Final Project of Fixed Income Securities

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Question 1.

1. 1 Type of Security

It is conventional mortgage loan with 15-year level pay. Essentially, the security is claim on a share of the cashflows generated by an underlying pool of mortgage loans.

1. 2 Issuer and Time

The issuer is Federal National Mortgage Association (FNMA). The issue date is Dec. 1st of 2016.

1. 3 Underlying Collateral, Origination & Borrowers

As we know, the underlying collaterals are those properties with geographic and demographic diversification. Each pool in the security has a lot of mortgaged loan that citizen got to finance their houses. Thus, the houses(properties) are the underlying assets. The origination is Dec 1st of 2016. The borrowers should be those people who got the loan to buy properties.

Question 2.

2. 1 Description

As shown in the table and 'Paydown' worksheet, the cashflows to data are complicated, which varies with the PSA and corresponding CPR. The CPR level comes higher and higher, while the PSA level comes down.

For this security, the balance came down with varying total payment. As for the total payment in each period, the scheduled payment generally came down while the unscheduled part (i.e. prepayment) came up at the first stage and came down after a

peak.

2. 2 Comparison

My pool is one pool out of 5,852 pools. This pool has a lower Weighted Average Coupon rate (3.404%) than the generic pool, which has a WAC as 3.6640%. Also, the Weighted Average Month for the generic pool is 339 months, while this pool has a WAM as 164. The net coupon rates are both 3.0%

Question 3.

3. 1 Build Simple PSA Model

Firstly, I began with a simple PSA model to project the security. I set the PSA as 171 at first. According to the information we gathered, the net coupon rate for this security is 3.00% while the servicing fee part is 0.404%.

Table I. Inputs for Simple PSA Model

PSA (Initial)	171
Weighted Average Months (WAM)	179
Beginning Balance	$337,903,338
Net Coupon Rate	3.000%
Servicing Fee	0.404%

The beginning balance for this security is $337,903,338. The Weighted Average Month (WAM) at the very beginning is 179 months. Now, we got all the inputs and get first projection.

Index	BeginningBlance	Payment	Interest	Servicing	Principal	EndingBlance	SMM	FractionRemaining	TotalInterest	TotalPrincipal	Prepayment	TotalPassthrough	Blance
0	3.37903e+08	2.39971e+06	844758	113761	1.44119e+06	3.36462e+08	0.000285448	0.999715	844758	1.44119e+06	96042.4	2.382e+06	3.37807e+08
1	3.36462e+08	2.39971e+06	841155	113276	1.44528e+06	3.35017e+08	0.000571795	0.999143	840915	1.44487e+06	191506	2.47729e+06	3.36174e+08
2	3.35017e+08	2.39971e+06	837542	112789	1.44938e+06	3.33567e+08	0.000859047	0.998285	836824	1.44814e+06	286305	2.57127e+06	3.34442e+08
3	3.33567e+08	2.39971e+06	833919	112301	1.45349e+06	3.32114e+08	0.00114721	0.997139	832488	1.451e+06	380351	2.66384e+06	3.32613e+08
4	3.32114e+08	2.39971e+06	830285	111812	1.45762e+06	3.30656e+08	0.00143629	0.995707	827910	1.45345e+06	473561	2.75492e+06	3.30688e+08
5	3.30656e+08	2.39971e+06	826641	111321	1.46175e+06	3.29195e+08	0.0017263	0.993988	823092	1.45548e+06	565848	2.84442e+06	3.28669e+08
6	3.29195e+08	2.39971e+06	822987	110829	1.4659e+06	3.27729e+08	0.00201723	0.991983	818039	1.45709e+06	657130	2.93225e+06	3.26556e+08
7	3.27729e+08	2.39971e+06	819322	110335	1.47006e+06	3.26259e+08	0.0023091	0.989693	812753	1.45827e+06	747325	3.01835e+06	3.24351e+08
8	3.26259e+08	2.39971e+06	815647	109840	1.47423e+06	3.24784e+08	0.00260191	0.987118	807239	1.45903e+06	836351	3.10262e+06	3.22056e+08
9	3.24784e+08	2.39971e+06	811961	109344	1.47841e+06	3.23306e+08	0.00289567	0.984259	801501	1.45936e+06	924129	3.18499e+06	3.19672e+08
10	3.23306e+08	2.39971e+06	808265	108846	1.4826e+06	3.21823e+08	0.00319039	0.981119	795542	1.45926e+06	1.01058e+06	3.26539e+06	3.17202e+08
11	3.21823e+08	2.39971e+06	804559	108347	1.48681e+06	3.20337e+08	0.00348607	0.977699	789368	1.45874e+06	1.09563e+06	3.34373e+06	3.14646e+08
12	3.20337e+08	2.39971e+06	800842	107847	1.49103e+06	3.18846e+08	0.00378272	0.974	782982	1.45777e+06	1.1792e+06	3.41996e+06	3.12008e+08
13	3.18846e+08	2.39971e+06	797114	107345	1.49525e+06	3.1735e+08	0.00408034	0.970026	776389	1.45638e+06	1.26123e+06	3.494e+06	3.09289e+08
14	3.1735e+08	2.39971e+06	793376	106841	1.4995e+06	3.15851e+08	0.00437894	0.965778	769595	1.45455e+06	1.34163e+06	3.56578e+06	3.0649e+08
15	3.15851e+08	2.39971e+06	789627	106336	1.50375e+06	3.14347e+08	0.00467853	0.96126	762605	1.45229e+06	1.42035e+06	3.63525e+06	3.03615e+08
16	3.14347e+08	2.39971e+06	785868	105830	1.50802e+06	3.12839e+08	0.00497912	0.956474	755423	1.4496e+06	1.49732e+06	3.70234e+06	3.00665e+08

