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INTRODUCING CLIMATE CONDITIONED LDM (ccLDM)

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Summary

In recent articles, we have described Andrew Davidson & Co. Inc.'s (AD&Co) overall approach to incorporating climate risks into our analytical framework,[1] and provided details on how our home-price appreciation (HPA) model will evolve within this framework.[2] Our LoanDynamics Model (LDM) is the other main component that will account for climate risk: LDM handles the mortgage holder's behavioral response to such risk by modifying the likelihood of prepaying or defaulting. Climate-conditioned versions of LDM and HPA have been integrated into our LoanKinetics (LK) tool and are currently undergoing internal testing. We will discuss the full LK implementation of the Climate Impact Suite (CIS) in a subsequent article. In this piece, we focus on how our prepayment, default, and severity models within LDM are evolving.

Key Input: The Technical Insurance Premium

Rather than modeling individual climate events and their effects on homeowners, ccLDM quantifies climate stress using the increase in home insurance premiums that becomes necessary when the frequency of climate-related events increases. Clients will obtain these projected increases from climate data analytics firms. Such firms, given a latitude and longitude (or property address), provide long-term forecasts of expected losses and various tail losses at the property level. These losses are represented as ratios relative to the replacement cost of the home and are broken down by type of peril: hurricane, convective storm, flooding, wildfire, etc.

The insurance premium input to ccLDM can be conceived of in at least two different ways:

1. Imagine a world where insurance companies can charge full, actuarially sound premiums. The vectors of losses could be directly transformed into a set of "technical insurance premiums." These vectors would be passed to ccLDM at the loan level, with the exact mechanism determined by the delivery method being used to call LDM.
2. In reality, within areas that have high climate risk, actual insurance premiums being paid may be nowhere near the levels implied by the technical insurance premium vector. Some expertise needs to be injected, by considering the dynamics of each state insurance market (or, in the case of flood, of the

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[1] E. Belbase and A. Levin, "Conditioning Mortgage Credit Analysis on Climate Risk: General Approach & Florida Case Study," *A Collection of Essays on Climate Risk and the Housing Market*, vol. 2 (March 2023).

[2] A. Levin, "Flood Insurance Spike in Florida: Effect on Home Prices and the Economics of Loan Guarantees," *The Pipeline*, no. 176 (March 2022).

NFIP) to create a vector that starts at the current premium level and increases to the level required for the insurance system to say solvent.

The current version of ccLDM assumes the user has chosen some method to create vectors of homeowner insurance costs as a percentage of the replacement value of the property backing the mortgage, either by using the technical premiums indicated by climate data vendors “as is,” or by modifying these premiums to account for underpricing in each market.

Model Dynamics

In order to understand the dynamics of our climate conditioning, it may be useful to think of a fixed rate borrower as having three payment obligations on their property: the mortgage, the insurance policy or policies required to obtain the mortgage, and property taxes. (Note that in addition to the standard hazard insurance, flood insurance is required by lenders in certain zones, and flood insurance is also required of anyone in Florida who has homeowner’s insurance via Citizens; there are similar requirements for wildfire-prone areas.) We can think of the second and third obligations as adjustable mortgages that mostly adjust upwards once a year.

Failure to pay insurance premiums can result in forced placement by the servicer, and failure to pay property taxes can result in foreclosure, with the property tax claim senior to the first mortgage. For many borrowers, both the second and third payments are escrowed via monthly payments as part of the mortgage payment. Borrower sensitivity to increases in any of the components of the total housing payment is expected to be similar.

Propensity & CLTV

Given the vector of annualized insurance premiums (relative to replacement cost) and a current estimated replacement cost to home value (for translating these premiums to dollar amounts), ccLDM calculates each monthly insurance premium as a ratio to the borrower’s principal-and-interest mortgage payment. These ratios may be adjusted for both inflation and income inflation. The Propensity Function then maps increases in these ratios to values between 0 and 1. These values represent the borrower’s overall propensity to exit LDM’s “current on payments,” or “C” state, either through selling (i.e., turnover) or by becoming delinquent on payments.

Depending on the equity position of the borrower, stressed levels of affordability are expected to result in different transitions out of the C state becoming more likely. In cases where we are not sure if equity is positive or negative (due to uncertainty in home value), the next transition being current to terminated (CtoT) due to turnover may be equally likely as a current to delinquent (CtoD) transition. On the other hand, a borrower with substantial equity is more likely to turnover, while a borrower clearly in negative equity is more likely to go delinquent.

