THE BANK OF NEW YORK MELLON

Memorandum

To: Model Validation Review Committee
Independent Model Validator: Mengmeng Fu
Model Name: QRM OCI (Model # 2122)
Model Owner:
Date: 05/29/2014

1. Executive Summary

a. Description of the Model

BNY Mellon was required to calculate OCI (i.e. Other Comprehensive Income) under four scenarios for CCAR exercise: Supervisory Baseline, Supervisory Adverse, Supervisory Severely Adverse and BHC Stress. The OCI is on the AFS (i.e. Available for Sale) investment portfolio and the derivatives held as cash flow hedges.

OCI was calculated as the sum of market value changes in the existing portfolio and new growth portfolio arising from the macro-economic value changes. The new growth portfolio consists of future reinvestments and forecasted incremental purchases.

Previously, the CCAR OCI was calculated using Black Rock Solutions analytics and Excel spreadsheets. However, the BlackRock platform cannot take in multiple interest rate changes overtimes. As a result, the interest rate scenarios are limited to instantaneous shocks at each tenor points. Also, due to BlackRock's limitation, a lot of simplified assumptions are made in future market value calculation and the mortgage rate and the credit spread were realized as two add-on components. Further, because the CCAR NII was modeled QRM, the reinvestment and incremental purchase assumptions are slightly different between CCAR NII and CCAR OCI. The detailed limitations could be found in validation report for CCAR OCI as of 12/31/2013 [1]. One level 2 issue was raised (issue #476) regarding these limitations.

It was then decided that the CCAR OCI model is to be moved on QRM platform. QRM model currently holds the BAU (business as usually) model for EVE (Economic Value of Equity) and NII (net interest income), as well as the CCAR NII forecasting.

QRM has the capability to take in market scnearios at different time steps and to automatically account for the outstanding balance increase/decrease due to principal pay-downs and bottom-up growth. It also has the capability to do full re-valuation at each future time step given the market rate and the portfolios at the corresponding time. The mortgage rate and the credit spread shocks are also directly realized in forecasting planning scenarios. The OCI is calculated based on the future market value report from QRM.

The validation was performed in parallel with the model development. Hence, feedbacks were given to the model developers directly and some of the issues are already addressed, especially the Level-1 issue on credit spread. The details could be found in Appendix C 'Validation Log'.

b. Model Purpose

The QRM OCI model is to replace the previous CCAR OCI model built on BlackRock Solution and Excel Spread sheet. It is to be used to calculate OCI (i.e. Other Comprehensive Income) under four scenarios for the 2015 CCAR exercise: Supervisory Baseline, Supervisory Adverse, Supervisory Severely Adverse, and BHC Stress.

c. Validation Scope

The following items are within the scope of the validation:

- Reviewed the methodology used and assessed the soundness of the assumptions used in this methodology
- Checked the accuracy of the model data, especially the newly implemented mortgage rates and credit spreads. The derivations of these two factors from CCAR scenarios, as well as their implementation in QRM platform, were all reviewed. The back-testing was performed on the 15Yr mortgage rate equations.
- Checked the calculation of the future market value (FMV) in QRM and the excel-based calculation file given QRM future market value report
- Reviewed the OCI differences introduced by the model change
- Performed sensitivity test (as well as a stress test on the 1st version of the model before level-1 issue was addressed)
- Performed Monte Carlo Simulation test in FMV environment
- Assessed the impacts for issues identified

The validation was performed in parallel with the model development. Feedbacks were given to the model owner directly. Model owner took actions to address these issues. Hence, there are multiple rounds of test results. In this validation report, unless specifically stated, the test results shown on the final model delivered as of 5/20/2014.

d. Impact of the model on BNY Mellon Assets/Liabilities

As of September 2013, there is $77 Billion AFS (Available for Sale) positions in the investment portfolio[1]; there are another $404 Million security hedges which are also covered by the OCI model. The before-tax OCI for all CCAR scenarios are:

[1] There are $2 Billion non-agency CMBS excluded from the OCI calculation due to a current level-2 issue with QRM platform.

Table 1: Before-Tax OCI for 2014 CCAR Scenarios

QRM OCI (ex CMBS)	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Supervisory Baseline	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Supervisory Adverse	(3,403)	(1,407)	(1,419)	(150)	493	416	757	483	108
Supervisory Severely Adverse	(1,811)	(421)	(336)	7	374	201	406	236	12
BHC Stress	(4,389)	(592)	92	565	543	41	393	127	97

e. Conclusion

Based on the model delivered to the validator as of 5/20/2014 which has addressed the Level-1 issue raised on credit spread, we raised four level-2 issues and two level-3 issues. Two level-2 issues should be addressed before CCAR 2015. One is on documentation, and the other is on CMBS positions; details in details in section 3.b 'Issues and Enhancements'.

The current model is good for use for all AFS investment portfolio positions and hedges, except account 'CMBS (Intex)'. If the level-2 issue on this CMBs account is not addressed before CCAR 2015, the non-agency CMBS OCI need to be calculated outside of the system and be added on to the overall OCI results.

2. Risks and Limitations

a. Standard Risks and Limitations of the Model

Because the CCAR OCI model is built on the QRM platform, it has the same limitation as the CCAR NII model. From the validation of CCAR NII in Dec. 2013, it was pointed that unemployment rate and exchange rate were not modeled. It was raised as an issue (Issue # 445) for the CCAR implementation of QRM; hence we did not raise it as a new issue for this model. The model owner has taken actions to configure QRM to incorporate FX shocks; the configuration is to be sent to the validator to close the issue on FX rates. For the OCI results shown in Table 1 (for CCAR 2014), it was decided that the FX shocks would not be applied right now, so that it would be consistent with the rest of CCAR 2014. For CCAR 2015, foreign exchange rate will be modeled in CCAR.

Currently, the QRM platform has an issue with the CMBS behavior model in the future market valuation environment so that an error returned for the account 'CMBS (Intex)'. The cause of the issue was identified and QRM is currently fixing this issue. Before this issue is addressed, this model cannot be used on 'CMBS (Intex)' account for OCI calculation.

OCI is unrealized gain or loss, i.e. the sum of market value changes in the existing portfolio and new growth portfolio arising from the macro-economic value changes. Thus, the quarter to quarter future market price change due to the outstanding balance change should be excluded

from OCI. However, QRM does not have the capability to distinguish the sources of the market value changes. In other words, market value change due to the change in the outstanding balance (i.e. $\text{Market Value}_{\text{Outstanding Balance Change from t}-1 \text{ to t}}$) cannot be directly excluded from the quarter to quarter market value changes. Currently, the methodology used the change in book value as an approximation for $\text{Market Value}_{\text{Outstanding Balance Change from t}-1 \text{ to t}}$. The validator think that this methodology has two issues: 1) face amount should be used instead of book value in this approximation; and 2) adjustment should also be made to address the situation that the investment portfolio be valued at discount in stressed scenario. Based on our test, we raised a level 2 and a level 3 issue correspondingly.

Last but not least, Monte Carlo simulation is used in future market value calculation as well. From previous validation for QRM [2], we know that it took at least 300 paths for the Monte Carlo simulation to converge. However if 300 paths is used in future value calculation, it will take 120-160 hours to finish one scenario since full revaluation is needed for every quarter (i.e. 9 times). QRM recommended that ‘‘clients with large Intex positions typically choose something between 10 and 50’. Right now, the model uses path number as 30; it is expected that the using 30 paths, some variances would be introduced. The validator performed a Monte Carlo simulation test on the market value calculation. For the 30 runs we did, the maximum and the minimum market value has a difference of $37MM. The OCI is the change in market value rather than the market value itself. We expect the variance of OCI given different random seeds would be smaller. However, the model owner should be aware that the currently calculated OCI number could be different, if a different random seed is used. We also recommend that that the model owner performed Monte Carlo simulation test on the OCI results if time allowed.

b. Conditions Where Model is “Inappropriate” for Use

Currently, the QRM platform has an issue with the CMBS behavior model in the future market valuation environment so that an error returned for the account ‘CMBS (Intex)’. The cause of the issue was identified and QRM is currently fixing this issue. Before this issue is addressed, this model cannot be used on ‘CMBS (Intex)’ account for OCI calculation.

