + a_2 r_i^s + a_3 h_i^d + a_4 h_i^s + \varepsilon_i$; (7)

Model 2: $x_i = a_0 + a_5 L_i + a_6 \xi_i + \varepsilon_i$; (8)

Model 3: $x_i = a_0 + a_7 d_i^j + a_8 d_i^r + \varepsilon_i$; and (9)

Model 4: $x_i = a_0 + a_1 r_i^d + a_2 r_i^s + a_3 h_i^d + a_4 h_i^s + a_5 L_i + a_6 \xi_i + a_7 d_i^j + a_8 d_i^r + \varepsilon_i$, (10)

where x_i is the foreclosure lag for the i-th defaulted mortgage; r_i^d and r_i^s are the interest rates at the month of default date and the selling date for the i-th defaulted mortgage, respectively; h_i^d and h_i^s are the housing returns at the month of default date and the selling date, respectively; L_i is the LTV ratio, ξ_i is the loss rate, d_i^j is a dummy variable indicating that the i-th defaulted mortgage was written in a U.S. state with a judicial foreclosure policy, d_i^r is a dummy variable representing the i-th defaulted mortgage written in a state with a redemption policy, a_0 to a_9 are the coefficients of linear regression model, and ε is the residual.

In Equations (7)-(10), Model 1 only considers the influences of the economic situations on the foreclosure lag, Model 2 is used to analyze the effects of the LTV ratio and the loss rate on the foreclosure lag, Model 3 is applied to see the influences of the judicial foreclosure and redemption policies on the foreclosure lag, and Model 4 is employed to examine the effects of the all influence variables on the foreclosure lag.

The constant coefficient a_0 represents the basic foreclosure lag. As for the economic circumstances, a_1 and a_2 are the effects of the interest rate on the foreclosure lag at the default date and at the selling date respectively. In addition, a_3 and a_4 are the effects of the housing return at the default date and at the selling date respectively.

At the default date, only the lender’s decision can influence the foreclosure lag.

Generally, the foreclosure lag depends mainly on the lender's expected loss when selling the collateral. The interest rates may also influence how quickly the lender decides to sell the house. The capital opportunity cost is likely to motivate the lender to reduce the foreclosure lag as much as possible if the interest rate is high at the default date. In this case, we expect $a_1 < 0$. However, if the mortgage is insured, the above inference is likely to be reversed, because the lender can recover the capital opportunity cost (interest) from the insurer during the period of foreclosure lag. Thus, the lender may pay more attention to reduce the expected loss of the collateral but less attention to reduce the capital opportunity cost. If the economy is prosperous, the lender is likely to set a high auction price for the collateral to reduce the loss given default. A prosperous economy is usually accompanied with a high interest rate, which increases the foreclosure lag. Therefore, for an insured mortgage, we may expect $a_1 > 0$.

Both the buy's and the lender's decisions may influence the foreclosure lag at the selling date. If the interest rate is low, the investor need not pay much to participate in the auction market, giving the buyer a strong incentive to invest in the foreclosed house. From this viewpoint, the low interest rate may reduce the foreclosure lag. Thus, we expect $a_2 > 0$. However, as mentioned above, the insurer must bear the interest for an insured mortgage during the foreclosure period. If the interest rate at the selling date is lower than the mortgage rate paid by the insurer, the lender is likely to be less willing to end the foreclosure process early. This will tend to cause the interest rate to be negatively correlated with the foreclosure lag at the selling date. In other words, if one uses the insured mortgage data for the analyses of foreclosure lag, one can expect $a_2 < 0$. Based on the above inferences, we conclude that the influence of the interest rate on the foreclosure lag at the selling date is ambiguous for an insured mortgage.

We use the lender's perspective to analyze the influence of the status of the housing market on the foreclosure lag at the default date. If the housing market is booming at this time, the lender is likely to ask a high auction price for the collateral, thereby ensuring a long foreclosure lag. In contrast, if the housing market is depressed on the default date, the lender is likely to ask a low auction price to shorten the foreclosure lag. Therefore, we expect $a_3 > 0$ in this case. This inference implies that the housing return at the default time is positively correlated with the foreclosure lag.