Crucial Role of HPA Model

The climate conditioned HPA (ccHPA) impacts the output of ccLDM in multiple ways. First, the underlying CtoD transition rate is dependent on CLTV, which is impacted by climate conditioning in the HPA model. Second, this climate conditioned CLTV impacts the relative likelihoods of the increased cost pressure resulting in turnover or delinquency. Finally, if the ultimate result is default, it also impacts the severity. Without a ccHPA, none of the outputs of ccLDM would be meaningful.

Illustrative Examples

We now provide examples to illustrate the effect of ccLDM climate tunings on the projected prepayment, delinquency, and default rates for a given borrower, subject to different climate insurance and home equity scenarios. This article is focused on ccLDM; the HPA vectors used here are hypothetical and not linked to ccHPA. In a subsequent article, we will utilize the full LK implementation of the CIS to illustrate ccHPA and ccLDM working in tandem with one another.

Our examples involve four scenarios, all based on a geographic area in which climate effects (flood and wind) already produce extremely high projected losses and high estimated technical insurance premiums, with losses rising still further over the next 12 years. One home represents a "medium risk" property within this area, while the other represents "high risk." The ratio of technical insurance premium to mortgage payment is already at 1.2 and 0.7, respectively, for these homes, rising to 1.67 and 1.04 over 12 years. (Note that given a vector of insurance premiums relative to replacement cost, multiple additional values are needed to re-express these relative to mortgage payment. Among other things, the values indicated here and in Figures 1 and 2 are based on an original LTV of 70. For higher LTV's – and holding the home value fixed – the ratio to mortgage payment is lower.) For our first two examples we treat these technical premiums as if they reflect what the homeowner is currently paying and will continue to pay; for our second two examples, we consider a situation wherein the (actual) current insurance rates are just 30% of mortgage payment, much lower than necessary for the insurance companies to remain solvent; we then increase these rates steadily over two years until they rise to the technical premium. Figure 1 illustrates the insurance to mortgage payment premiums over time for all 4 examples.

Figure 1. Insurance Premium Ratio to Principal and Interest (for Original LTV = 70)