Figure 1. Projection at 171 PSA

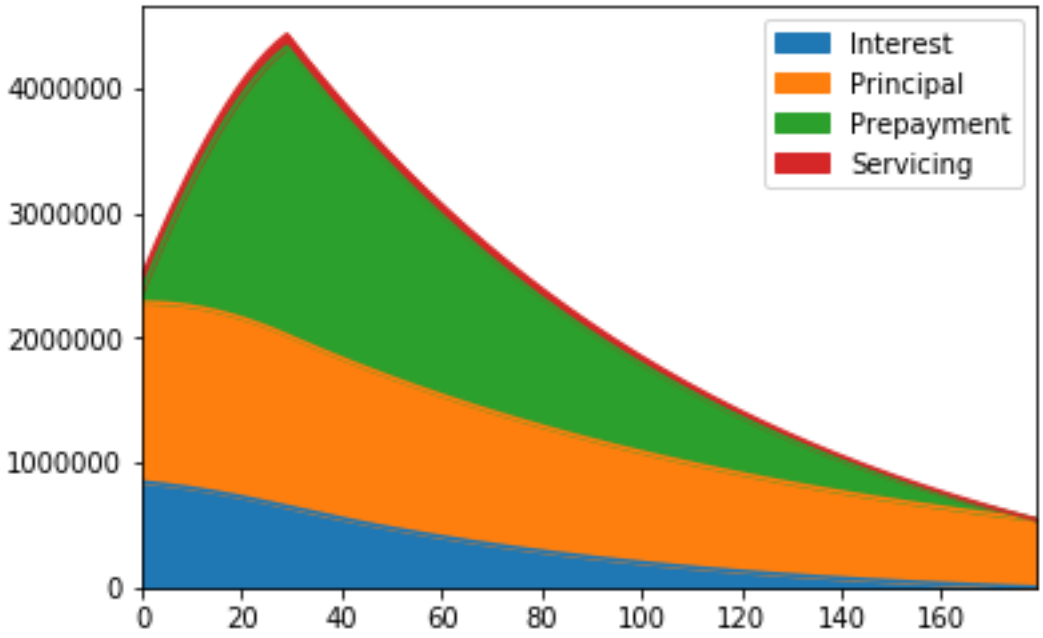

Figure 2. Cashflow Projection at 171 PSA

3. 2 Calibrate Model with Historical Prepayment Data

The graph proves our model to be a right one with correct trends. Then, it's time to pick up the best PSA which fits the historical data to do projection. As for this security, we know its historical prepayment number:

Table II. MA 6 & MA 3 for Historical Data

Date	Unsched	MA 6	MA 3
16-Dec	972901.47		
17-Jan	848508.11		
17-Feb	991425.61		
17-Mar	1553584.15		937611.73
17-Apr	782768.15		1131172.623
17-May	2311411.14		1109259.303
17-Jun	4767132.2	1243433.105	1549254.48
17-Jul	2609997.78	1875804.893	2620437.163
17-Aug	2334954.88	2169386.505	3229513.707
17-Sep	1029450.47	2393308.05	3237361.62
17-Oct	2786955.74	2305952.437	1991467.71
17-Nov	1937541.23	2639983.702	2050453.697
17-Dec	2731178.53	2577672.05	1917982.48
18-Jan	2328837.78	2238346.438	2485225.167

Then, we can calculate both the 3-month and 6-month Moving Average for the historical data. Also, we have the prediction of prepayment based on our simple PSA model, indicating we can calculate the absolute errors between them. If we change the PSA and seek the minimal errors, we will find **we should use the 6-month Moving Average and PSA level as 389.27** is the best for projection.

3. 3 Get Optimal Projection

The next step is to get the projection based our optimal PSA. I saved the projection in an excel sheet 'Optimal Projection'.

BeginningBlance	Payment	Interest	Servicing	Principal	EndingBlance	SMM	FractionRemaining	TotalInterest	TotalPrincipal	Prepayment	TotalPassthrough	Blance
3.37903e+08	2.39971e+06	844758	113761	1.44119e+06	3.36462e+08	0.000651111	0.999349	844758	1.44119e+06	219074	2.50503e+06	3.37683e+08
3.36462e+08	2.39971e+06	841155	113276	1.44528e+06	3.35017e+08	0.00130692	0.998043	840608	1.44434e+06	437556	2.7225e+06	3.35804e+08
3.35017e+08	2.39971e+06	837542	112789	1.44938e+06	3.33567e+08	0.0019675	0.996079	835903	1.44655e+06	655011	2.93746e+06	3.33703e+08
3.33567e+08	2.39971e+06	833919	112301	1.45349e+06	3.32114e+08	0.00263293	0.993457	830649	1.44779e+06	871005	3.14945e+06	3.31385e+08
3.32114e+08	2.39971e+06	830285	111812	1.45762e+06	3.30656e+08	0.00330328	0.990175	824852	1.44808e+06	1.0851e+06	3.35803e+06	3.28851e+08
3.30656e+08	2.39971e+06	826641	111321	1.46175e+06	3.29195e+08	0.00397862	0.986235	818519	1.44739e+06	1.29687e+06	3.56278e+06	3.26105e+08
3.29195e+08	2.39971e+06	822987	110829	1.4659e+06	3.27729e+08	0.00465904	0.98164	811658	1.44572e+06	1.50588e+06	3.76326e+06	3.23151e+08
3.27729e+08	2.39971e+06	819322	110335	1.47006e+06	3.26259e+08	0.00534461	0.976394	804279	1.44307e+06	1.71171e+06	3.95906e+06	3.19992e+08
3.26259e+08	2.39971e+06	815647	109840	1.47423e+06	3.24784e+08	0.00603543	0.970501	796392	1.43943e+06	1.91394e+06	4.14976e+06	3.16634e+08
3.24784e+08	2.39971e+06	811961	109344	1.47841e+06	3.23306e+08	0.00673156	0.963968	788089	1.4348e+06	2.11215e+06	4.33496e+06	3.13082e+08
3.23306e+08	2.39971e+06	808265	108846	1.4826e+06	3.21823e+08	0.0074331	0.956803	779142	1.42918e+06	2.30595e+06	4.51428e+06	3.0934e+08
3.21823e+08	2.39971e+06	804559	108347	1.48681e+06	3.20337e+08	0.00814014	0.949014	769804	1.42258e+06	2.49494e+06	4.68733e+06	3.05415e+08
3.20337e+08	2.39971e+06	800842	107847	1.49103e+06	3.18846e+08	0.00885277	0.940613	760010	1.415e+06	2.67875e+06	4.85376e+06	3.01313e+08
3.18846e+08	2.39971e+06	797114	107345	1.49525e+06	3.1735e+08	0.00957108	0.93161	749776	1.40646e+06	2.857e+06	5.01323e+06	2.9704e+08
3.1735e+08	2.39971e+06	793376	106841	1.4995e+06	3.15851e+08	0.0102952	0.922019	739117	1.39695e+06	3.02935e+06	5.16541e+06	2.92603e+08
3.15851e+08	2.39971e+06	789627	106336	1.50375e+06	3.14347e+08	0.0110251	0.911854	728051	1.38649e+06	3.19545e+06	5.30999e+06	2.8801e+08
3.14347e+08	2.39971e+06	785868	105830	1.50802e+06	3.12839e+08	0.0117611	0.901129	716596	1.37509e+06	3.355e+06	5.44669e+06	2.83267e+08
3.12839e+08	2.39971e+06	782098	105322	1.51229e+06	3.11327e+08	0.0125031	0.889862	704771	1.36277e+06	3.50768e+06	5.57522e+06	2.78384e+08