We use both the investor's and the lender's attitudes to analyze the effect of the status of the housing market on the foreclosure lag at the selling date. We infer that investors have a strong motive to buy collateral in a bull market because they expect a good return from their investment. Such a situation reduces the foreclosure lag. In contrast, the foreclosure lag increases in a bear market. However, in the bull market, the lender is likely to set a high auction price for the collateral, increasing the foreclosure lag. We therefore cannot directly infer the influence of the housing return on the foreclosure lag at the selling date.

For loan characteristics, a_5 and a_6 are respectively the magnitudes of the effects of the LTV ratio and the loss rate on the foreclosure lag. One expects $a_5 < 0$, because the lenders are likely to prefer a short foreclosure lag to avoid the increased losses likely to accompany a high LTV mortgage. In addition, the bank could ask for a low house price to quickly sell the collateral property at auction. This low auction price could increase the lender's loss. However, a larger discount (e.g., lower auction price) auction price for the collateral may imply its worse quality (i.e., bad location and older building) and thus has a longer foreclosure lag. Under such situation, there is a positive relationship between the loss rate and the foreclosure lag. Therefore, we cannot expect whether $a_6 > 0$ or $a_6 < 0$.

As for state policies, the values of a_7 and a_8 represent the respective magnitudes of the effects of different state policies on the foreclosure lag. Specifically, we infer that the foreclosure lag increases a_7 days and a_8 days because of the respective policies of judicial foreclosure and redemption.

After calculating these increased foreclosure lags, we use Equations (4) and (5) to calculate the expected increases in the capital opportunity costs corresponding to the gamma and exponential distributions. If the increase in the foreclosure lag is less than 1 year based on the policy of a given state, we can simplify the calculation in Equation (3), using instead the formula $e^{r_C \Delta x} - 1 \cong r_C \Delta x$ to calculate the increased capital opportunity cost. We then compute $a_7 r_C D^{-1}$ and $a_8 r_C D^{-1}$ as the increased capital opportunity costs respectively for a state using judicial foreclosure and a state using redemption.

3. Empirical Findings

In this section we describe the empirical analyses based on the models presented in Section 2. We use data provided from the FHA databank to construct distributions for the foreclosure lag and estimate its expected capital opportunity cost. The databank contains the insured mortgage contracts for 13,153,880 U.S. loans. The sample period is from 1/1/1998 to 11/1/2011. The values for the LTV ratios, loss rates, and foreclosure lags were also obtained from this databank. We define the foreclosure lag as beginning on the date the borrower stops monthly payments and ending on the date the house is sold. After data cleaning, we collected 489,990 foreclosure sample points to construct the foreclosure lag distribution. The housing prices were obtained from the U.S. monthly House Price Indexes (Not Seasonally Adjusted). Regarding the short interest rates, we used the interest rates for a 3-month U.S. treasury bill. To analyze the influence of the different state strategies on the lag, we divide the data into two groups based on the policies of each state. These state policies are summarized in Appendix A. The results in Appendix A are taken from Table 1 in Colins, Lam and Herbert (2011). Because the policies of three U.S. territories (Puerto Rico, Guam, and Virgin Islands) are unknown, we did not include them with the states. There are 167,430 and 321,410 foreclosure sample from the judicial foreclosure and non-judicial foreclosure states respectively; there are 172,450 and 316,390 foreclosure sample from the redemption and non-redemption sates respectively. Table 1 presents for each group the following descriptive statistics: mean, standard deviation, maximum value, minimum value, median, skewness, kurtosis, and number of observations.

[Insert Table 1 here]

As shown in the Table 1, the average foreclosure lag is 695.43 days for foreclosure sample. In other words, on average, a lending bank needed nearly two years to complete the foreclosure process. As mentioned previously, the borrower usually has 90 days to remit the proceeds to the lender. If the debt is unpaid at the end of this waiting period, the lender initiates a forced sale of house. Because the minimum period of the foreclosure lag is 131 days, we can infer that the shortest period for the foreclosure auction is 41 days; the longest period is 4,337 days, nearly 12 years. In this worst case, the lender must wait a very long time to recover the outstanding balance of the mortgage. During this period, the lenders or insurers also accumulate a steep capital opportunity cost.

Table 1 shows that the mean foreclosure lag is much longer (179.22 days) in judicial foreclosure states (811.22 days) than in non-judicial foreclosure states (632 days). The mean foreclosure lag, on the other hand, is only slightly longer (24.29 days) in redemption states (709.1 days) than that in non-redemption states (684.81 days). These results confirm that lenders can be forced to confront long delays because of state policies (Collins, Lam and Herbert, 2011). Note that the difference in mean foreclosure lags is more than 7 times greater between judicial foreclosure and non-judicial foreclosure states than between redemption and non-redemption states (179.2/24.29=7.4). This result shows why lenders should consider the state's policy to avoid large capital opportunity costs resulting from a long foreclosure lag.