3. Issues and Enhancements

a. LEVEL 1 - Outstanding Issues

None

b. LEVEL 2

1) CMBS: The model currently sent does not cover the non-agency CMBS account (which has a market value of $2 Billion as of 3Q2014). In the model development, it was found by the model owner that an error message was returned for the non-agency CMBS account ‘CMBS

(Intex)'. After a communication with QRM analysts, the model developer found that it was an issue with the QRM platform. QRM is currently taking actions to address this issue. It is expected that with Q2 release, this issue could be addressed. It should also be kept in mind that if this issue is not addressed before CCAR 2015, the non-agency CMBS OCI need to be calculated outside of the system and be added on to the overall OCI results.

Model Owner Response: QRM is currently taking actions to address this issue. It is expected that with Q2 release, this issue could be addressed. Thus, this issue is expected to be addressed before CCAR this year. ETA: 9/30/2014

2) Documentation: Based on our documentation review, the model owner should improve the model documentation as follows:
   - Describe the detailed setup needed on QRM platform to run the CCAR OCI on QRM. It should cover the activation of the credit pricing model, as well as the FMV setup provided by QRM;
   - Describe how credit spreads are derived from the CCAR scenarios provided by Federal Reserves and/or Moody's; such description should also cover the specific treatment for the MBS new volume and non-MBS new volume. The implementation of the credit spreads into QRM platform should also be described.
   - Describe how 15Yr and 20Yr Mortgage rates are derived given the 30Yr mortgage rates; its implementation in QMR platform should also be described;
   - Update the model document [14] to shows the new calculation equation for OCI given the QRM calculated future market value report. The appropriateness of the calculation should be given as well (especially on the normalization of the market value change);
   - After the sensitivity test by model owner was performed, the results should be analyzed and documented;
   - The procedures files in place should be updated to reflect the changes given that the OCI model switched from BlackRock platform to QRM platform.

   This issue has to be addressed before the implementation of this OCI model in CCAR 2015.

Model Owner Response: We are working on the model documentation right now. ETA: 6/30/2014

3) Sensitivity Test: According to 'CCAR 2014 Common Themes' from Federal Reserve regarding CCAR, it is stated that ([7], page 13):

   "*...Most notably, BHCs did not conduct sufficient sensitivity analysis duration model development, and instead relied on the model validation function to carry it out...*"

   In the development of this QRM OCI model, the model owner did not conduct sensitivity test either, the current sensitivity test performed in Test 3 were from the validator. We recommend the model owner further perform an extended sensitivity test with shocks on both side of the factors and with various latitudes of shocks.

Model Owner Response: We will perform such testing. ETA: 7/30/2014

4) Using Face Amount instead of Book Value in Market Value Change Normalization: The current model uses quarter-to-quarter book value change to remove the change in market value due to outstanding balance changes (called 'normalization of market value). However, in the forecasting procedure, the changes of the book value do not only arise from the outstanding balance change (i.e. amortization, prepayment, new purchase, reinvestment, etc.); the amortization or depreciation of premium / discount also contributes to the book value change. Hence, we recommend that the change of face amount to be used in the market value normalization, instead of book value, for investment portfolio positions. We assessed the impact of such change in Test 6. The results showed that the total before tax OCI would have an additional $550-$650MM losses (depending on scenarios).

Model Owner Response: In the extreme example where in a particular bond, the whole pool of mortgages defaults, with 50% recovery, face value will be zero and market value will be close to 50 cents. Thus, a large market value change will be realized. Book value, however, would account for recoveries, but potentially has other issues mentioned by validation. We need to investigate further. ETA: 7/30/2014

c. LEVEL 3

1) Investment Portfolio valued at discount: Currently in the market value normalization, the book value change is used as an approximation of the market value change due to outstanding balance change. This approximation is less accurate when the market value is far away from par. However, for Adverse and BHC scenarios, the investment portfolio will be valued more at a discount (less than 95 cents per dollar) for many quarters. The impact analysis showed that the OCI losses are overestimated as a result (Test 7). We recommend adding a ratio to the OCI calculation equation at account level (see equation (5)) to address this.

Model Owner Response: This question will be addressed together with Level-2 issue #4. ETA: 7/30/2014

2) MUNI Curve: In the review of the input data (section 6.c), we that the MUNI curve is using implied forward forecasting method, instead of applying shocks given the CCAR scenarios. Based on our test (Test 8), we can see that the Muni curve shocks given implied forward method are usually smaller than CCAR shocks except the Severely Adverse. Because the MUNI is used as the discount, the less the shock leads to the less decrease in market value; the OCI for the muni positions could be underestimated. We think it is better that the shock to the MUNI is derived from CCAR scenarios as all other curves. Because there are only $5.76 Billion muni positions (7.7% of the total investment portfolio), we raised this as a level

3 issue. We performed an analysis using data from 2008 to 2013 trying to link the MUNI curve with the Libor curve. For the short-end (i.e. 3M) of the curve, the Muni curve's quarterly change has a stronger relationship with the quarterly Libor rate change. For 5Y and 10Y, the relationships are stronger for the rate level. The model developer might consider building some similar statistic relationship between Muni and Libor.

Model Owner Response: We are to change the method of MUNI curve forecasting by this year's CCAR. ETA: 8/30/2014

d. Recommendation

1) Currently QRM does not have a tool or interface in place for the user to easily validate the future market value calculation function. Hence, the validator designed a series of tests based on the previously validated current value calculation functions and the future balance forecasting functions. However, we recommended that the implementation of future market value calculation be verified again once QRM has such direct tool or interface in place.

2) Monte Carlo simulation is used in future market value calculation as well. From previous validation for QRM [2], we know that it took at least 300 paths for the Monte Carlo simulation to converge. However if 300 paths is used in future value calculation, it will take 120-160 hours to finish one scenario since full revaluation is needed for every quarter (i.e. 9 times). QRM recommended that ''clients with large Intex positions typically choose something between 10 and 50'. Right now, the model uses path number as 30; it is expected that the using 30 paths, some variances would be introduced. The validator performed a Monte Carlo simulation test on the market value calculation. For the 30 runs we did, the maximum and the minimum market value has a difference of $37MM. The OCI is the change in market value rather than the market value itself. We expect the variance of OCI given different random seeds would be smaller. However, the model owner should be aware that the currently calculated OCI number could be different, if a different random seed is used. We also recommend that that the model owner performed Monte Carlo simulation test on the OCI results if time allowed.

e. Closed LEVEL 1 Issues

In the process of the validation, there were several issues identified related with the Credit Spread:

- The credit pricing model is not fully activated (as discussed in section 6.b)
- The credit spreads were not defined correctly (as discussed in section 6.c)

As a result, the validator observed strange results on both the sensitivity test results and the stress test result on the first version of model that the model developer sent over (details could be found in Appendix B). Specially, huge gain is observed in first quarter for stress scenario

which is designed by the model validator to approximate the severely adverse scenario. Thus, the validator raised a level 1 issue to the model owner.

The model owner took immediate actions to address this issue. The credit spreads were redefined (as discussed in more details in section 6.c) and the credit pricing model was fully activated (as discussed in more details in section 6.b). A newer version of the model was delivered to the model validator; we checked its implementation in Test 1. In Test 5, we compared the model results on Baseline before and after actions were taken to address this level 1 issue. We also reviewed the results for all four CCAR scenarios and assessed its appropriateness. The sensitivity test to credit spread was re-performed as well (Test 3).

Overall, we think the new model generates reasonable results. Thus, this Level 1 issue was addressed.

5. Review of Model Documentation for Compliance with Guidelines

The model owner has the model document for the CCAR OCI [14] and the model document for 2014 CCAR implementation in QRM [15]. However, the former does not covers the implementation of OCI on QRM platform and the latter described the implementation of CCAR on QRM platform but does not cover OCI calculation. The model calculation files are also provided [10][11][12][13].

The model owner should create model documents to cover the following specific for QRM based OCI:

1) Describe the detailed setup needed on QRM platform to run the CCAR OCI on QRM. It should cover the activation of the credit pricing model, as well as the FMV setup provided by QRM;
2) Describe how credit spreads are derived from the CCAR scenarios provided by Federeal Reserves and/or Moody's; such description should also cover the specific treatment for the MBS new volume and non-MBS new volume. The implementation of the credit spreads into QRM platform should also be described.
3) Describe how 15Yr and 20Yr Mortgage rates are derived given the 30Yr mortgage rates; its implementation in QMR platform should also be described;
4) Update the model document [14] to shows the new calculation equation for OCI given the QRM calculated future market value report. The appropriateness of the calculation should be given as well (especially on the normalization of the market value change);
5) After the sensitivity test by model owner was performed, the results should be analyzed and documented;
6) The procedures files in place should be updated to reflect the changes given that the OCI model switched from BlackRock platform to QRM platform.