Figure 3. Optimal Projection

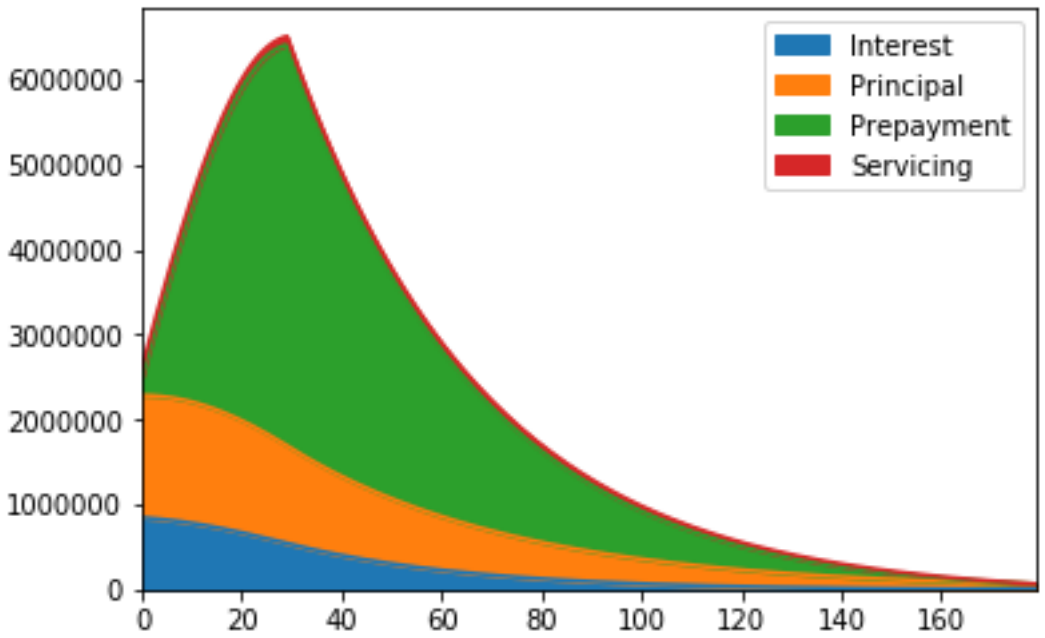

Figure 4. Cashflow Projection for Optimal PSA

3. 4 Get Spot Rate Curve

Since the spot rates of STRIPS are the data for 2/15/17, one reasonable way is to assume today is 2/15/17 and get the spot rate curve. I collected the LIBOR overnight rate for 2/15/17 and then do interpolation for all these key rates. Then, I got the spot rate curve as shown below:

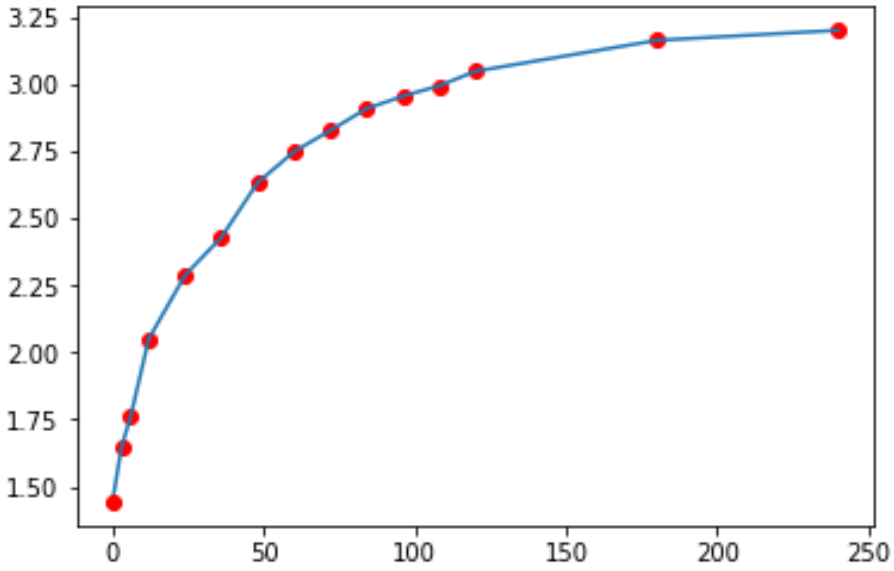

Figure 5. Spot Rate Curve with Key Rates Specified

3. 5 Discount and Get DV01 and Modified Duration

Based on our information about current Z-spread as 52 basic points, we parallel shifted the spot rate curve for 52 bps and discount the cashflow of this security.