Figure 1 shows the distribution of foreclosure lags for the entire sample. Most of the lags (99%) range from 300 days (10 months) to 2000 days (5.5 years). Because the shape of the distribution seems to conform to both the exponential and gamma distributions, we use these models to fit the real data.

[Insert Figures 1 here]

The estimated parameters for the exponential and gamma distributions for the total sample and the four state policy groups are shown in Table 2. The parameter for the exponential distribution (hereafter denoted as β^E) is 695.43, and the parameters for the gamma distribution (hereafter denoted as α^G and β^G) are 437 and 93.51 respectively. Table 2 gives the lower and upper bounds at the 5% significance level for each parameter. Note that the expected values for the exponential and gamma distributions are equivalent to β^E and $\alpha^G \times \beta^G$ respectively. Therefore, the expected foreclosure lag for both distributions is 695.43 days (approximately two years).

[Insert Table 2 here]

The estimated parameters for β^E are 811.22, 632.00, 709.10 and 684.81 for the judicial foreclosure states, non-judicial foreclosure states, redemption states, and non-redemption states, respectively. The estimated α^G and β^G values are 9.34 and 86.86 for the judicial foreclosure states, 8.02 and 78.80 for the non-judicial foreclosure states, 8.02 and 88.42 for the redemption states, and 7.34 and 93.33 for the non-redemption states.

After estimating the parameters for each distribution, we use a QQ-plot to illustrate the fit of the theoretical foreclosure lags to the exponential and gamma distributions. The QQ-plot diagrams are shown in Figures 2 and 3 for the exponential and gamma distributions respectively. If the theoretical distribution provides a good fit to the data, the line in the QQ-plot should be roughly linear with 45° slope. The QQ-plot for the exponential distribution looks more linear, but its slope is not 45°. We infer that the exponential distribution provides a good fit to the real data after linear transformation, except when the foreclosure lag is less than 500 days. Based on the QQ-plot for the gamma distribution, it is not a good fit. However, the foreclosure lag matches the gamma distribution if the lag is less than 1000 days.

[Insert Figures 2 and 3 here]

We then use the foregoing estimated parameters to calculate the capital opportunity cost during the foreclosure lag. For simplicity, we let $D = 360$ days. According to Equations (4) and (5), the capital opportunity costs are $((1 - \frac{93.51}{360} r_C)^{-7.437} - 1)$ and $((1 - \frac{695.43}{360} r_C)^{-1} - 1)$ for the exponential and gamma distributions respectively. The relationship between the capital opportunity costs and the mortgage rates is illustrated in Figure 4.

[Insert Figure 4 here]

Figure 4 shows a positive relationship between the expected capital opportunity cost and the mortgage rate. Lenders can use these results to effortlessly estimate the expected capital opportunity cost for a given mortgage rate. In our empirical example, the expected capital opportunity cost for foreclosure lag is nearly twice the mortgage rate. Note that the capital opportunity cost calculated for the exponential distribution is slightly higher than that calculated for the gamma distribution. This means that when the exponential distribution is used, a change in the mortgage rate has a relatively large effect on the capital opportunity cost. Specifically, if we let the mortgage rate be 5%, the expected capital opportunity cost is \$0.1069 per \$1 of the outstanding mortgage balance using the exponential distribution, and

\$0.1021 per \$1 of the outstanding mortgage balance using the gamma distribution. Therefore, if the lender ignores the capital opportunity cost, the lender or the insurer incur losses of more than 10% of the outstanding mortgage balance. The larger the mortgage rate, the greater the penalty for ignoring the capital opportunity cost. These results can help the lending bank discuss the problem of the trade-off between the foreclosure lag and the auction price.

Table 3 displays how the economic situations, loan characteristics and state foreclosure policies impact the foreclosure lag. In this table, all estimates are significant at 1% level. Based on the results from Model 1, a_1 = 2250.5, a_2 = -261, a_3 = 640.09, and a_4 = -297.16. Note that the signs for the effects at the default date (i.e., a_1 and a_3) and the selling date (i.e., a_2 and a_4) are opposite. These results reveal that the economic circumstances at the default date and the selling date have opposite effects on the foreclosure lag.

