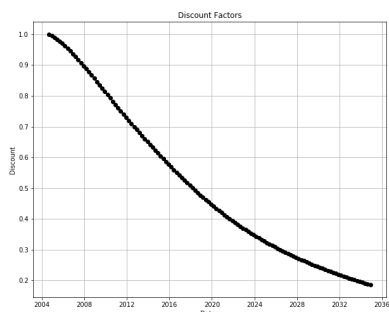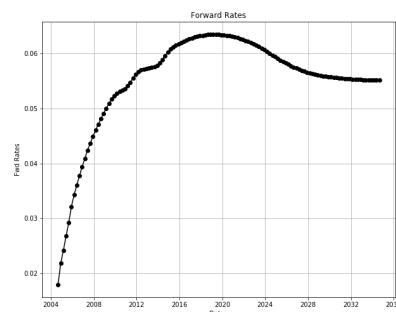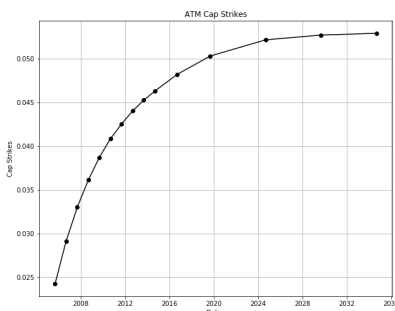# 1   Hull-White (HW) Model
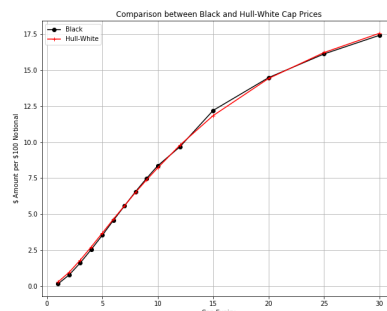
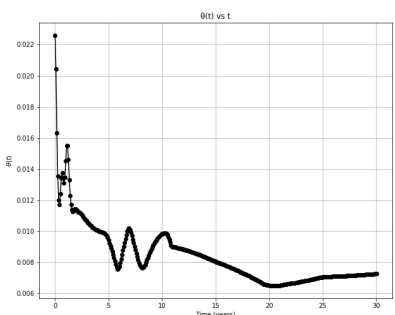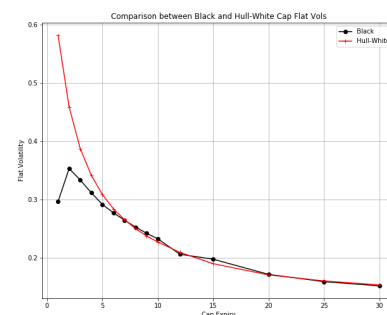**(a)** Discount Factors

(b) Forward Rates

(c) ATM Cap Strikes

(d) Comparison of Models

(e) $\theta(t)$

(f) Flat Vol implied by HW

We have provided a few of the values of $\theta(t)$ in the table below. For the entire table, please refer to theta.csv submitted. Since we've ignored leap years, the time in years jumps after every 4th year.

Time (years)	$\theta(t)$	Time (years)	$\theta(t)$	Time (years)	$\theta(t)$
1	0.01454	6.00274	0.00774	12.00822	0.00883
2	0.01139	7.00274	0.01011	15.00822	0.00805
3	0.01062	8.00548	0.00774	20.0137	0.00653
4.00274	0.01004	9.00548	0.00888	25.01644	0.00706
5.00274	0.00943	10.00548	0.00983	30.01918	0.00727

The flat volatility implied by the Hull-White model differs from the Black model considerably at the start because

we have minimized the sum of squared errors while calibrating. Since the cap prices for lower maturities are lower, the error in relative terms becomes very high which drives the deviation in volatility (which is a normalized measure). Since the σ parameter in hull-white is not time-varying, we do not have the flexibility to fit option prices and vols exactly.

2 Pricing REMIC Bonds

The prices of nine bonds(including residual), standard errors, effective durations, convexities and implied OAS are showed as below.

Bond	Prices	STE	Effective Duration	Convexity	OAS
CG	7.801970e+07	1170.674219	2.148574	0.070628	0.017885
VE	5.404682e+06	54.878692	1.849726	0.040340	0.019347
CM	1.474515e+07	911.839236	3.786522	0.402167	0.011456
GZ	2.308297e+07	3417.092741	5.072736	1.493161	0.007141
TC	2.073038e+07	4311.193435	5.099139	1.790644	0.005073
CZ	2.351614e+07	15738.494930	7.783615	5.258332	-0.001506
CA	3.401054e+07	1794.624346	3.023132	0.465557	0.012104
CY	1.408762e+07	5430.698627	5.889609	3.143928	0.001129
R	4.196412e+05	224.234629	-9.263457	-5.439945	

The OAS is typically interpreted as compensation for uncertain cash flows. For example: The OAS of a callable corporate bond should remove the value of the short call option from the Z-spread. A positive value would be compensation for credit, liquidity, and idiosyncratic risk. However, for our FRMC REMIC, there is no credit risk. We also do not remove the option value (prepayment). Hence, we should interpret the OAS value largely to represent compensation for prepayment risk, with perhaps a little bit of liquidity and idiosyncratic risk.