Estimating Effects of Adjustable Mortgage Rate Resets

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ABSTRACT

The recent Global Financial Crisis has highlighted the need for the improvement in the credit risk forecasting and stress-testing methods in retail lending. Adjustable rate mortgages in the US proved to be one of the hardest hit loan categories. From a modeling perspective, capturing the impact of interest rate adjustments is a significant problem in understanding and pricing the risk of these products.

Leveraging Dual-Time Dynamics, we begin with the usual decomposition of vintage performance data into maturation, environment, and credit quality. However, since interest rate resets are timed relative to the start of the loan, we allow for an additional impulse function at each reset to capture the impact of the reset on delinquency and default. We used this approach to model data from US non-conforming securitized loans originated as far back as 2003 with performance data through 2010.

Our analysis reveals a significant difference in the shape of the mortgage reset response functions across product types (i.e. 2-year ARM vs. 5-year ARM) and consumer groups. The amplitude of the response function has been found to be highly correlated to the relative magnitude of the interest rate change. The results of the analysis allow us to create calibrated mortgage reset response functions for specific customer groups and products given a future mortgage interest rate scenario. Combined with vintage-level, one-dimensional maturation function, this function can be used directly in delinquency and loss forecasting on both account and vintage level.

1. Introduction

Adjustable rate mortgages (ARMs) are an important product in the US. Although only 7.5% of all US mortgages are subprime ARMs, losses from those can be a disproportionately large fraction of mortgage industry losses. (Agarwal & Ho 2007) In addition, 2-year ARMs are the most commonly used product by mortgage investors hoping to resell the property before the mortgage interest rate resets.

US Adjustable Rate Mortgages (ARMs) will have an initial fixed rate period that is usually priced well below the market rate for Fixed rate loans. Then for a 2-year, 3-year, or 5-year ARM, a reset of the interest rate will occur at two, three, or five years respectively. (Stanton & Wallace 1999) Subsequent periodic resets will also occur, but the initial reset will be the strongest because of the change from a below-market initial rate to the full market rate.

2. Methodology

For a given performance rate, $r(\nu,\ a,\ t)$, one can construct a nonlinear model with dependence upon vintage ν, months-on-books (age) a, and calendar date t (Breeden 2007; Breeden 2010):

$$r(\nu,\ a,\ t) \ = \ e^{f_m(a)} \ \cdot \ e^{f_Q(\nu)} \ \cdot \ e^{f_g(t)} \ \cdot \ \varepsilon_{\nu,\, a,\, t} \ \text{, where} \tag{1}$$

$e^{f_m(a)}$ – maturation function, capturing product lifecycle effects.
$e^{f_Q(\nu)}$ – vintage quality, measuring credit quality issues due to changes in underwriting.
$e^{f_g(t)}$ – exogenous curve, capturing calendar time shocks to the vintages.
$\varepsilon_{\nu,\, a,\, t}$ – residual error from modeling.

For fixed-rate loan products that are not actively managed (like fixed-rate mortgages and auto loans), the maturation function is a one-dimensional. All three fuctions are estimated nonparametrically. For adjustable-rate mortgage products, the response of the borrowers to the change in interest rate will also be timed to the age of the loan and should be also taken into account. The maturation function can now be viewed as a function of both account age (months-on-books) and the elapsed time since the mortgage interest rate reset, $f_m(a,\ t_r)$.

In that case the decomposition formula becomes:

$$r(\nu,\ a,\ t) \ = \ e^{f_m(a,\, t_r)} \ \cdot \ e^{f_Q(\nu)} \ \cdot \ e^{f_g(t)} \ \cdot \ \varepsilon_{\nu,\, a,\, t} \tag{2}$$

To simplify the problem, we modeled just the initial rate reset for the ARM. We can represent the maturation function as the combination of two separate functions of account age, a and time since the interest rate reset, t_r:

$$e^{f_m(a,\,t_r)} = e^{f_m(a)} \cdot e^{\lambda_i f_r(t_r)} \tag{3}$$

$f_m(a)$ is one-dimensional maturation function that can be estimated using the standard nonlinear decomposition procedure (1) and treated as a fixed input. $\lambda_i f_r(t_r)$ is the rate reset response function with calibration factor λ_i. The response function captures the initial reaction of an account to any mortgage rate reset. This framework can also be used to allow for an additional impulse response functions at each reset to capture the impact of those reset on delinquency and default.