The values of a_1 and a_2 reflect the influence of the interest rate on the foreclosure lag at the default time and the selling time respectively. The results show that the correlation between the interest rate and the foreclosure lag is positive at the default date and negative at the selling date. The likely reason for these different outcomes is that we used insured mortgage data for our analyses. As previously mentioned, we expect $a_1 > 0$ for an insured mortgage. The empirical evidence proves that this inference is correct. In addition, the results show that $a_2 < 0$. As previously mentioned, we infer that the interest rate and foreclosure lag are negatively correlated from the fact that the lender is likely to extend the foreclosure period if the interest rate at the selling date is lower than the mortgage rate. This result also shows that the lender’s decision decides the effect of the interest rate on the foreclosure lag at the selling date.

The value of a_3 can be used to describe the influence of the housing return on the foreclosure lag at the default time. Our results show that the housing return is positively correlated with the foreclosure lag at the default date. This outcome is consistent with our inference in the previous section: if the housing market is booming at the default date, the lender is likely to ask a higher auction price, which increases the foreclosure lag. In contrast, if the housing market is depressed at the default date, the foreclosure lag is reduced.

Note that a_4 stands for the influence of the housing return on the foreclosure lag at the selling time. Our results show they are negatively correlated, signifying that the influence of the housing return on the foreclosure lag at the selling date is determined by the investor's decision. We can infer from this that the buyer has a strong desire to buy the collateral if the housing market is booming at the selling date. The result is a short foreclosure lag. In contrast, the foreclosure lag is long if the housing market is depressed at the selling date.

[Insert Table 3 here]

Based on the results from Model 2, we obtain $a_5 = -38.078$ and a_6 =40.432. Therefore, the foreclosure lag is significantly negatively correlated with the LTV ratio but positively correlated with the loss rate. We can infer from this outcome that if the LTV ratio is high, lenders may wish to shorten the foreclosure lag to avoid a large loss. Thus, the LTV ratio is negatively related with the foreclosure lag. In addition, our results reveal that the loss rate is positively related with the foreclosure lag. This result implies a larger loss rate is due to a worse collateral quality, which induces the increase in the foreclosure lag. Our empirical results can also help lenders calculate the capital opportunity cost from the LTV ratio and loss rate.

The results estimated by Model 3 reveal that judicial foreclosure and redemption policies both significantly influence the foreclosure lag. Using Model 3, we estimate the basic foreclosure lag to be 611.11 days. A judicial foreclosure policy adds another 186.93 days, meaning that the lender must waste about half a year waiting for the foreclosure to be finalized. Alternatively, the results from Model 3 show that delay caused by a redemption policy is only 51.73 days, about 1.7 months; the lender must wait only 80% of a month more to recover the outstanding balance of the mortgage.

The results in Model 3 can be used to show the effects of various state policies on the foreclosure capital opportunity cost. As previous mentioned, $a_7 r_C D^{-1}$ and $a_8 r_C D^{-1}$ are the increased foreclosure capital opportunity costs respectively for judicial foreclosure policy and redemption policy. Using Table 3, we find that the increase in the expected foreclosure capital opportunity cost from a judicial foreclosure policy and a redemption policy are respective $0.52\, r_C$ and $0.1437\, r_C$. Given the mortgage rate, one can exactly calculate the increase expected capital opportunity cost incurred form foreclosure policies. For example, if we let $r_C = 5\%$, the increased expected foreclosure capital opportunity cost is \$0.026 per \$1 UPB in the judicial foreclosure case and \$0.00719 per \$1 UPB in the redemption case.

Model 4 is used to register the effects of all the influential variables: a_0 = 603.61, a_1 = 1757.8, a_2 = -2054.5, a_3 = 585.29, a_4 = -322.5, a_5 = -20.825, a_6 = 18.27, a_7 = 175.89, and a_8 = 47.983. Our conclusions from testing Model 4 are the same as from testing Models 1–3.

4. Conclusion

When a mortgage defaults, the lender usually resorts to the right of foreclosure to recover the unpaid mortgage balance. As we know, it usually takes a long time for the foreclosure process; thus, lenders bear the cost for the mortgage interest lost during this period. Although the fees for the foreclosure process and the capital opportunity cost are treated as debt in the mortgage contract and reimbursed by the borrower, lenders still incur a loss if the foreclosed house sells for less than the foreclosure cost and the unpaid mortgage balance. Therefore, to avoid excessive loss from the defaulted loan, lenders need a well-specified model to accurately calculate the foreclosure lag and its capital opportunity cost.