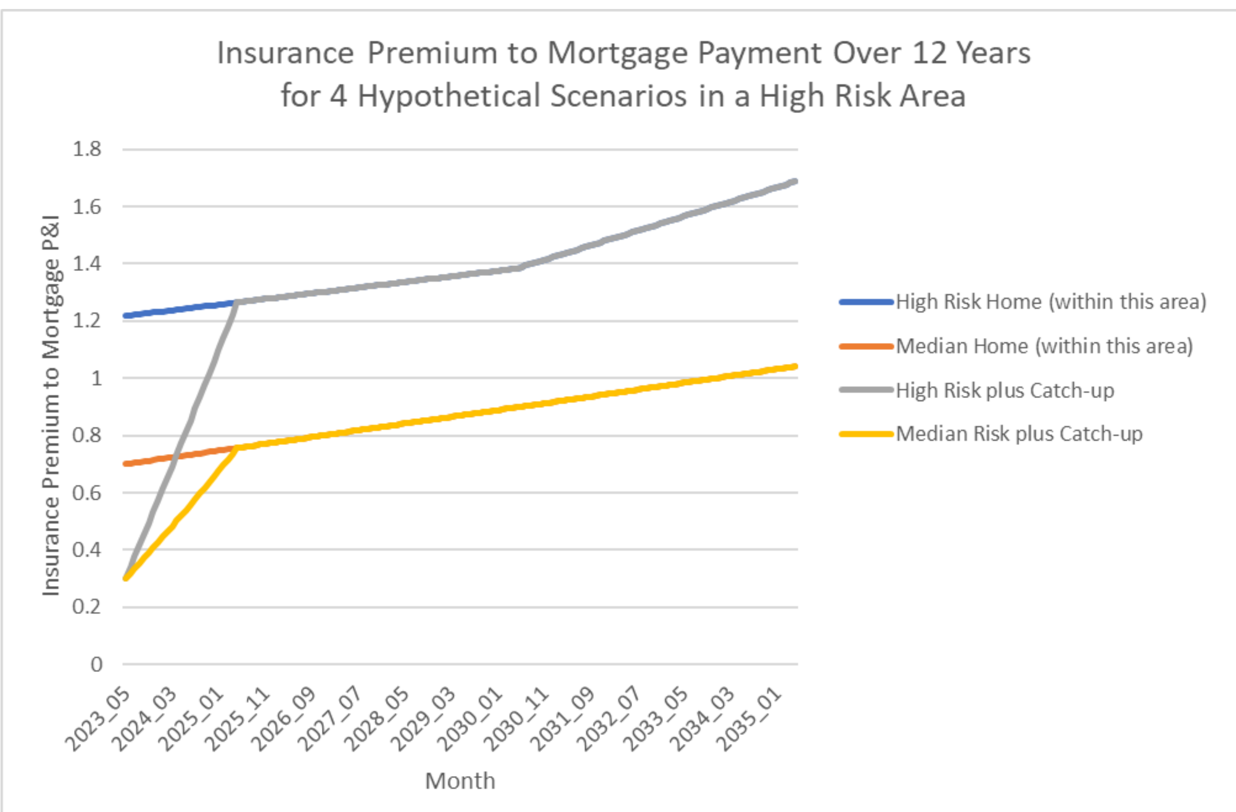
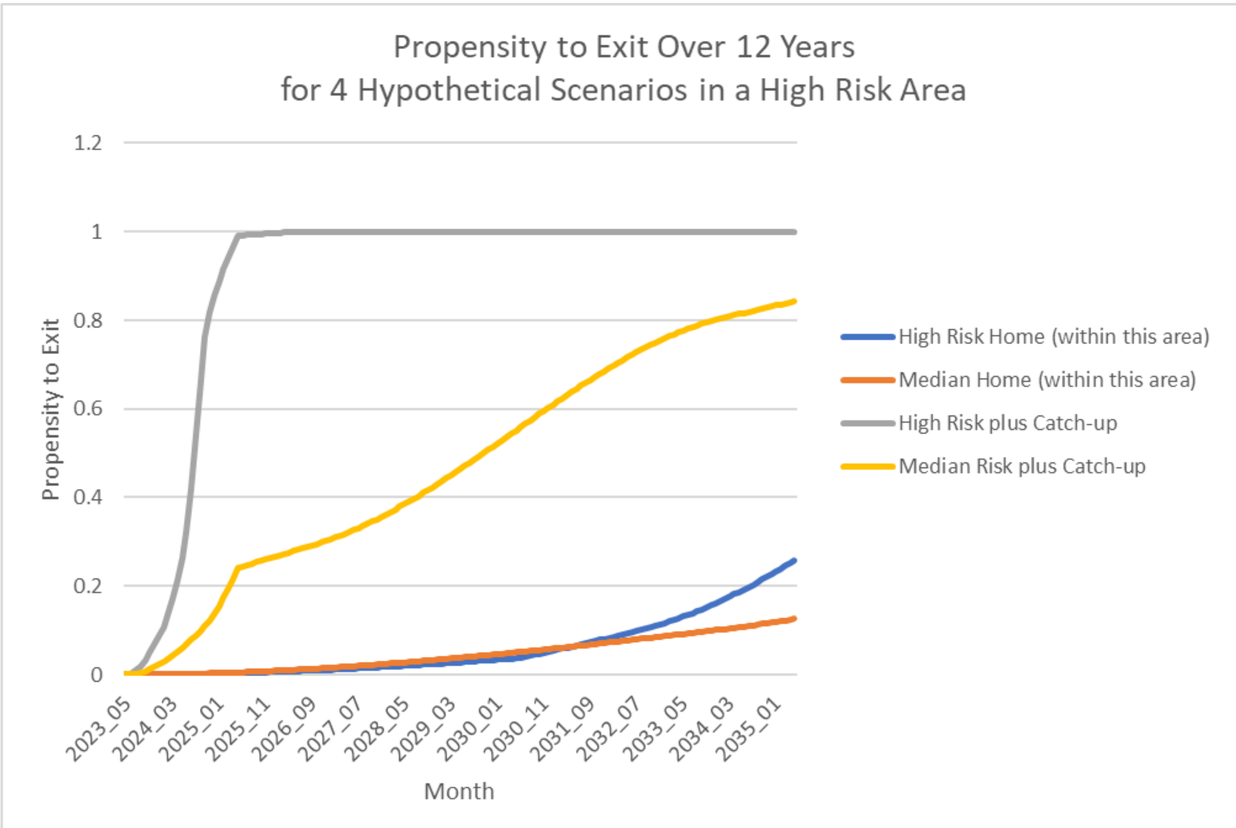