Hence, we raised a level 2 issue on documentation. This issue has to be addressed before the implementation of this OCI model in CCAR 2015.

6. Validation Detail

a. Conceptual Framework and Assumptions

BNY Mellon was required to calculate OCI (i.e. Other Comprehensive Income) under four scenarios for CCAR exercise: Supervisory Baseline, Supervisory Adverse, Supervisory Severely Adverse a d BHC Stress. The OCI is on the AFS (i.e. Available for Sale) investment portfolio and the derivatives held as cash flow hedges.

Many model limitations were identified in the previous CCAR OCI model built on BlackRock Solution and Excel Spreadsheet platform [1]. The model owner built a new model on QRM platform and planned to use this new model for 2015 CCAR. The model validator started validating the model while the model development kept rolling forward. Thus, the model developer could address issues raised by the validator before the finalization of the model.

QRM model currently holds the BAU (business as usually) model for EVE (Economic Value of Equity) and NII (net interest income), as well as the CCAR NII forecasting. QRM has the capability to take in interest rate curves at different time steps and to automatically account for the outstanding balance increase/decrease due to principal pay-downs and bottom-up growth. It also has the capability to do full re-valuation at each future time step given the market rate and the portfolios at the corresponding time. The mortgage rate and the corporate bond (i.e. credit spread) shocks are also directly realized in forecasting planning scenarios.

The CCAR OCI model delivered to the Model Risk Management Group is on CCAR 2014 (i.e. 3Q13 portfolio). It uses the same instrument modeling and the behavior assumptions models as the BAU QRM estimation [2]; it also shares the forecasting scenarios (which hold the forecasts for interest rates and macro-economic variables) and the planning strategies (which hold the balance sheet forecast under difference scenarios) as the CCAR NII forecasting [3].

For each of the nine quarters, QRM takes the macro-economic rates (e.g. HPI, Libor rates, mortgage rates and corporate bond rates) from the input forecasting scenarios for the corresponding quarter to calculate the market value of the outstanding balances, at the end of the quarter. The outstanding balances of each quarter changed based on 1) scheduled/unscheduled principal payment given the macro-economic scenarios (from the forecasting scenarios); 2) reinvestment/incremental purchase from the planning strategies.

The quarter to quarter future market price change from QRM cannot be directly used as the OCI. This is because OCI is unrealized gain or loss, i.e. the sum of market value changes in the existing portfolio and new growth portfolio **arising from the macro-economic value changes.** However, the quarter to quarter future market price change also includes the market price change due to the increase/decrease in the outstanding balance.

Hence, the OCI should be calculated as:

$$OCI_t = [MarketValue_t - MarketValue_{t-1}] - Market\ Value_{Outstanding\ Balance\ Change\ from\ t-1\ to\ t} \quad (1)$$

However, QRM does not have the capability to distinguish the sources of the market value changes. In other words, $Market\ Value_{Outstanding\ Balance\ Change\ from\ t-1\ to\ t}$ cannot be estimated. This is a model limitation. As a result, the OCI for each quarter t is calculated as:

$$\begin{aligned} OCI_t &= [MarketValue_t - MarketValue_{t-1}] - [BookValue_t - BookValue_{t-1}] \\ &= [MarketValue_t - BookValue_t] - [\ MarketValue_{t-1} - BookValue_{t-1}] \end{aligned} \quad (2)$$

In equation (2), the component $[BookValue_t - BookValue_{t-1}]$ is to exclude the market price changes caused by the change of outstanding balance, i.e. it is used as an approximation for $Market\ Value_{Outstanding\ Balance\ Change\ from\ t-1\ to\ t}$.

However, the validator thought it is more appropriate to use the outstanding balance change (i.e. QRM field 'face amount') for the investment portfolio positions. In QRM,

$$\begin{aligned} EndingFaceAmount_t = {} & Beg.FaceAmount_t \\ & -Scheduled\ Principal\ Payment\ (i.e.amortization\ and\ maturity) \\ & -Unscheduled\ Principal\ Payment\ (i.e.prepayment\ and\ default) \\ & +New\ Volume\ (i.e.reinvestment\ and\ incremental\ purchase) \end{aligned} \quad (3)$$

Hence, we can see that all these items that contribute to the face amount changes should be excluded from the OCI calculation. On the other hand, there are additional items contributes to the book value changes in QRM report, e.g. amortization/depreciation of premium. Hence, we recommend that for investment portfolio, equation (2) should be replaced by equation (4)

$$\begin{aligned} OCI_t &= [MarketValue_t - MarketValue_{t-1}] - [FaceAmount_t - FaceAmount_{t-1}] \\ &= [MarketValue_t - FaceAmount_t] - [\ MarketValue_{t-1} - FaceAmount_{t-1}] \end{aligned} \quad (4)$$

It should be noticed that for the security hedging positions, equation (2) should be used instead of equation (3). This is because security hedging positions are all swaps; for QRM instrument Swap, the 'face amount' is the notional amount, rather than the outstanding balance.

In Test 6, we assessed the impact of using face amount change instead of book value change in the OCI calculation for the investment portfolio. The result showed that if face amount is used instead of book value to normalize the market value change, the total before-tax OCI over the nine quarters will have additional $550-650MM losses given different CCAR scenarios. We raised this as a level-2 issue.

Still, no matter whether face amount or book value is used to normalize the market value change, it is an approximation of $Market\ Value_{Outstanding\ Balance\ Change\ from\ t-1\ to\ t}$. This approximation is less accurate when the market value is far away from par. In the following Table 2, we checked the ratio between market value and book value for the investment portfolio

over the nine quarters for all of the four scenarios. We could see that for Adverse and BHC scenarios, there are situations when 1 dollar in book value is less than 95 cents in market value. Similar results are observed between the market value and the face amount.

Table 2: Ratio of Market Value over Face Amount, from 3Q13 to 4Q15

Baseline	**3Q13**	**4Q13**	**1Q14**	**2Q14**	**3Q14**	**4Q14**	**1Q15**	**2Q15**	**3Q15**	**4Q15**
Market Value ($MM)	74,995	75,728	83,836	91,852	93,666	93,849	92,976	92,148	91,196	90,601
Book Value ($MM)	74,487	75,731	84,289	92,825	94,992	95,384	94,857	94,177	93,403	93,078
Market Value/Book	1.0068	1.0000	0.9946	0.9895	0.9860	0.9839	0.9802	0.9785	0.9764	0.9734
Face Amount ($MM)	74,358	75,714	84,412	93,054	95,242	95,650	95,159	94,528	93,807	93,526
Market Value/Face	1.0086	1.0002	0.9932	0.9871	0.9835	0.9812	0.9771	0.9748	0.9722	0.9687
Adverse	**3Q13**	**4Q13**	**1Q14**	**2Q14**	**3Q14**	**4Q14**	**1Q15**	**2Q15**	**3Q15**	**4Q15**
Market Value ($MM)	74,995	71,712	78,801	86,134	88,767	90,032	90,572	91,303	91,587	91,721
Book Value ($MM)	74,487	75,773	84,648	93,700	96,489	97,196	97,224	97,066	96,740	96,730
Market Value/Book	1.0068	**0.9464**	**0.9309**	**0.9193**	**0.9200**	**0.9263**	**0.9316**	**0.9406**	**0.9467**	**0.9482**
Face Amount ($MM)	74,358	75,760	85,054	94,562	97,418	97,983	97,859	97,580	97,179	97,148
Market Value/Face	1.0086	0.9466	0.9265	0.9109	0.9112	0.9188	0.9255	0.9357	0.9425	0.9441
Severely Adverse	**3Q13**	**4Q13**	**1Q14**	**2Q14**	**3Q14**	**4Q14**	**1Q15**	**2Q15**	**3Q15**	**4Q15**
Market Value ($MM)	74,995	74,956	82,543	90,387	92,824	93,707	93,510	93,421	93,000	92,830
Book Value ($MM)	74,487	75,217	83,453	91,750	94,273	94,687	94,356	93,877	93,283	93,095
Market Value/Book	1.0068	0.9965	0.9891	0.9851	0.9846	0.9896	0.9910	0.9951	0.9970	0.9972
Face Amount ($MM)	74,358	75,186	83,752	92,348	94,943	95,325	94,955	94,443	93,835	93,621
Market Value/Face	1.0086	0.9970	0.9856	0.9788	0.9777	0.9830	0.9848	0.9892	0.9911	0.9915
BHC	**3Q13**	**4Q13**	**1Q14**	**2Q14**	**3Q14**	**4Q14**	**1Q15**	**2Q15**	**3Q15**	**4Q15**
Market Value ($MM)	74,995	68,927	67,652	66,942	65,781	66,537	66,745	67,173	67,264	67,686
Book Value ($MM)	74,487	73,434	72,699	71,769	69,989	70,001	70,156	70,176	70,126	70,436
Market Value/Book	1.0068	**0.9386**	**0.9306**	**0.9327**	**0.9399**	0.9505	0.9514	0.9572	0.9592	0.9610
Face Amount ($MM)	74,358	73,422	72,758	71,895	70,178	70,249	70,449	70,514	70,520	70,871
Market Value/Face	1.0086	0.9388	0.9298	0.9311	0.9373	0.9472	0.9474	0.9526	0.9538	0.9551