If the mortgage is uninsured, lenders might decide to sell the collateral quickly at a low auction price, accepting the increased loss resulting from the steep discount. Alternatively, they might decide to seek a high auction price, which would require them to wait longer for the property to be disposed and accept the greater foreclosure capital opportunity cost resulting from the long foreclosure lag. Thus, lenders face a trade-off when they choose the auction price for the foreclosed houses. To properly analyze this trade-off, it is important for lenders to accurately predict the foreclosure lag and the associated capital opportunity cost. If the mortgage is insured, lenders can recover the forgone interest from the FHA during the foreclosure lag. Accurately predicting a lender's capital opportunity cost during the foreclosure lag is also important for insurers. To the best of our knowledge, no study has addressed this need. In this paper, we have suggested an appropriate model for estimating the foreclosure lag and calculating its capital opportunity cost. Our models can help lenders and insurers to reasonably estimate their possible costs and control their potential losses from foreclosed mortgages.

We used data obtained from the FHA databank to perform an empirical analysis based on two versions of our model, one assuming an exponential distribution for the foreclosure lag and the other assuming a gamma distribution. In our sample, we find that the average foreclosure lag for the entire sample is 695.43 days. In other words, the lending banks needed on average almost two years to complete the foreclosure process. By diagramming the actual foreclosure lags in a QQ-plot, we find the exponential distribution provides a good fit to the real data after linear transformation

By using the distribution of the foreclosure lags, lenders can easily calculate the expected capital opportunity cost during the foreclosure process. Using our methods, the expected capital opportunity cost is a function of the mortgage rate and the parameters in distribution. In our empirical example, the expected capital opportunity cost per monetary unit of the outstanding mortgage balance is nearly twice the mortgage rate. Therefore, the higher the mortgage rate, the greater the penalty for ignoring the expected capital opportunity cost. We also find that the expected capital opportunity cost is slightly higher if we use the exponential model than if we use the gamma model.

We also examine whether the foreclosure lag is influenced by the interest rate, the housing return, the LTV ratio, the loss rate, and the various judicial foreclosure and redemption policies embedded in state laws. Economic circumstances (i.e., interest rate, housing return) are likely to influence both the lender's and the investor's decisions regarding the foreclosed house. These decisions, in turn, impact the foreclosure lag and the capital opportunity cost incurred during the foreclosure lag. We analyze the influence of the economic circumstances on the foreclosure lag at two time points: the date the borrower stops payments and the date the house is sold. The results show that the interest rate and the housing return are significantly positively correlated with the foreclosure lag at the date borrower stops payments, but they are significantly negatively correlated with the foreclosure lag at the date the house is sold. Thus, our empirical results prove that the economic circumstances at the default date and the selling date have opposite effects on the foreclosure lag.

Furthermore, we find the foreclosure lag is significant negatively correlated with the LTV ratio but is significant positively correlated with the loss rate. Our results imply that if the LTV ratio is high, lenders may prefer a lower auction price to shorten the foreclosure lag for avoiding a great loss. Also, our findings demonstrate that a larger loss rate may be due to a lower collateral quality, which causes an increasing foreclosure lag.

In addition, state policies have significantly effects on the period of the foreclosure lag.

According to our Models 3, the increased expected capital opportunity costs are $0.52\,r_C$ and $0.1437\,r_C$ for the judicial foreclosure and redemption policies respectively. In other words, the cost is more than three-and-a-half times greater with the judicial foreclosure policy ($0.52\,r_C/0.1437\,r_C=3.6$). This result clearly shows that lenders should take the policy of their state into account when determining the mortgage rate, so as to avoid the loss resulting from a long foreclosure lag. Our results provide useful information for lenders who want to determine their expected capital opportunity costs based on the interest rate, housing return, LTV rate, loss rate, and state policies.