3. Analysis Summary and Results

In the following analysis, we used account-level data from US non-conforming securitized adjustable-rate mortgage loans originated as far back as 2003 with performance data through June 2010. The individual loan data was grouped at the product (i.e. 2-year ARM, 5-year ARM etc.) and US state/geographic region levels. For each combination of product and region, we performed nonlinear decomposition via Dual-time Dynamics measuring maturation, exogenous, and credit quality functions. The maturation curves for delinquency rates were further decomposed into base, $f_m(a)$ and impulse, $f_r(t_r)$ functions reflecting overall delinquency trend as a function of the loan age (months-on-books) and the impact of the interest rate change as a function of time since the rate reset.

We found a significant difference in the shape of the mortgage reset response functions across product types and consumer groups. For example, the response function for a 5-year ARM is much wider than that of the shorter term ARMs.

An example of the account delinquency rate maturation curves for the adjustable 2-year mortgage loans is shown in Figure 1. Two-year ARMS can enforce the reset in either month 25 or month 26, so those two groups were analyzed separately. The dataset used to produce Figure 1 contains securitized adjustable rate loans originated in the states of California, Arizona, Nevada and Florida with initial mortgage reset occurring at 25 and 26 months since loan origination. The time distribution of interest rate resets included into this dataset is shown in Figure 2. As is clearly seen from Figure 1, the initial interest rate reset is followed by a strong spike in the delinquency rate (a $\sim 50\%$ increase). The spike has a fast rise followed by a more gradual quasi-exponential decay. The subsequent rate resets appear to have a much less pronounced effect on the delinquency rate as compared to the initial reset at 25/26 months.

The timing of the initial rise of the delinquency spike suggests that a significant portion of the early delinquencies occurs prior to the rate reset (Figure 1). Therefore, a detailed modeling of the initial rise of the response function could become a powerful tool to quantify and forecast the contribution of "strategic" delinquencies and defaults.

In order to quantify the response to the interest rate reset, we subtracted the one-dimensional base maturation function, $f_m(a)$ from the total maturation curves. The resulting residual maturation curve can be fit to the analytical models or used for nonparametric estimation. The normalized response curves for the dataset described above are shown in Figure 3. For simplicity, triangular-shape linear functions were used to approximate the rate reset impulse function, $f_r(t_r)$.

The amplitude of the response function has been found to be highly correlated to the relative magnitude of the interest rate change based on both vintage and account-level analysis. In Figure 4 the dependence of the difference between the total maturation curve and base maturation curve of the 60-89 DPD Delinquency Account Rate is shown as a function of the amplitude of the initial mortgage rate increase. The relative amplitude of the interest rate change also seems to be affecting the shape of the impulse function, making it wider for interest rate increases in excess of $\sim$ 40% of the original rate (Figure 4, *lower right panel*). For lower amplitude rate changes, the shape of the response function is stable and it can be presented in the form: $e^{\lambda(\Delta R/R) f_r(t_r)}$, where ΔR and R are the change in the interest rate and the original interest rate, and λ is a linear function of $\Delta R/R$. This simplified relation allows one to create calibrated mortgage reset response functions and produce delinquency and loss forecasts given a future mortgage interest rate scenario.