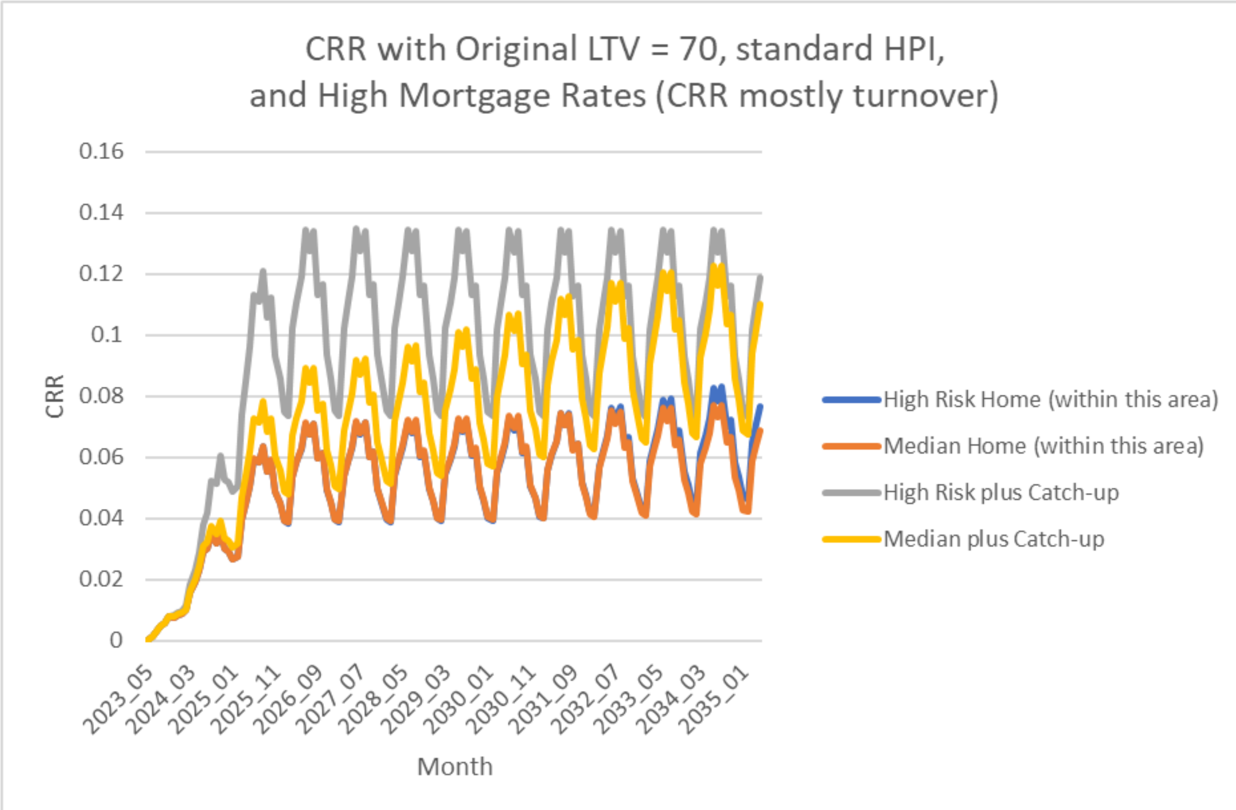
Figure 2 displays the corresponding propensity to exit for each scenario over the next 12 years. Note that this propensity is currently based solely on the *increase* in insurance premium that the homeowner experiences from the analysis date onward; in this framework, if the homeowner is already paying a high premium at the time of purchase, then the homeowner is assumed capable of affording it. Thus, in our first two scenarios propensity does not increase significantly, while the second two scenarios reach a propensity of 1 very quickly (high risk home) or 0.84 gradually (median risk home, represented by the yellow line; note, the propensity increases further outside of the 12-year window).