Right now, in most cases $[BookValue_t - BookValue_{t-1}]$ is positive; thus from equation (2) we can tell that the current approximation overestimate the OCI losses by ignoring the fact that the investment portfolio will be valued at discount given stressed scenarios. We performed an impact analysis (Test 7) by calculating the OCI as follows:

$$OCI_t = \sum_K OCI_{t,account\ K} \quad (5)$$

Where,

$$OCI_{t,account\ K} = \left[MarketValue_{t,account\ K} - MarketValue_{t-1,account\ K}\right] - \left[BookValue_{t,account\ K} - BookValue_{t-1,account\ K}\right] \times \frac{MarketValue_{t,account\ K}}{BookValue_{t,account\ K}}$$

Test 7 showed that in all four scenarios, the OCI loss will decrease if equation (5) were used instead of equation (2); we raised this as a level 3 issue of the model.

The OCI from equation (2) are before tax; the tax rate will be applied to get the after-tax OCI, i.e.

$$After - Tax\ OCI_t = (1 - Tax\ Rate) \times Before - Tax\ OCI_t \quad (6)$$

The model currently sent does not cover the non-agency CMBS account (which has a market value of $2 Billion as of 3Q2014). In the model development, it was found by the model owner that an error message was returned for the non-agency CMBS account 'CMBS (Intex)'. After a communication with QRM analysts, the model developer found that it was an issue with the QRM platform. The 'CMBS (Intex)' account use QRM's behavior model for CMBS behavior. The QRM CMBS behavior model DLL performs a check to see if historical files are more than two months older than the portfolio as-of date. The problem arises in that the new volumes occurring more than two months past the final date in the historical files. In this case, QRM incorrectly pass the origination date (of the new volume) instead of the portfolio as-of date. Thus, whenever there is new volume that calls a QRM behavioral model more than two months after the final history date in the text files the model will receive this error. QRM is currently taking actions to address this issue. It is expected that with Q2 release, this issue could be addressed. We raised this as a level-2 issue for the model; it should also be kept in mind that if this issue is not addressed before CCAR 2015, the non-agency CMBS OCI need to be calculated outside of the system and be added on to the overall OCI results.

Because the CCAR OCI model is built on the QRM platform, it has the same limitation as the CCAR NII model. From the validation of CCAR NII in Dec. 2013, it was pointed that unemployment rate and exchange rate were not modeled. It was raised as an issue (Issue # 445) for the CCAR implementation of QRM; hence we did not raise it as a new issue for this model. The model owner has taken actions to configure QRM to incorporate FX shocks; the configuration is to be sent to the validator to close the issue on FX rates. For the OCI results shown in Table 1 (for CCAR 2014), it was decided that the FX shocks would not be applied right now, so that it would be consistent with the rest of CCAR 2014. For CCAR 2015, foreign exchange rate will be modeled in CCAR.

Last, the current QRM model does not have default behavior model; this is a level 2 issue on the QRM model [2]. However, this does not affect the OCI. OCI is the unrealized gain/loss. The defaults are realized losses which are captured in the OTTI. The credit risk in OCI is captured though the credit spread, rather than the default model. Thus we don't think this is a model issue or limitation for OCI model.

b. Code Review

QRM is a vendor based system; we do not have access to its codes. The code review of the future market value calculation is realized through implementation test.

Besides QRM's code, the customization of QRM is also part of the code review. Because all the other customization setup has been reviewed as part of QRM validation [2], we covered specifically the customization setup for future market value calculation. QRM gives a very detailed setup steps for calculating market value, we reviewed the current setups step by step following QRM guidance (please see Appendix A).

Later, from the sensitivity test and stress test (see Appendix B), the validator noticed that the credit spreads are not implemented correctly; as a result, the stressed scenario has less OCI loss than the base scenario. With several rounds of conversation with QRM, the cause of the issue was identified. Several setups needed to be activated for the QRM OCI run:

- Activate 'Credit Spread - Credit Pricing Model' in the definition of each product;
- Activate 'Enable spreads during analysis cycles' in Run Parameters definition;
- Activate 'Include OAS in call decision' in Run Parameters definition.

These setups are not listed in QRM guidance (Appendix A) because they are more related with credit spread modeling, rather than the future market value. We also found that the credit spread is not modeled correctly given the current CCAR scenarios. As a result, a level-1 issue was raised on credit spread. This is a level-1 issue because the OCI results are not reasonable based on the stress testing results.

The model owner took actions immediately. The QRM setups were changed and the model developer also changed the method used to define the credit spread to be used in the OCI model (detailed in section 6.c). After both changes were made, the model results now look reasonable (as shown in Test 5); hence this level 1 issue is addressed and closed.

We performed the implementation test (Test 1) based on the new model after this Level 1 issue was addressed. We also reviewed the spreadsheet [10][11][12][13] which used QRM's 'Future Market Value' report to calculate the OCI. The calculation is consistent with equation (2).

Hence, the code review is satisfactory now.

c. Accuracy and Appropriateness of Input Data, Data Cleaning and Verification

The OCI calculation used the same portfolio data, market data, and forecasting (CCAR) investment strategy. We validated this as part of the CCAR NII validation on QRM platform for 2014 CCAR [3].

The CCAR OCI model also used the same yield curves and HPI as that was validated in 2014 CCAR NII [3]. However, we found that the setup used for MUNI is not appropriate for OCI purpose. Currently, the forecasting of the MUNI curve is based on 'implied forward method'. This is because CCAR QRM OCI inherits the market curve setup from CCAR QRM NII forecasting. However, MUNI curve is not used in CCAR NII calculation since all these positions are fixed-rate and the interest income rate is input rather than derived from the MUNI curve. However, the OCI calculation would use the MUNI curve since it is a discount curve and the OCI is based on market value change.

As we know, the implied forward curve will usually be pretty steep thus generate high rates. In Test 8, we compared the MUNI curve shocks (based on implied forward) with the Libor curve shock under each scenario at 4Q13, 4Q14 and 4Q15 under each scenario. The results showed

that the Muni curve shocks are smaller than all curves except for Severely Adverse in 4Q13, Severely Adverse and BHC in 4Q14 and 4Q15. Because the MUNI is used as the discount, the less the shock leads to the less decrease in market value; the OCI for the muni positions could be underestimated. We think it is better that the shock to the MUNI is derived from CCAR scenarios as all other curves. Because there are only $5.76 Billion muni positions (7.7% of the total investment portfolio), we raised this as a level 3 issue.
Besides, the model owner further implemented credit spread and mortgage rate into QRM platform CCAR. We reviewed how the mortgage rates and credit spreads are implemented.

1) Mortgage Rate

On QRM platform, mortgage rate could affect the prepayment speed of the MBS products; the mortgage rate required are 15Yr mortgage rates, 20Yr mortgage rate and 30Yr mortgage rate, for underlying mortgage collateral pools with different maturities. In CCAR scenarios, Federal Reserve only provides the 30Yr mortgage rates. Hence, the model owner needs to model the 15Yr mortgage rates and 20Yr mortgage rate from the 30Yr.

ADCo provides a linear function to derive 15Yr rates from 30Yr rates:

pmtg_15[i] = 1.0637 * pmtg_30[i] - 0.9151 (7)

There is no information available regarding how this equation is derived. From its format and the coefficients, this is likely to be from the linear regression. We did a back-testing between the modeled 15Yr mortgage rate and the actual mortgage rate (Test 9). The test results showed the equation models the 15Yr mortgage rate pretty good. The 20Yr mortgage rates were linearly interpolated between the 15Yr rate and the 30Yr rate.

In QRM, these mortgage rates were input into the indexes '30Y Mortgage', '20Y Mortgage' and '15Y Mortgage' in the (CCAR) planning forecasting scenarios.