4. Conclusions

The adjustable rate mortgages display a relatively wide range of behaviors with respect to the consumer response to the interest rate change. The performance of these loans can be successfully studied and forecasted in the framework of Dual-Time Dynamics allowing the separation of internal dynamics (maturation) and credit quality of the portfolio or individual loan from the external factors. We found that the term of the loan and the relative amplitude of the initial interest rate change are the two main parameters determining the response to the interest rate reset. Our analysis reveals a significant difference in the shape of the mortgage reset response functions across product types and consumer groups. The amplitude of the

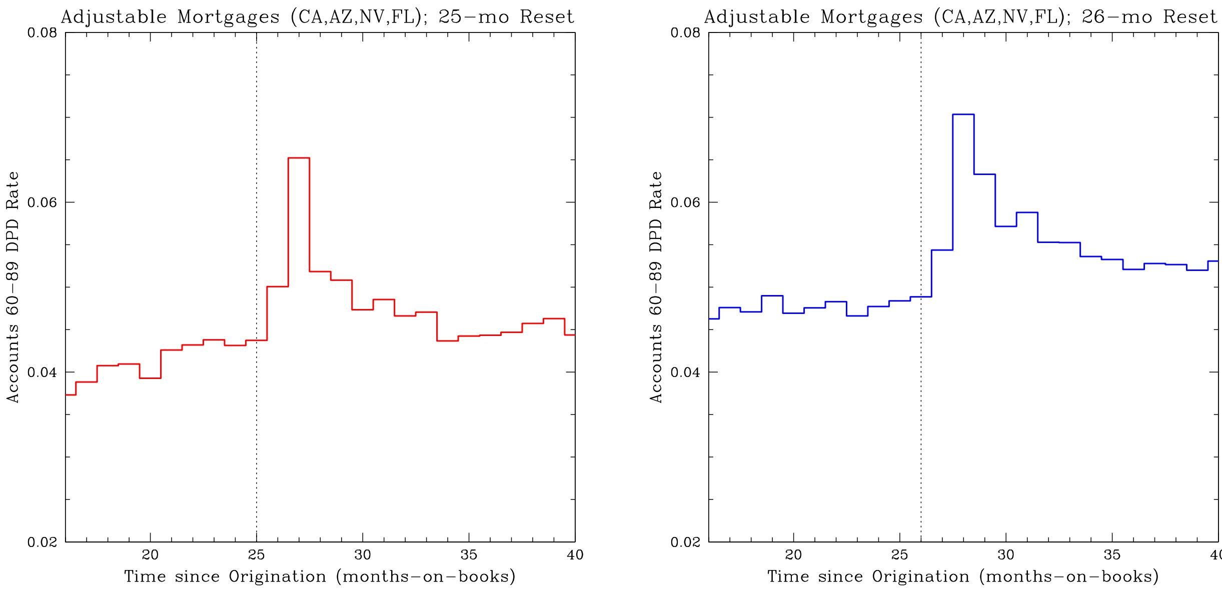

Fig. 1.— A month-on-books view of 60-89 DPD Delinquency Account Rate curves for 2-year adjustable rate mortgages (ARM) originated in states of California, Arizona, Nevada and Florida with initial mortgage reset occurring at 25 months (*left panel*) and 26 months (*right panel*). The initial rate reset times are shown with vertical dotted lines. Note the prominent peak in the delinquency rate following the reset by 2 months.