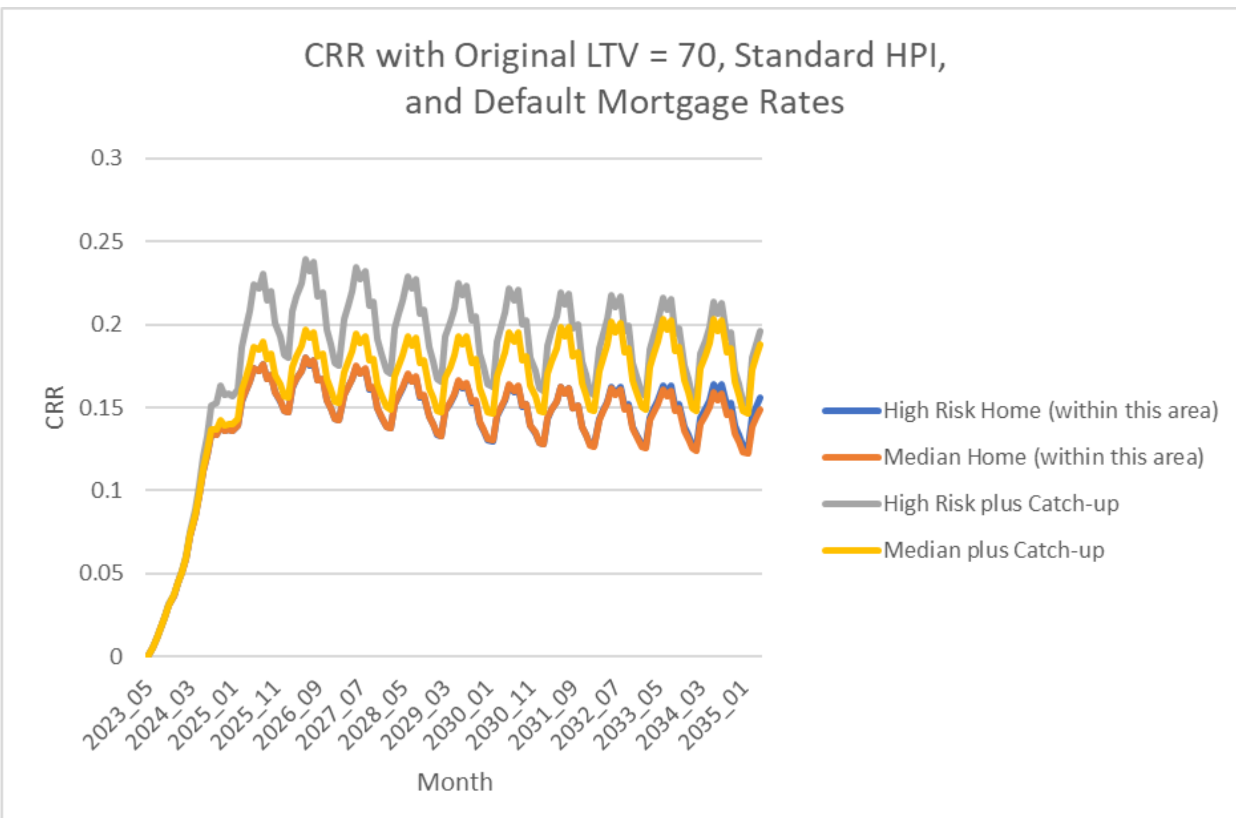
Figure 2. Propensity to Exit (for Original LTV = 70)



As previously described, the propensity to exit is divided between a tendency to sell (turnover) and a tendency to become delinquent, depending on the mortgage holder's equity in the home. In Figure 3, we display the conditional repayment rate (CRR) over 12 years, assuming that the mortgage holder has high equity; specifically, the LTV begins at 70 remains well below 80 throughout the time period. In this situation, any propensity to exit is assigned entirely to turnover; when the propensity reaches 1, the climate conditioned turnover tuning achieves its maximum value of 2. The first graph in Figure 3 assumes an economic environment wherein mortgage rates are extremely high in comparison with the borrower's current rate. These high rates create a situation wherein the projected CRR is due almost entirely to turnover, so we can easily view the effect of the climate conditioned tuning parameter over time. The second graph shows a rate scenario in which CRR includes both turnover and refinancing.