One thing to notice is that these mortgage rates are not used in the discounting of the mortgage related products; the credit spread shocks derived from the corporate bond rates are used to capture the widening of the spread. Both the model developers and the model validator have considered whether it would be better to shock the spread for the mortgage rate based on the mortgage rates. After the discussion, the model validator believed that the current practice is reasonable. Conceptually, the BBB corporate rate is more used for discounting while the mortgage rate is quoted for coupon payment, rather than valuation purpose.

Hence, we think the current practice of mortgage rates in the model is reasonable.

2) Credit Spread

The credit spread is derived from the spread between the corporate bond BBB rates and the 10-year Treasury rates; it is used to capture the credit spread widening under stressed scenarios.

The credit spreads for other ratings will be derived based on multipliers. This set of multipliers is used in CCAR 2014 practice.

AAA to AA-	42.95%
A+ to A-	61.23%
BBB+ to BBB-	100.00%
BB+ to BB-	204.73%

Such spreads will be applied to each position based on its rating. For new volumes, it is assumed to be AA rating. This is because as of 3Q14, the majority of the investment portfolio is AAA or AA rating.

AAA	AA	A	Other
18.98	63.31	16.42	1.28

When we reviewed the definition of credit spread input into QRM for the version 1 model (i.e. the model delivered in April, before credit spread Level-1 issue was addressed), we noticed that the credit spread for each of the 9 quarters were directly used, i.e.

Credit Spread[i] =Multiplier * (BBB Corporate Bond Rate [i] – Treasury 10Y Rate [i]) (7)

However, this method has an issue. For the current investment portfolio as of 3Q13, the market prices are all input; thus, OAS/MTM spreads are derived in the current valuation process. Such OAS/MTM spreads are used in the future market value calculation process for the existing volume. Thus, the discount rate for these existing volumes in future market value calculation will be:

Discount Rate [i] = Underlying Yield Curve [i] + Credit Spread[i] +MTM Spread (8)

However, these credit spreads are not used when these OAS/MTM spreads are derived in the current valuation process, i.e.

Discount Rate [0] = Underlying Yield Curve [0] +MTM Spread (9)

In other words, there is a double-counting for spread in equation (8) and thus driving the discounting rate too high in the future market value calculation.

Besides the double-counting issue for the existing volume credit spread, there is another issue for the credit spread of the new volume in MBS product. As the new volumes are all assumed to be AA-rated, it is reasonable to use the credit spread in discounting, i.e.

Discount Rate [i] = Underlying Yield Curve [i] + Credit Spread[i] (10)

However, for MBS product, its spread is actually OAS spread. Looking at the current MTM spread for the MBS product and the current AA spread, we will find that the difference are pretty large, i.e. 37 bps vs. 95bps. The MBS products are the biggest component of the investment portfolio; some specific treatment for it is more preferable.

As stated in section 6.b and Appendix B, back then we also found errors in QRM credit spread setup which made the sensitivity of the model to credit spread unreasonable and would make the OCI results unacceptable (i.e. resulting in huge OCI gain in stressed scenario). As a result, we decided to raise a level-1 issue on the model on the credit spread that:

- The credit pricing model is not fully activated
- The credit spreads were not defined correctly (as discussed in section 6.c)

The model owner took immediate actions to address this level-1 issue. The QRM setups were fixed to fully activate the credit pricing model (as discussed in section 6.b) and the credit spreads are redefined as follows.

i. For Existing Positions

Because the OAS/MTM spreads are derived in the current valuation process. In the CCAR implementation, only the widening/narrowing of these spreads should be captured. Thus, widening of the spreads for each scenario is calculated as:

Shocks to Credit Spread[i] =Multiplier * (Credit Spread [i]-Credit Spread [3Q13]) (11)

Here, the credit spread is the spread between BBB corporate rate and the 10-year Treasury rate.

ii. For MBS New Volumes

It is assumed that the MBS OAS of the current portfolio will stay at the same level, as currently assumed for the existing MBS positions. Thus, its credit spread will be:

Credit Spread [i]_MBS_NewVolume = MBS OASpread [3Q13] + Shocks to Credit Spread[i]_AA (12)

Here, the shock to AA rating is used because it is assumed that all new volume is rated AA.

iii. For Non-MBS New Volumes

It is assumed that all new volume will be AA rated; thus the credit spread will be:

Credit Spread [i]_Non-MBS_NewVolume
= AA Credit Spread [3Q13] + Shocks to Credit Spread[i]_AA (13)

We think these new credit spread definitions are reasonable. We also reviewed how they are realized into QRM platform. In the credit spread tree, two more ratings are given besides the normal AAA to BB rating. The two new ratings are called 'AA_Mortgage' and 'AA_New Vol' respectively. For AAA to BB rating, the shocks to credit spreads from equation (11) is used; for 'AA_Mortgage', the credit spread from equation (12) is used and for 'AA_New Vol' equation (13) is used. When new volumes are generated, the model will assign 'AA_Mortgage' for MBS

products and ‘AA_New Vol’ for others. Thus, these credit spreads will be assigned correctly in the discounting procedure. We think this practice is solid.

d. Tests Used

A series of tests were performed in the validation; here we briefly discussed the purpose of the test, the method used the test results. The details could be found in section 6.e (Test Results).

1) Implementation Test

The implementation is divided into two parts; the first part is to verify QRM's calculation for the future market value (FMV) and the second part is to verify the calculation of OCI given QRM's FMV results.

The test result is satisfactory.

2) Model Change Impact Analysis

The purpose of this test is to check the OCI changes introduced by this new model. The model owner performed the test on the before-tax OCI results for each CCAR 2014 scenario given the portfolio as of 3Q14 [8]. This test not only assessed the model change impact; thus in 2015 CCAR procedure, the model owner could know better the difference in OCI due to the scenario differences, rather than model changes.

Overall, we think that the test results look reasonable.

3) Sensitivity Test

The model validator performed the sensitivity tests for model validation. The sensitivity test was performed on the baseline scenario. The purpose of the sensitivity test is to assess the sensitivity of the OCI results to the risk factors. In the test, we covered the following factors in the model:

- Yield Curve: Parallel shift all yield curves by 50bps;
- Credit Spread: Parallel increase all credit spread by 50bps;
- Mortgage Rate: Parallel increase mortgage rate by 50bps;
- HPI: decrease HPI by relatively 5%;
- Incremental investment amount: increase the incremental Investment amount (i.e. new purchase) by 5%.

The test results showed that the yield curve and the credit spread are the two main drivers of the OCI. This is because these two factors drive the discount rate to be used in the valuation process.

The mortgage rate and HPI has little impacts on the OCI result. This is because they only affect the prepayment speed of the MBS products. In other words, they only affect the outstanding balances. The OCI calculation excludes the market value change due to the outstanding balance change. Hence, such result is as expected.

The OCI is lease sensitive to the incremental amount change. . This is as expected since the incremental amount will only affects the new volume to be added to the portfolio.

According to 'CCAR 2014 Common Themes' from Federal Reserve regarding CCAR, it is stated that ([7], page 13):

> *"...Most notably, BHCs did not conduct sufficient sensitivity analysis duration model development, and instead relied on the model validation function to carry it out..."*

In the development of this QRM OCI model, the model owner did not conduct sensitivity test either, we raised this as a level 2 issue.

4) MC Convergence Test

This test is performed to check what kind of variance will be introduced by using only 30 paths in the future market value calculation.

From previous validation for QRM [2], we know that it took at least 300 paths for the Monte Carlo simulation to converge. However if 300 paths is used in future value calculation, it will take 120-160 hours to finish one scenario since full revaluation is needed for every quarter (i.e. 9 times). QRM recommended that ''clients with large Intex positions typically choose something between 10 and 50'. Right now, the model uses path number as 30; it is expected that the using 30 paths, some variances would be introduced. The validator performed a Monte Carlo simulation test on the market value calculation. For the 30 runs we did, the maximum and the minimum market value has a difference of $37MM. The OCI is the change in market value rather than the market value itself. We expect the variance of OCI given different random seeds would be smaller. However, the model owner should be aware that the currently calculated OCI number could be different, if a different random seed is used. We also recommend that that the model owner performed Monte Carlo simulation test on the OCI results if time allowed.

5) Impact Analysis – Addressing Level 1 Issue on Credit Spread

This test is performed to illustrate the differences on the OCI results after the Level 1 issue identified in the validation process was addressed.