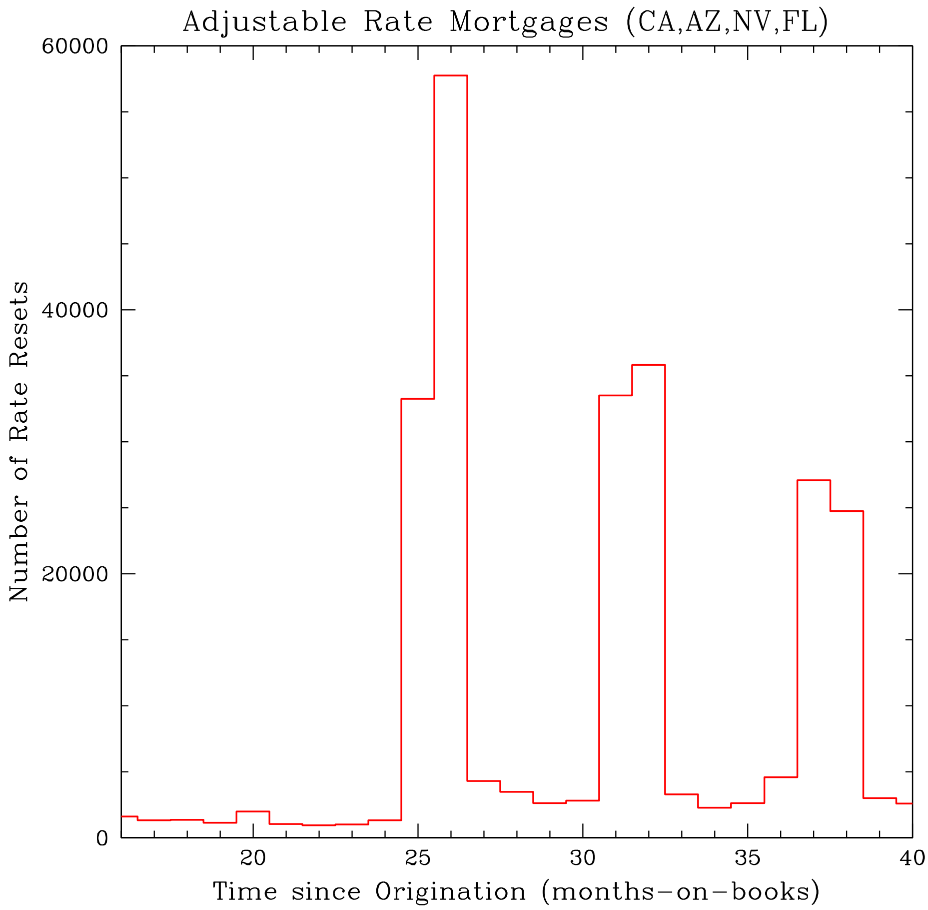

Fig. 2.— The distribution of interest rate resets for the 2-year adjustable mortgages originated in states of California, Arizona, Nevada and Florida used in the analysis.