Figure 3. CRR Given High Equity and Two Mortgage Rate Scenarios





In contrast, Figures 4–6 display the climate conditioned CtoD tuning, always current to delinquent (ACtoD) transition rates, and CDR for a low equity situation, in which the borrower starts at 90 LTV and the projected

HPA pushes the CLTV ever higher over time. Note that we used a synthetic, pessimistic HPA projection in order to create this outcome; however, for homes with very high climate risk, the ccHPA will also tend to push prices lower (and CLTV higher). In this situation, the projected default rate is already much higher than before, even for a “base insurance” scenario in which the insurance premiums hold steady. However, when the borrower is also faced with very high increases in premium, the effect is exacerbated by the propensity to exit, which here affects mainly the delinquency rates rather than turnover. Figure 5 displays the resulting ACtoD rates over time, which as previously noted are already inflated due to the very low HPI; and Figure 6 displays the overall CDR. Note that the “climate conditioned” component of CDR arises from the ccLDM tuning value for the CtoD transition shown in Figure 4. Figure 5 illustrates the fact that this transition does increase drastically for the “High Risk Catch-up" scenario compared with the lower risk cases; however, CDR is an annualized value that is also affected by other transitions such as delinquent to current (DtoC), delinquent to severely delinquent (DtoS), etc., which do not currently incorporate a climate-based tuning, so the multiplicative effect of climate conditioning is not as large in Figure 6.