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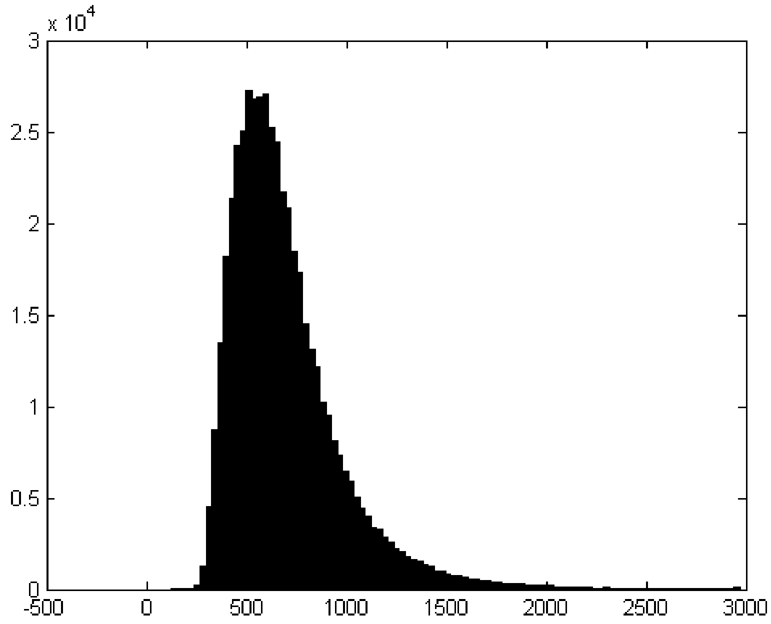
Appendix

This appendix shows the summary of state strategies. All of the results are obtained from the Table 1 in Colins, Lam and Herbert (2011).

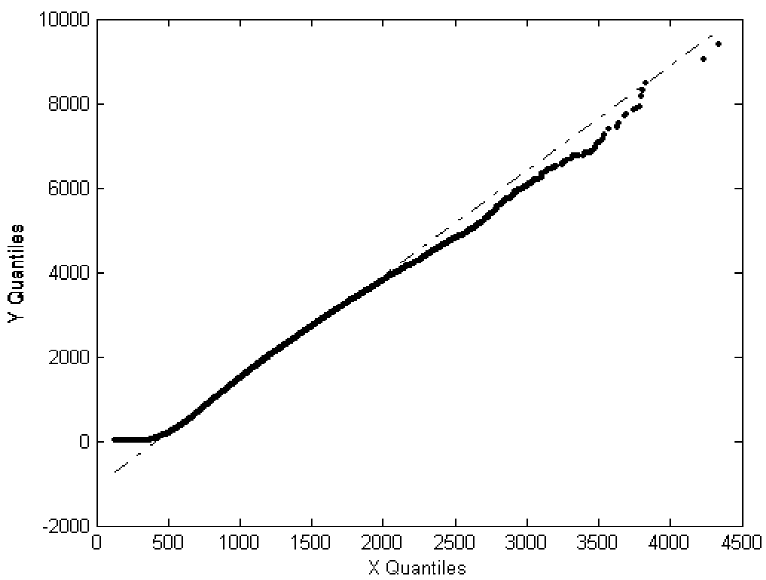
State	Judicial	Redemption	State	Judicial	Redemption
Alabama	No	Yes	Nebraska	Yes	No
Alaska	No	Yes	Nevada	No	No
Arizona	No	Yes	New Hampshire	No	No
Arkansas	No	Yes	New Jersey	Yes	Yes
California	No	Yes	New Mexico	Yes	Yes
Colorado	No	No	New York	No	No
Connecticut	Yes	No	North Carolina	Yes	No
Delaware	Yes	No	North Dakota	Yes	Yes
DC	No	No	Ohio	No	No
Florida	Yes	No	Oklahoma	No	No
Georgia	No	No	Oregon	Yes	Yes
Hawaii	No	No	Pennsylvania	No	No
Idaho	No	Yes	Rhode Island	Yes	No
Illinois	Yes	Yes	South Carolina	Yes	No
Indiana	Yes	No	South Dakota	No	Yes
Iowa	Yes	Yes	Tennessee	No	Yes
Kansas	Yes	Yes	Texas	No	No
Kentucky	Yes	Yes	Utah	No	No
Louisiana	Yes	No	Vermont	Yes	Yes
Maine	Yes	Yes	Virginia	No	No
Maryland	Yes	No	Washington	No	No
Massachusetts	Yes	No	West Virginia	No	No
Michigan	No	Yes	Wisconsin	Yes	Yes
Minnesota	No	Yes	Wyoming	No	Yes
Mississippi	No	No	Puerto Rico	Miss	Miss
Missouri	No	Yes	Guam	Miss	Miss
Montana	No	No	Virgin Islands	Miss	Miss