In the process of the validation, there were several issues identified related with the Credit Spread:

- The credit pricing model is not fully activated
- The credit spreads were not defined correctly (as discussed in section 6.c)

As a result, the validator observed strange results on both the sensitivity test results and the stress test result on the first version of model that the model developer sent over (details could

be found in Appendix B). Specially, huge gain is observed in first quarter for stress scenario which is designed by the model validator to approximate the severely adverse scenario. Thus, we raised a level 1 issue to the model owner. The model owner took immediate actions to address this issue. The credit spreads were redefined (as discussed in more details in section 6.c) and the credit pricing model was fully activated (as discussed in more details in section 6.b). A newer version of the model was delivered to the model validator.

In the test we compared the baseline results before and after the issue addressed. We also analyzed the 4 CCAR scenarios given the new model. Overall, we think the test results are satisfactory.

6) Impact Analysis – face vs. book

In the review of the methodology, the model validator recommended that face amount should be used instead of book value to normalize the market value change. This test was performed to assess the impact of such change.

From the test, we concluded that if we used face amount instead of book value to normalize the market value change, the total before tax OCI would have an additional about $550-650MM losses (depending on scenarios). We raised this as a level 2 issue.

7) Impact Analysis – Investment Portfolio Valued at Discount

In the review of the methodology, the validator pointed out that the current methodology is assuming that the investment portfolio is valued closed at par; however, in the stressed scenarios (especially Adverse and BHC), the investment portfolio is valued at discount (less than 95%) for many quarters. Hence, the validator recommended a ratio to be applied to address this situation; an equation (5) was given.

This test was performed to assess the impact of such change. From the test, we concluded that for all scenarios, the OCI loss will decrease if equation (5) is used instead of the current method This is because right now, in most cases $[BookValue_t - BookValue_{t-1}]$ is positive; thus in equation (2), the current approximation overestimate the OCI losses by ignoring the fact that the investment portfolio will be valued at discount given stressed scenarios. We raised this as a level 3 issue.

8) Curve comparison – Muni vs. Libor

In the review of the input data (section 6.c), the validator pointed out that the MUNI curve is using implied forward forecasting method. In the test, we compared the MUNI curve shocks (based on implied forward) with the Libor curve shock under each scenario at 4Q13, 4Q14 and 4Q15 under each scenario.

From the results, we can see that the Muni curve shocks are smaller than all curves except for Severely Adverse in 4Q13, Severely Adverse and BHC in 4Q14 and 4Q15. Because the MUNI is used as the discount, the less the shock leads to the less decrease in market value; the OCI for the muni positions could be underestimated. We think it is better that the shock to the MUNI is derived from CCAR scenarios as all other curves. Because there are only $5.76 Billion muni positions (7.7% of the total investment portfolio), we raised this as a level 3 issue.

The validator also did an analysis based using data from 2008 to 2013, using the rate level as well as the rate quarterly change for 3M, 5Y and 10Y respectively. The test results are shown in table E.10 below. We can see that for the short-end (i.e. 3M) of the curve, the Muni curve's quarterly change has a stronger relationship with the quarterly Libor rate change. For 5Y and 10Y, the relationships are stronger for the rate level. The model developer might consider building some similar statistic relationship between Muni and Libor.

9) Back-testing on 15Yr Mtg. Rate

The model owner used an equation provided by ADCo to model 15Yr mortgage rate from 30Yr mortgage rate. The test is performed to review the back-testing on this equation. We used Freddie Mac PMMS rate as the mortgage rates. The modeled 15Yr mortgage rates were compared with the actual 15Yr mortgage rate from Jan. 2001 to Apr. 2014. Overall, we think the modeled rate follow the trend of the actual rate and the differences are relatively small. Hence, we think the function is satisfactory.

e. Test Results

1) Implementation Test

The implementation can be divided into two parts; the first part is to verify QRM's calculation for the future market value (FMV) and the second part is to verify the calculation of OCI given QRM's FMV results.

1.1) Implementation Test- FMV calculation

The valuation functions and the future balance forecasting functions of QRM were all validated in the QRM validation [2]. However, the future market value calculation is one step forward; it calculates the market values as of each quarter given the forecasted balanced and the input market data as of the corresponding quarter. The calculation is performed at bucket level[2] and is reported at account level.

According to communication with QRM analysts, currently QRM does not have a tool or interface in place for the user to easily validate the future market value calculation function. Hence, the validator has to design the test ourselves. Because the current value calculation function and the future balance forecasting functions were already developed, we developed the test based on these two functions. We setup a portfolio in the 'current' environment and input a market in the 'current' environment; then we setup the 'current' date to be the future date and let the market data to be those from the corresponding future date. In other words, we used the current value calculation function to check the future value calculation function.

However, to do this at the portfolio level, there are two limitations:

- For investment portfolio, the market prices are input for each position; an MTM spread is generated in current valuation process for each position and this position will use the same MTM for market value calculation in the future valuation process. In other words, the market value in the current valuation process always equals to the input market price multiplies the outstanding balance.
- The outstanding balances, though reported in account level, are projected based on bucket level. In other words, the outstanding balance (i.e. field 'face amount' in QRM) ideally should be adjusted at CUSIP level rather than account level, when the future portfolio level is input into 'current' valuation process environment.

QRM analysts confirmed that such limitations could be not address at portfolio level (when there is hundreds of thousands of positions); they suggested pick several CUSIPs to perform the implementation test. However, the validator thought it is necessary to cover the entire OCI portfolio (i.e. AFS investment portfolio + security hedge portfolio). Thus, we decided to do the

[2] The bucket is defined in the stratification specification set for each account; for investment portfolio accounts, it is usually at CUSIP level.

calculation using the following method. The future market value of each account calculated in the 'current' environment is as:

$$FMV_t = EconomicValue_t \times \frac{MarketValue_0}{EconomicValue_0} \times \frac{FaceAmount_t}{FaceAmount_0} \quad (9)$$

Where,

1. FMV_t is the future market value of the account at time t, calculated in the current valuation process environment.
2. $MarketValue_0$ is the market value of the account as of now (i.e. 3Q2013).
3. $EconomicValue_0 / EconomicValue_t$: Economic value is the discounted value of the cash flows, without the MTM spread. The discount factors are based on the input underlying interest rate curve for the 'current' market. $EconomicValue_0$ is the economic value of the account as of now (i.e. 3Q2013); $EconomicValue_t$ is the economic value of the account given the interest rate curve as of time t.
4. $FaceAmount$is the outstanding balance of account as of now and as of time t respectively.

The economic values and market values are from QRM valuation report 'Market Value and Exposure Derivatives.xlsm' for each of the future quarters input in the 'current' environment. The face amounts are from QRM forecast planning report 'Forecast Audit.xlsm'. Used the calculated $FMV_t$for each quarter, we did the comparison with the future market value from QRM FMV report 'Future Market Value.xlsm', at account level.

The comparisons were performed for three quarters: 4Q13, 4Q14 and 4Q15, to be the representative as short-term, mid-term and long-term FMV calculation in the CCAR process. When we looked at the results, we set the threshold to be 1) difference larger than 1%; or 2) difference larger than $10MM for each account at any quarter. The detailed comparison results for each quarter at each quarter could be found in 'Future Market Value Comparision.xlsx'.

The results showed that the following accounts in table E.1 exceeded the threshold in one or more quarters. This was mostly due to the fact that in equation (5) we used $\frac{MarketValue_0}{EconomicValue_0}$ to approximate the market value from economic value and used $\frac{FaceAmount_t}{FaceAmount_0}$ to approximate the face amount decrease of each CUSIP in the account. Both approximations will get less and less accurate as the composition of the account changes due to the scheduled principal pay downs (i.e. maturity and amortization) and the un-scheduled principal pay downs (i.e. prepayment and default) for each account. There are three other reasons: 1) MUNI curve forecasting: as we stated in level-3 issue, implied forward is used for the Muni curve method hence in the market value calculation in the 'current' environment, MUNI curve from the implied forward method should be input; 2) the credit spread should be activated for 'current' market value calculation environment; and 3) the account 'Other - equities & funds' is a 'Non-Earning Instrument'. Hence, its market value is not calculated. In FMV calculation, its market value will equals to the input book value.