Figure 4. Climate Conditioned CtoD Tuning Given Low Equity

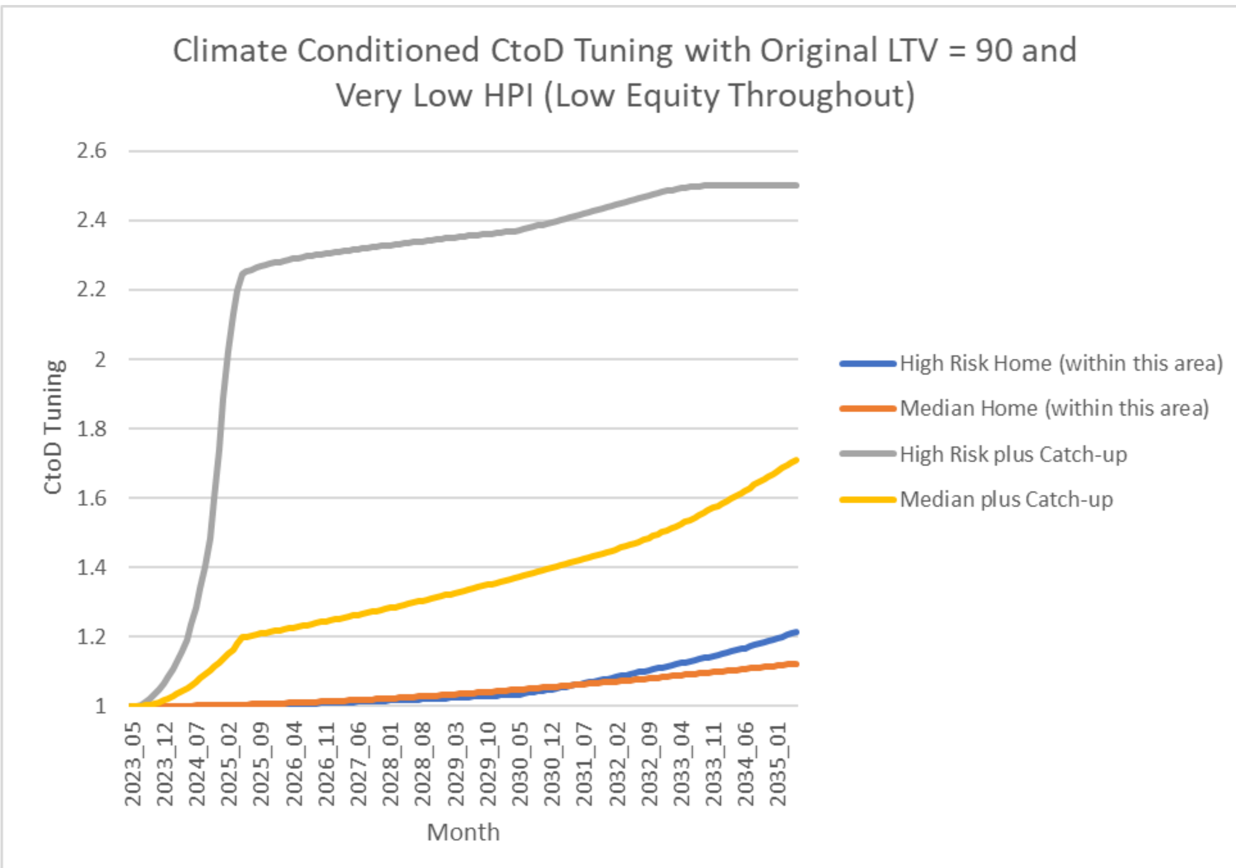


Figure 5. ACtoD Transition Rate Given Low Equity

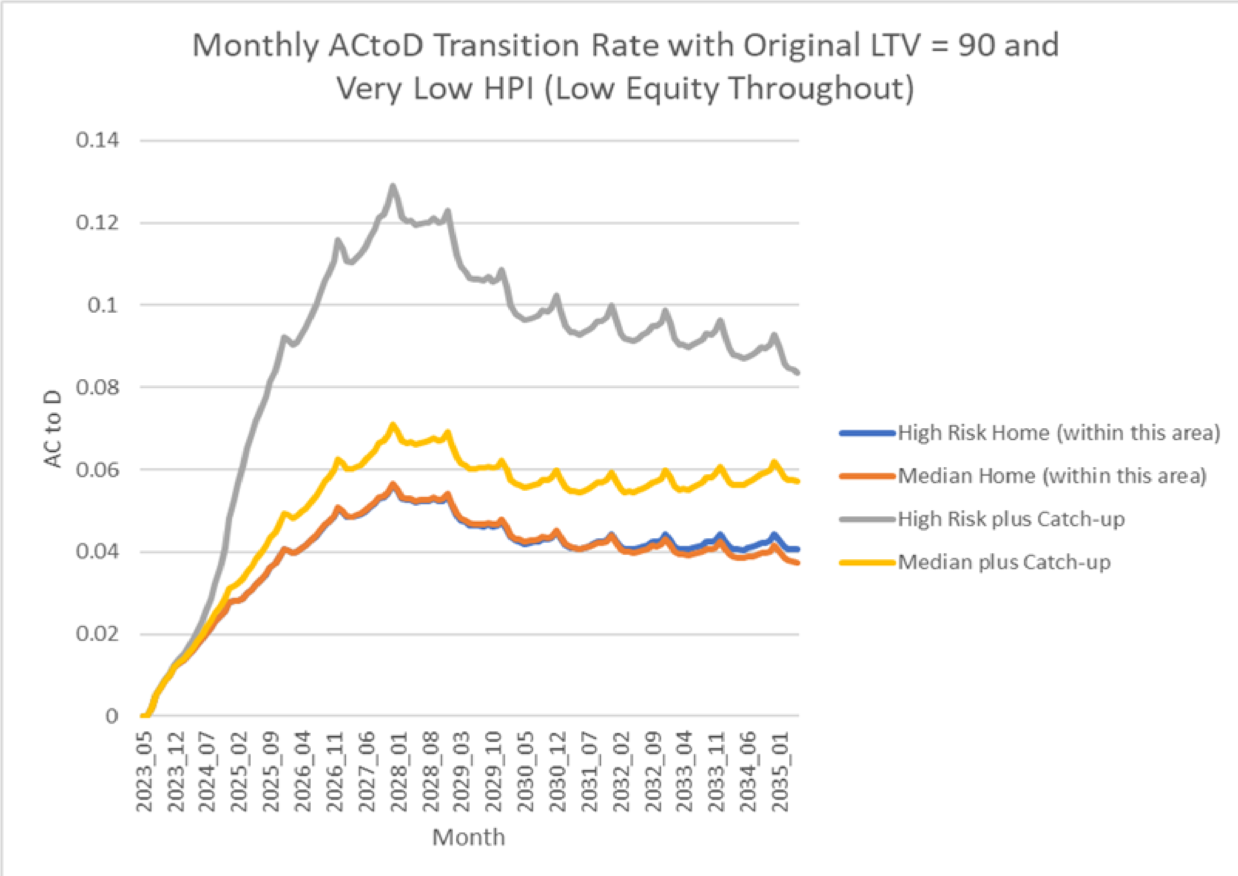
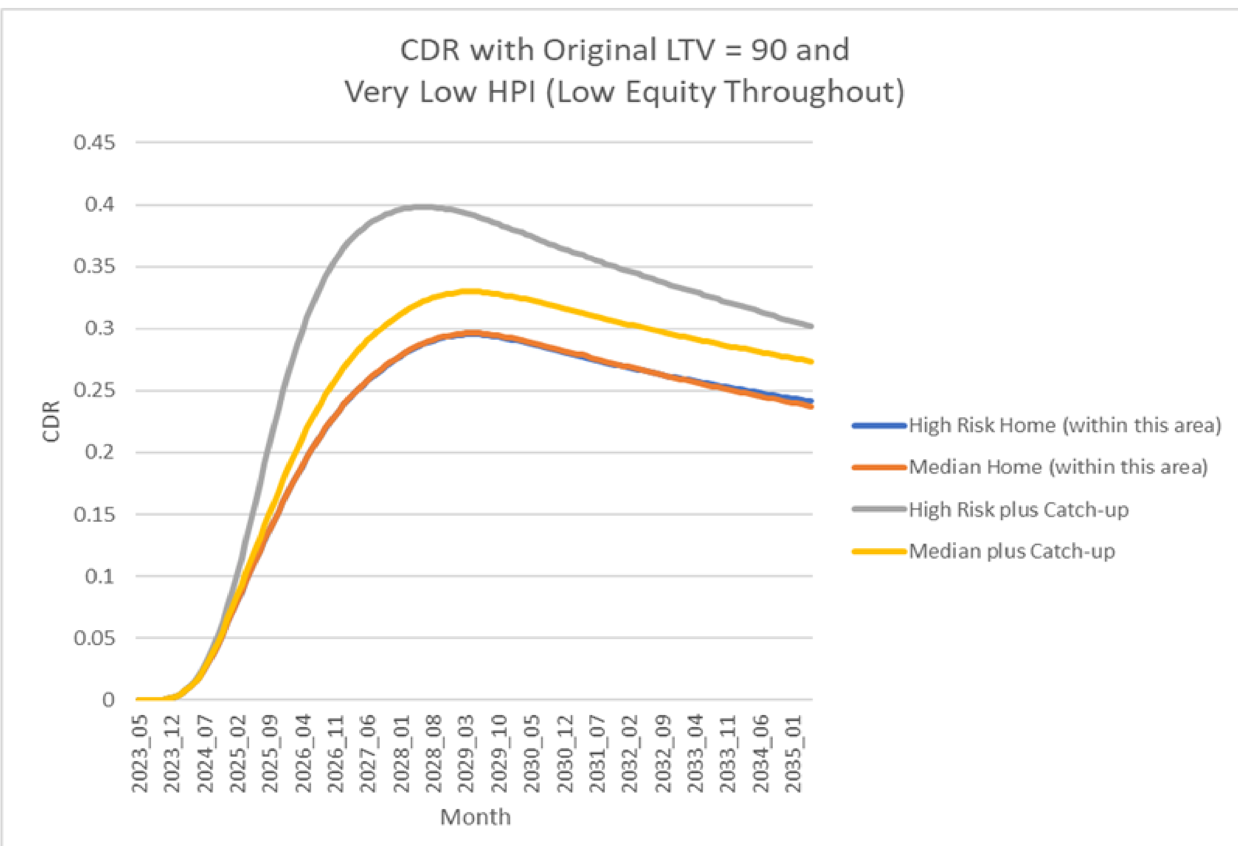