Figure 1: Distribution of foreclosure lags based on the sample data



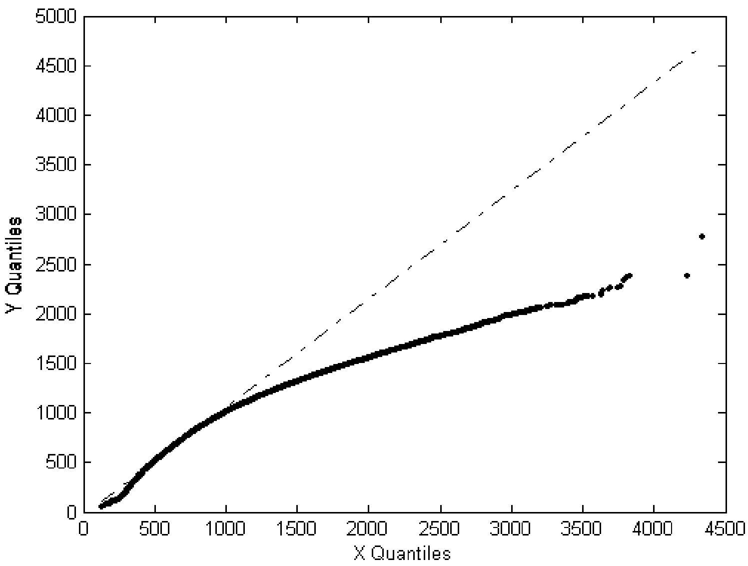
Note: The horizontal (x) axis represents the foreclosure lags in days. The vertical (y) axis indicates the frequency of foreclosure lags.

Figure 2: QQ-plot for the exponential distribution



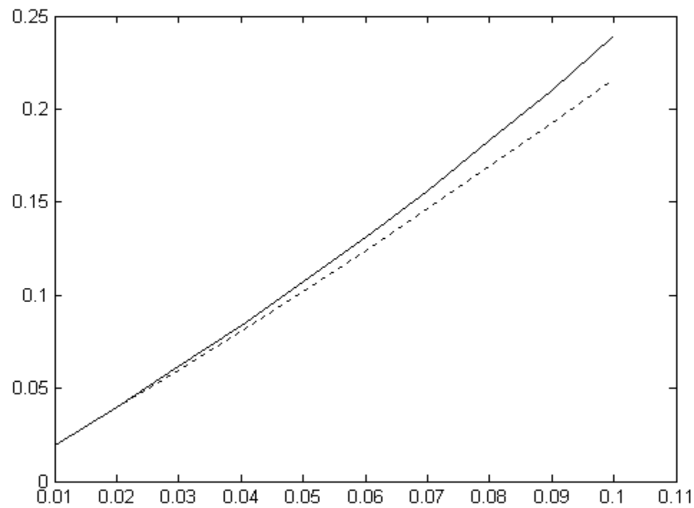
Note: The horizontal (x) axis represents the real foreclosure lag in quantiles. The vertical (y) axis indicates, also in quantiles, the theoretical foreclosure lag values generated from the exponential distribution with $\beta^E = 695.43$, where β^E is the estimated parameter for the exponential distribution.

Figure 3: QQ-plot for the gamma distribution



Note: The horizontal (x) axis represents the real foreclosure lag in quantiles. The vertical (y) axis indicates, also in quantiles, the theoretical foreclosure lag values generated from the gamma distribution with $\alpha^G = 7.437$ and $\beta^G = 93.51$, where α^G and β^G are the estimated shape and scale parameters for the gamma distribution, respectively.

Figure 4: Expected capital opportunity costs for foreclosure lags corresponding to different mortgage rates



Note: The horizontal (x) axis represents the mortgage rates. The vertical (y) axis indicates the capital opportunity costs during the foreclosure period. The solid and dashed lines denote the capital opportunity costs of foreclosure calculated from the exponential and gamma models respectively.