Table E.1: Accounts Failed FMV at Portfolio Level

Balance Sheet	4Q13 Diff		4Q14 Diff		4Q15 Diff	
	%	$MM	%	$MM	%	$MM
Assets						
Investment Portfolio						
Municipal Bonds - Callable	-4.4%	(27)	-3.4%	(16)	-2.6%	(7)
ABS						
Auto ABS (Intex)	-0.2%	(2)	-1.0%	(8)	-2.4%	(11)
Agency MBS						
Agency Pools - Intex						
Agency MBS Fixed Rate						
FHLMC						
FHLMC MBS 15 Yr Fixed	-0.1%	(3)	-0.1%	(3)	-0.6%	(22)
FNMA						
FNMA MBS 15 yr Fixed	0.0%	1	0.0%	1	-0.5%	(23)
Agency CMO (Intex)	0.0%	3	0.3%	21	0.3%	19
Agency CMBS (Intex)	-0.4%	(3)	17.7%	93	12.4%	64
Corporate Bonds						
Corporate Bonds - Fixed	0.0%	0	-0.3%	(4)	-0.9%	(11)
Covered Bonds	-0.2%	(5)	-0.4%	(10)	-1.2%	(18)
CDO/CLO						
USD CDO (Intex)	-0.2%	(3)	5.8%	70	4.8%	53
International MBS						
Buy To Let						
GBP Buy to Let (Intex)	-15.7%	(22)	-16.3%	(21)	-16.7%	(19)
Municipal Bonds	-2.8%	(160)	-0.5%	(23)	2.1%	89
Other						
Other - equities & funds	11.3%	14	11.3%	14	11.3%	14
SIV						
SIV Other Float	-27.4%	(10)	-28.1%	(9)	-29.1%	(9)
Other	23.3%	96	23.8%	94	25.7%	92
Sovereign Debt						
Sovereign Bonds	-0.3%	(58)	-0.4%	(64)	1.6%	170
Non-Agency MBS						
Non-Agency Prime MBS (Non-Intex)	-2.9%	(2)	-11.1%	(6)	-17.0%	(6)
Alt-A MBS (Intex)	1.3%	24	5.3%	76	9.7%	106
Prime MBS (Intex)	2.0%	24	6.7%	63	9.4%	69

Thus, for these 17 accounts[3], we further performed the position level FMV comparison. We first input the MUNI curves from the implied forward and activated the credit spreads. Then for each account, we chose one CUSIP. The CUSIP is chosen so that it is the largest CUSIP that matures after December 2015. For each of the CUSIP, we calculated the corresponding MTM spread;

[3] For 'Other - equities & funds' we do not di position level FMV comparison since it is a 'Non-Earning Instrument'.

then we changed the valuation method from Market Price Input to discount curve + MTM spread and input the MTM spreads for these accounts. Thus, the market value calculated in the 'current' valuation could be used directly rather than approximated from the economic value. Also, because for this test there is only one position in each account, the composition of the account stay constant thus $\frac{FaceAmount_t}{FaceAmount_0}$ will be an accurate multiplier rather than approximation. The position level comparison results are in table E.2 below.

Table E.2: Accounts Failed FMV at Position Level

Balance Sheet	4Q13 Diff (%)	4Q14 Diff (%)	4Q15 Diff (%)
Assets			
Investment Portfolio			
Municipal Bonds - Callable	-0.1%	0.6%	0.6%
ABS			
Auto ABS (Intex)	-0.1%	0.0%	-0.1%
Agency MBS			
Agency Pools - Intex			
Agency MBS Fixed Rate			
FHLMC			
FHLMC MBS 15 Yr Fixed	0.0%	0.0%	0.0%
FNMA			
FNMA MBS 15 yr Fixed	0.0%	0.0%	0.0%
Agency CMO (Intex)	-0.1%	-0.3%	-0.7%
Agency CMBS (Intex)	-0.6%	0.0%	0.0%
Corporate Bonds			
Corporate Bonds - Fixed	0.0%	0.0%	0.0%
Covered Bonds	0.0%	0.0%	0.0%
CDO/CLO			
USD CDO (Intex)	-0.1%	-0.4%	-0.9%
International MBS			
Buy To Let			
GBP Buy to Let (Intex)	0.0%	-0.1%	-0.2%
Municipal Bonds	-0.1%	0.5%	0.2%
Other			
SIV			
SIV Other Float	0.0%	0.0%	-0.1%
Other	0.0%	0.0%	0.0%
Sovereign Debt			
Sovereign Bonds	0.0%	0.0%	0.0%
Non-Agency MBS			
Non-Agency Prime MBS (Non-Intex)	0.0%	0.0%	0.0%
Alt-A MBS (Intex)	0.2%	-0.1%	-0.5%
Prime MBS (Intex)	-0.1%	-0.8%	-1.6%

As we can see, except for 'Prime MBS (Intex)' account at 4Q2015, all the other accounts are within the threshold of 1%. For ''Prime MBS (Intex)' we thought the differences are due to the fact that in the 'current' valuation environment, we cannot input all nine future scenarios; hence, any previous burn-out effect after 3Q2013 cannot be captured in the 'current' valuation environment. But the FMV calculation environment captures all these since all 9 quarters are input and are considered in the FMV calculation. In other words, there are gap between the current valuation environment and FMV valuation environment. This is not an implementation issue, but a limitation of QRM verification tools. We raised a recommendation that the implementation test be performed again once QRM could provide a direct tool/process to validate the calculation of future market value.

1.2)Implementation Test- OCI calculation

The second part of implementation test is to verify the calculation of OCI, given the QRM calculated future market value.

In the test, we run QRM planning analysis for AFS investment portfolio and security hedging portfolio. QRM report 'Future Market Value.xlsm' is exported. Using this QRM report and equation (2), we got the before-tax OCI and compared with the results provided by the model developer [10][11][12][13]; the results were perfect match for each quarter. The detailed calculation and comparison could be found in 'ReplicationTest_NewCreditSpread'.

2) Model Change Impact Analysis

The purpose of this test is to check the OCI changes introduced by this new model. The model owner performed the test on the before-tax OCI results for each CCAR 2014 scenario given the portfolio as of 3Q14 [8]. This test not only assessed the model change impact; thus in 2015 CCAR procedure, the model owner could know better the difference in OCI due to the scenario differences, rather than model changes.

Table E.3 shows the test results. We can see that overall, the loss/grain pattern from year to year still holds with the model change. Also, it still holds that given BNY Mellon's investment portfolio, the overall OCI loss for all nine quarters will be Adverse > BHC > Baseline > Severely Adverse. Thus we can be comfortable that such order is due to the characteristic of BNY Mellon's investment portfolio.

Then, when we looked into the detailed results, we would find that overall, the QRM method generates larger OCI losses than the previous BlackRock based model; especially the OCI for severely adverse scenario changed from a small gain to a loss. Given all the issues and limitations we raised on the previous BlackRock based model in the validation [1], the validator thinks the current model's results is more reasonable.

Last, we looked at the QRM OCI results differences between scenarios. The sensitivity test (Test 3) showed that the yield curve and the credit spread (i.e. spread between corporate BBB rate and 10Y Treasury Rate) drive the OCI because these two macro-economic factors dominating the discount rates for the investment portfolio and the hedges.

- Baseline: The credit spread stays declined a little bit while the yield curve for this scenario keeps going up. In every quarter, the increase in yield curve (looking at 10Y treasury rate) is larger than the decrease in credit spread. Thus, the overall discount rates increased in every quarter. Hence, the baseline has losses in every quarter and the losses are relatively even distributed across the quarters.

- Adverse: The yield curve keeps increasing aggressively and the credit spread increased about 100bps. As a result, the discount rates increased sharply and leading to very large OCI loss in 2013 and 2014. Starting from 2015, the yield curve begins to go down and the spread narrows down. Thus, some OCI gains are observed then.

- Severely Adverse: The credit spread widened a lot for this scenario; however, the yield curve in this scenario is so low that it canceled out the effect of widened credit spread. As a result, overall, the severely stressed scenario is the scenario has the least OCI losses over the 9 quarters.

- BHC: The credit spread is the widest for this scenario and at the beginning; the yield curve is high as well. Thus, it has the largest loss at the front. However, later the yield curve of BHC is much lower than Adverse scenario. Hence, the OCI gains are observed earlier for BHC scenario and the overall OCI loss is smaller than Adverse.

Overall, we think that the test results look reasonable.