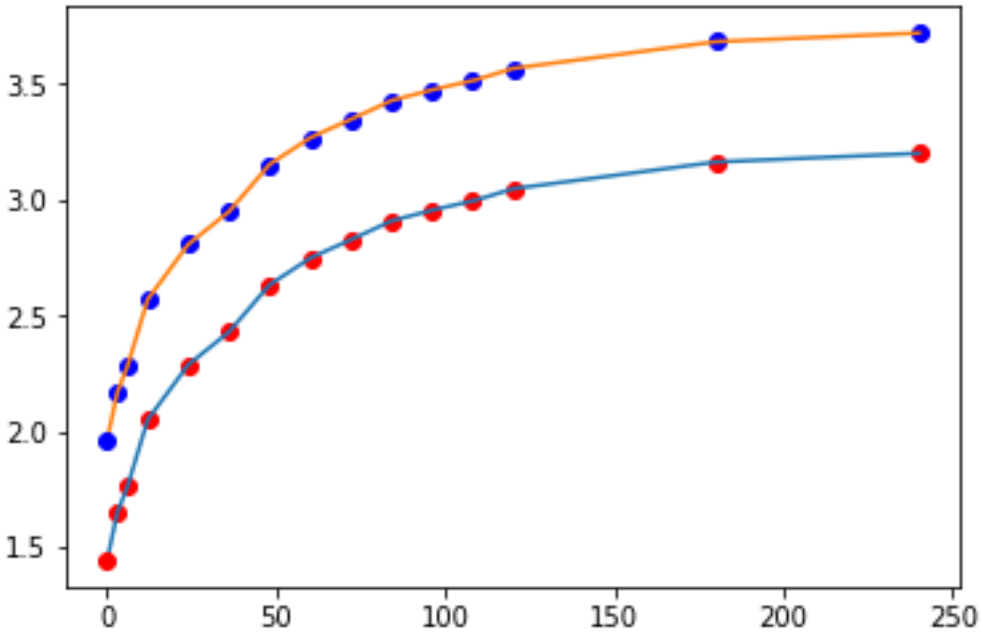

Figure 6. Original & Shifted Spot Rate Curve

Then, I got the price by discount the cashflows and sum it up.

Table III. Output of Price etc.

Price	$294,393,624.901
YTM	0.0314505402876
DV01	83833.0736154
Modified Duration	2.84765248037

The calculations of DV01 and Modified Duration are based a small movement in YTM and the corresponding price dollar change or percent change. The YTM I got for this security is about 3.15%. As shown in the table, DV01 is 83833 while Modified Duration is 2.85.

Question 4.

Generally, the information we got shows that when interest rate comes up, the PSA level comes down slightly, while the PSA level comes up significantly when interest rate level comes down. The reason is that many people still have to prepay their loan because of several reasons like moving or financial planning though the interest rate comes up. On the contrary, people tends to refinance at a lower interest rate when it comes down, so the PSA level increases significantly. To get a collective option, I **use the average value of PSA change with changing interest rate to evaluate it**.

Since I used 389 as my original PSA level, so the value change should not at the same level with a PSA about 100. Thus, I **assumed the percent change for PSA level is the same for the different banks and mine**. In order words, if their PSA increase from 100 to 120, which is 20%, my PSA will increase from 389 to 467.

Table IV. PSA Sensitivity with Interest Rate

Change	-300	-200	-100	-50	0	50	100	200	300
AVG	1162	898	351	186	130	109	98	89	86
Percent AVG	811.30%	557.39%	142.61%	21.74%	0.00%	-11.30%	-16.52%	-19.13%	-22.61%

4. 1 Changing by 50 Basic Points

Then, we calculate the change of DV01 and Modified Duration when the PSA changes. The output is shown in the Table IV:

Table V. DV01 and Modified Duration

Change	-100	-50	0	50	100
AVG	351	186	130	109	98
Percent AVG	1.7	0.431	0	-0.162	-0.246
My PSA	944.409	473.898	389.271	345.283	324.963
DV01	37404.7	**72574.6**	83833.1	**90728.4**	94197.3
Modified Duration	1.41118	**2.50015**	2.84765	**3.06062**	3.16783

As we can see, the DV01 of increasing 50 bps is 90728.4 and the Modified Duration in this case should be 3.06062. At the same time, the DV01 of decreasing 50 bps is 72574.6 and the Modified Duration would be 2.50015.