Table 1: Summary statistics for the sample of foreclosure lags

	All States	Judicial States	Non-judicial States	Redemption States	No-redemption States
mean	695.43	811.22	632	709.1	684.81
standard deviation	284.39	294.49	251.33	275.12	282.44
maximum value	4337	3803	4236	3482	4236
median	634	745	574	651	623
minimum value	131	172	131	131	132
skewness	1.9507	1.9061	2.0533	1.734	1.9677
kurtusis	9.9221	9.4416	10.439	8.2243	10.025
number	489,990	167,430	321,410	172,450	316,390

Note: This table shows the means, standard deviations, maximum and minimum values, medians, skewness, kurtosis, and sample sizes for the foreclosure lag distribution based on the different state policies regarding judicial foreclosure and redemption. The data were taken from the FHA databank. The sample period begins on 1/1/1998 and ends on 11/1/2011.

Table 2: Estimated parameters for the exponential and gamma distributions

			Exponential Distribution		
	All data	Judicial	Non-Judicial	Redemption	No-Redemption
β^{E}	695.43	811.22	632.00	709.10	684.81
β_{L}^{E}	693.21	806.79	629.50	705.28	682.09
β_{U}^{E}	697.66	815.67	634.50	712.93	687.55
			Gamma Distribution		
	All data	Judicial	Non-Judicial	Redemption	No-Redemption
α^{G}	7.44	9.34	8.02	8.02	7.34
α_{L}^{G}	7.40	9.27	7.98	7.96	7.30
α_{U}^{G}	93.15	86.30	78.44	87.83	92.89
β^{G}	93.51	86.86	78.80	88.42	93.33
β_{L}^{G}	7.47	9.41	8.06	8.08	7.38
β_{U}^{G}	93.87	87.41	79.17	89.01	93.77

Note: The estimated parameter for the exponential distribution is β^{E}. The estimated shape and scale parameters for the gamma distribution are α^{G} and β^{G} respectively. The lower bounds for β^{E}, α^{G} and β^{G} are β_{L}^{E}, α_{L}^{G} and β_{L}^{G} respectively and the upper bounds are β_{U}^{E} α_{U}^{G} and β_{U}^{G} respectively. All values of the lower and upper bounds are calculated by the 5% significance level.

Table 3: Estimates of the coefficients in the linear regressions for the foreclosure lag

	Model 1	Model 2	Model 3	Model 4
Constant	656.41***	712.67***	611.11***	603.61***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Interest rate at	2250.5***	0	0	1757.8***
default date	(0.0000)	0	0	(0.0000)
Interest rate at	-2261***	0	0	-2054.5***
selling date	(0.0000)	0	0	(0.0000)
Housing return	640.09***	0	0	585.29***
at default date	(0.0000)	0	0	(0.0000)
Housing return	-297.16***	0	0	-322.5***
at selling date	(0.0000)	0	0	(0.0000)
LTV	0	-38.078***	0	-20.825***
	0	(0.0000)	0	(0.0000)
Loss Rate	0	40.432***	0	18.27***
	0	(0.0000)	0	(0.0000)
Judicial state	0	0	186.93***	175.89***
	0	0	(0.0000)	(0.0000)
Redemption	0	0	51.731***	47.983***
state	0	0	(0.0000)	(0.0000)

Note: The linear models are as follows:

Model 1: $x_i = a_0 + a_1 r_i^d + a_2 r_i^s + a_3 h_i^d + a_4 h_i^s + \varepsilon_i$;

Model 2: $x_i = a_0 + a_5 L_i + a_6 \xi_i + \varepsilon_i$;

Model 3: $x_i = a_0 + a_7 d_i^j + a_8 d_i^r + \varepsilon_i$; and

Model 4: $x_i = a_0 + a_1 r_i^d + a_2 r_i^s + a_3 h_i^d + a_4 h_i^s + a_5 L_i + a_6 \xi_i + a_7 d_i^j + a_8 d_i^r + \varepsilon_i$,

where x_i is the foreclosure lag for the i -th loan; r_i^d and r_i^s are the interest rate at the month of default date and the month of selling date respectively; h_i^d and h_i^s are the housing return at the month of default date and the month of selling date respectively; L_i and ξ_i are the respective loan-to-value ratios and loss rates for the i -th loan; d_i^j and d_i^r indicate respectively the judicial foreclosure and redemption policies; $a_{\cdot}$ are the coefficients for linear models and ε is the residual. P-values appear in parentheses. *** denotes significance at the 1% level. Models 1, 2, and 3 analyze respective the effects of economic situations, the loan characters and the state foreclosure policies on foreclosure lag. Model 4 shows the analyses for all effects.