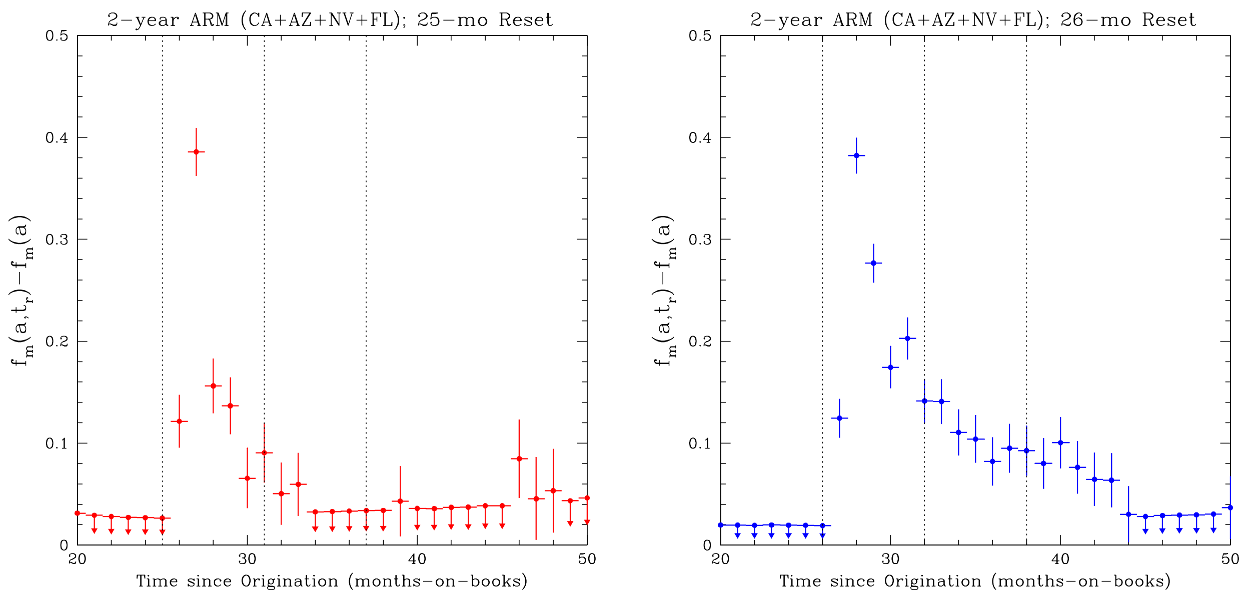

Fig. 3.— The difference between the total maturation curve, $f_m(a,\ t_r)$ and base maturation curve, $f_m(a)$ of the 60-89 DPD Delinquency Account Rate for 2-year ARMs originated in states of California, Arizona, Nevada and Florida with initial mortgage reset occurring at 25 months (*left panel*) and 26 months (*right panel*). The rate reset times are shown with vertical dotted lines.

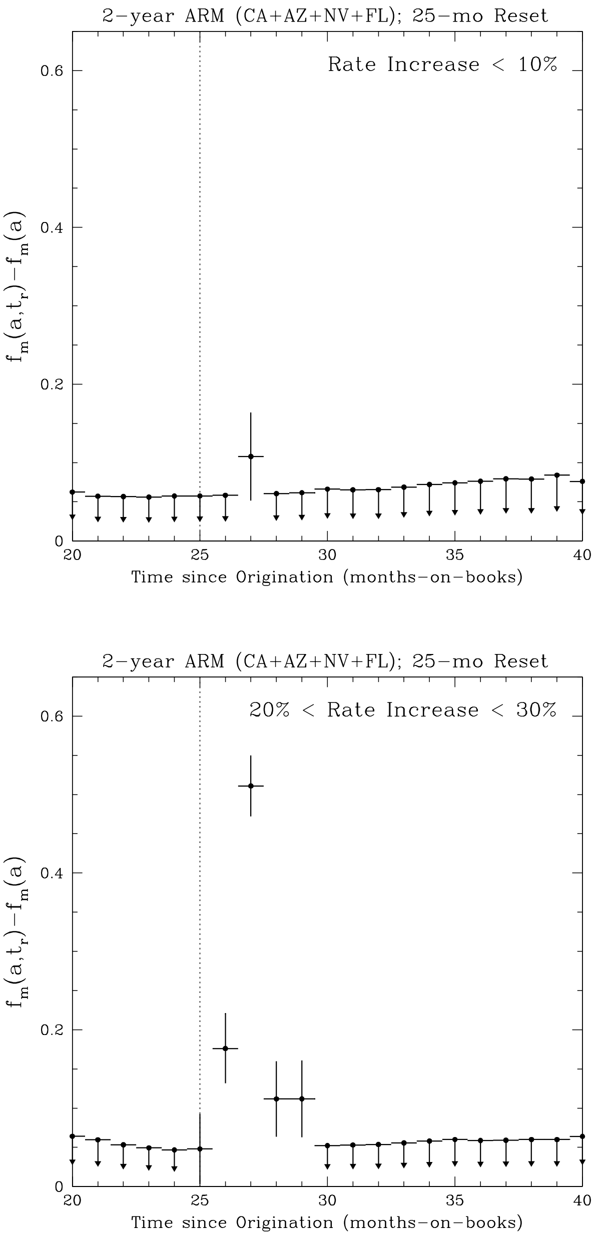

Fig. 4.— The difference between the total maturation curve, $f_m(a,\ t_r)$ and base maturation curve, $f_m(a)$ of the 60-89 DPD Delinquency Account Rate as a function of the amplitude of the initial mortgage rate reset. The initial rate reset position is shown with vertical dotted lines.

response function has been found to be highly correlated to the relative magnitude of the interest rate change. The results of the analysis allow us to create calibrated mortgage reset response functions for specific customer groups and products given a future mortgage interest rate scenario. Combined with the one-dimensional maturation function common to all vintages, this function can be used directly in delinquency and loss forecasting on both account and vintage level.

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