4. 2 Comments on Risk Characteristics

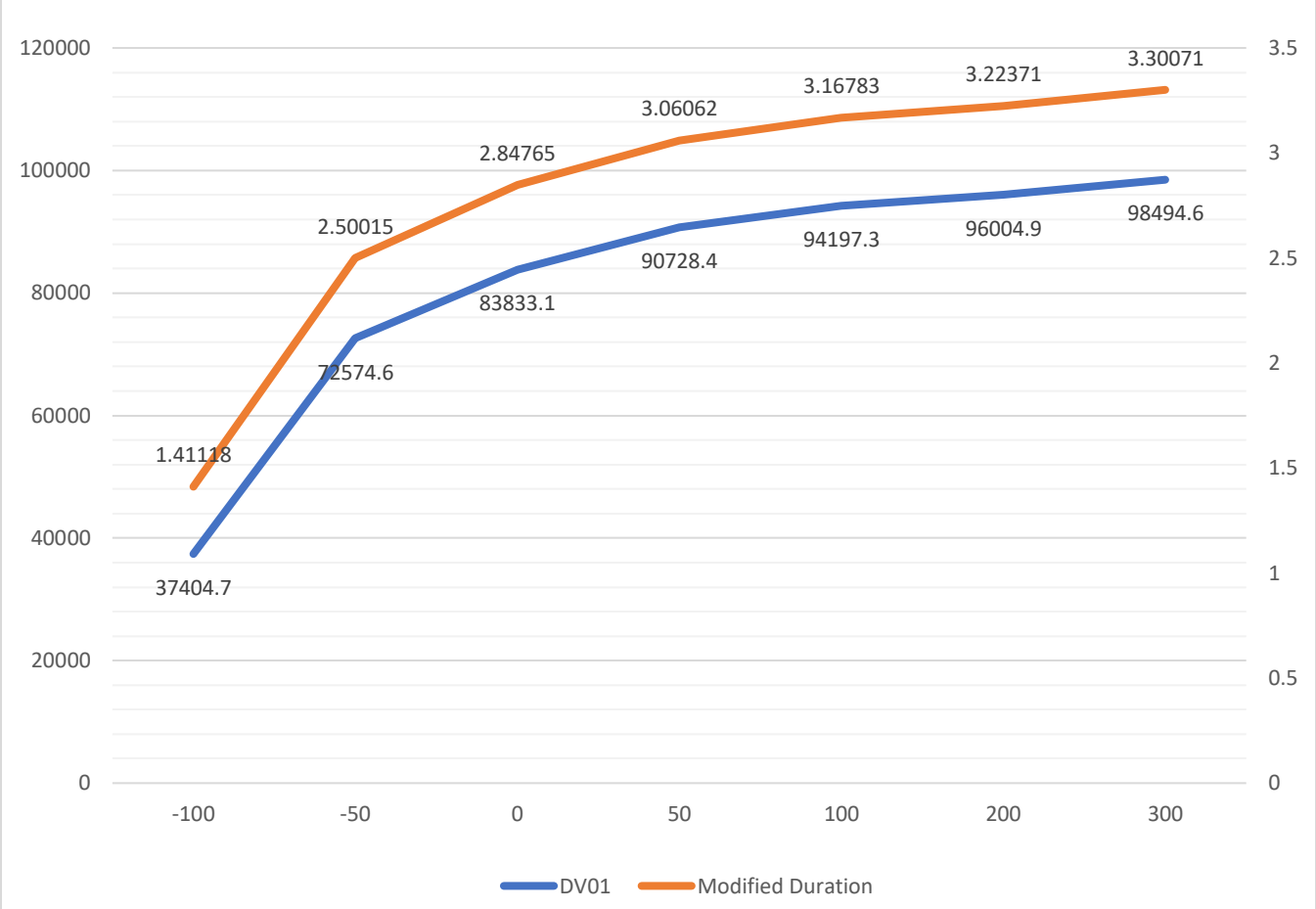

Figure 7. DV01 & Modified Duration

As we can see in Figure 7, the increase in interest rate will not change the DV01 and Duration level as large as the decrease do. When interest rate comes up as large as 300 basic points, the DV01 and Modified Duration just increase slightly. But when the interest rate comes down the DV01 and Modified Duration comes down dramatically because of lots of prepayment. Thus, **prepayment risk is significant when interest rate comes down**.

4. 3 Sudden Change by 2%

I think the local model, which is my model, can still perform well when rate suddenly come up for 2%, because the increase in interest rate won't change PSA level too much. As we can see in the former Figure 7, the Modified Duration would be 3.22371 and the DV01 would be 96004.9.

However, due to a large PSA level at the very beginning. The local approximation can hardly handle a large decrease in interest rate. A very large PSA can lead to a big CPR level, indicating investors will prepay all the loan within a period, which is shorter than the Weighted Average Month as 164. Thus, this model with PSA level at 389 can hard handle the situation properly.

If we insist on using the model, we will get the DV01 as 2658.29 when interest rate coming down 2%. Also, the Modified Duration would be 0.253077. Both these numbers are weird.