Figure 6. CDR Given Low Equity



Concluding Thoughts

We finish by pointing out limitations in our initial approach and indicating several plans for improvement. First, our estimates for behavioral response to increasing insurance costs as a function of the size of the affordability shock are necessarily rough. The historical data on large pay shocks comes from instruments such as IO ARMs and option-ARMs resetting. Those resets tend to concentrate extremely large pay shocks into a single period, whereas we are trying to estimate the cumulative impact of significant, but not as large, annual increases in costs. Those borrower populations may also have been different. This limitation will be mitigated over time, as we obtain property-matched loan performance data for areas with distinct levels of observed insurance cost increases.

Second, in terms of borrower affordability, the three largest components of housing cost are mortgage payments, insurance, and property taxes; we have left property taxes out of the analysis. Areas with the highest insurance increases may overlap with areas with higher rates of property tax increases (local infrastructure is as affected by climate as housing). The path to mitigating this limitation includes working with data vendors to include property taxes as part of the property-level input. Monthly utility costs may be a fourth component to consider including in our models.

An additional limitation is that we have implemented climate conditioning via tuning. Similar to the way in which the impact of additional disclosure variables in agency pools made its way from being implemented as on-top multipliers to being "inside the function," we anticipate that climate conditioning will become more closely tied to the LDM functional form over time.

Nevertheless, the way we have climate conditioned our models is a significant step forward. The framework is flexible, granular, and allows for a level of detail that does not yet exist in the realm of climate risk analysis for mortgage loans and securities. As climate models themselves evolve, improve, and provide information on a wider range of phenomena, our framework is well positioned to capture the link between borrower costs and behavioral responses.