Table E.3 Model Change Impact on After-Tax OCI

a) Before-Tax OCI by Quarter

Blackrock OCI	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Supervisory Baseline	(109)	78	(128)	(112)	(106)	24	(288)	57	(290)
Supervisory Adverse	(2,127)	(1,633)	(1,189)	(1,284)	211	155	387	461	448
Supervisory Severely Adverse	(1,070)	(774)	(240)	(115)	395	490	387	626	358
BHC Stress	(3,920)	619	(442)	148	482	390	92	254	129

QRM OCI (ex CMBS)	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Supervisory Baseline	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Supervisory Adverse	(3,403)	(1,407)	(1,419)	(150)	493	416	757	483	108
Supervisory Severely Adverse	(1,811)	(421)	(336)	7	374	201	406	236	12
BHC Stress	(4,389)	(592)	92	565	543	41	393	127	97

b) Before-Tax OCI by Year

	BlackRock			QRM (exCMBS)		
	2013	2014	2015	2013	2014	2015
Supervisory Baseline	(109)	(268)	(497)	(208)	(1,224)	(628)
Supervisory Adverse	(2,127)	(3,895)	1,450	(3,403)	(2,483)	1,764
Supervisory Severely Adverse	(1,070)	(734)	1,862	(1,811)	(375)	856
BHC Stress	(3,920)	807	865	(4,389)	608	659

3) Sensitivity Test

According to 'CCAR 2014 Common Themes' from Federal Reserve regarding CCAR, it is stated that ([7], page 13):

> *"...Most notably, BHCs did not conduct sufficient sensitivity analysis duration model development, and instead relied on the model validation function to carry it out..."*

In the development of this QRM OCI model, the model owner did not conduct sensitivity test either, we raised this as a level 2 issue.

Still, the model validator performed the sensitivity tests for model validation. The sensitivity test was performed on the baseline scenario[4]. The purpose of the sensitivity test is to assess the sensitivity of the OCI results to the risk factors. In the test, we covered the following factors in the model:

- Yield Curve: Parallel shift all yield curves by 50bps;
- Credit Spread: Parallel increase all credit spread by 50bps;
- Mortgage Rate: Parallel increase mortgage rate by 50bps;
- HPI: decrease HPI by relatively 5%;
- Incremental investment amount: increase the incremental Investment amount (i.e. new purchase) by 5%.

The results are summarized in Table E.4.

Table E.4: Sensitivity Test Summary

$MM	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Base	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Difference on OCI ($MM)									
Yield Curve Up 50bps	(713)	(13)	(10)	(26)	(18)	(9)	2	3	17
Credit Spread Up 50bps	(1,484)	(60)	(44)	(55)	(47)	(68)	(54)	(37)	7
Mortgage Rate Up 50bps	0.3	(0.3)	(0.3)	(0.7)	0.3	0.7	0.4	0.2	(1.0)
HPI Down 5%	(0.7)	(3.0)	(2.9)	(2.9)	(1.0)	0.1	0.2	0.5	0.3
Incremental up 5%	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	(0.1)

i. Yield Curve

The yield curve is used mostly as the discount curve. For some of the variable rate mortgage,

[4] The sensitivity tests for Yield Curve and credit spread were performed on the model after Level-1 issue on credit spread was addressed. For Mortgage rate, HPI and Incremental amount, the tests were performed on the version 1 model between level-1 issue was addressed. The new model was delivered to the validator on 5/21; thus we don't have time to redo all the sensitivity tests since it took 12-16 hours to finish one scenario. However, the conclusion of the tests still holds because the level-1 issue on credit spread only affects the credit spread; we isolated each factor in the sensitivity test. We re-do the yield curve because it is the main driver for the model. For the other three factors, our previous finding still holds.

yield curve will also be input into ADCo to generate the mortgage rate, since the mortgage rates input in QRM only have 15Y, 20Y and 30Y fixed rate.

As expected, the OCI losses increased a lot given +50bps parallel shift. When we looked at the results closer, for the existing volume, the outstanding balances (i.e. face amount) for most fixed rate accounts do not change, since their amortization and prepayments are not related with the yield curve, but the market value of decreased a lot. For variable rate agency MBS accounts and non-agency MBS (part of which are variable rates), the face amount for the existing volume changes are much larger. This is because the prepayments are affected by yield curve for these positions. If these prepaid amount is reinvested (through new volume), the total face amount (i.e. face amount of the existing volume and of the new volume) of the account does not change; but if the account is not 100% reinvestment, the total face amount will change as well. Overall, the yield curve affects mostly the discount curve and thus affects the market value.

ii. Credit Spread

This test result is based on the model after the Level 1 issue on credit spread was addressed.

The credit spread affects the OCI purely through discounting; thus we noticed that the face amounts for all accounts stayed unchanged. Meanwhile, given that the credit spread widened, the OCI loss will increased. Yield curve and Credit spread are the two main drivers for the OCI since they affects the discount rates. Credit spread's impact is even larger since it is not used on the numerator of the discount cash flow equation at all.

iii. Mortgage Rate

The mortgage rate does not affect the OCI number much. This is because the mortgage rate only affects the prepayment speed of the MBS related products. In other words, the mortgage rate only affects the outstanding balances. The OCI calculation excludes the market value change due to the outstanding balance change. Hence, such result is as expected.

If we look at the forecasting closer, we can see that as the mortgage rates go up, the outstanding balances for the existing volumes increase as the prepayment slows down. Meanwhile, because the new volumes are calculated based on the prepayment and principal payment of these positions (either in 'Bottom Up Growth tab' for agency MBS or in 'Reinvestment' for non-agency MBS), the total outstanding balance does not change much. In other words, the outstanding balances of the new volume decrease with the mortgage rate.

The market value slight changes because the existing volume composition is not exactly the same as those set for the new volume. Thus, given the mortgage rate increase, there will be more existing volume stayed and less new volume generated. The market value will be different even if there is no outstanding balance change in total.

iv. HPI

The HPI does not affect the OCI number much either. The reason is similar to that of mortgage rate. Based on the current modeling, HPI only affects the prepayment speed of the MBS products. In other words, HPI only affects the outstanding balances. The OCI calculation excludes the market value change due to the outstanding balance change. Hence, such result is as expected.

If we look at the forecasting closer, we can see that as HPI decrease, the outstanding balances of the existing volume increases as the prepayment slows down; due to the same reason as mortgage rate, the total outstanding balance does not change much. In other words, the outstanding balances of the new volume decrease with the mortgage rate. The slight change in the market value is due to the change of account composition, same as that caused by the mortgage rate.

v. Incremental Amount

We can see that the OCI is least sensitive to the incremental amount change. This is as expected since the incremental amount will only affects the new volume to be added to the portfolio. However, as we stated, the OCI calculation excludes the market value change due to the outstanding balance change. The OCI differences around of 100K-200K is due to the fact that the composition change of the portfolio will be carried over to the second quarter and that equation (2) is an approximation thus we cannot entirely exclude the impact of the increased volume.

Overall, the sensitivity test result is satisfactory.

Because it takes very long (over 12 hours per scenario) to run a sensitivity test scenario in the QA environment, we only performed one-side sensitivity tests for each model factor due to the limitation of resource. Ideally, the sensitivity test should be performed for shocks on both side and with various latitudes of shocks. We recommend that the model developer performed a more though sensitivity tests. This is raised as part of the level 2 issue on sensitivity test.

4) MC Convergence Test

In the FMV calculation, Monte Carlo simulation is used to calculate the market value for positions with optionality included. In this situation, they are the structured products. In future market value (FMV) calculation, the FMV process are to be repeated for 9 times; thus due to the time reason, the Monte Carlo simulation path used for FMV calculation cannot be as much as those used for the 'current' environment valuation process. It is recommended by QRM that 'clients with large Intex positions typically choose something between 10 and 50'. Right now, the model uses path number as 30. Previously, it has been identified in the QRM validation [2] that 300 paths are needed for the Monte Carlo simulation to converge. Hence, it is expected that the using 30 paths, some variances would be introduced.

In this test, we used 30 different random seeds to generate the values for the entire investment portfolio; we did not include security hedging positions since none of these positions use Monte Carlo simulation valuation method. We performed the test in the 'current' valuation environment. This is because the FMV process will take over 12 hours to finish each wrong; thus it will take at least 15 days non-stop to do this test in the FMV environment. As stated, because the market value in the 'current' valuation environment is directly from the market price for all investment positions, we performed the test on the economic value, instead of market value. This will hardly affect the test results; because the differences between market value and economic value is from the MTM spread added to the underlying discount curve. This MTM spread will be held constant.

Table E.6 below summarized the test results; as we can see, for the 30 runs with different random seeds, the mean is $76,012MM and the standard deviation is $8.397MM. The maximum is $76,031MM and the minimum is $75,944MM; the width between the two is $37MM.

Table E.6: Monte Carlo Simulation Convergence Test Summary

	Investment Portfolio Economic Value ($MM)
Max	$ 76,031
Min	$ 75,994
Average	$ 76,012
Stdev	$ 8.397

The random seed currently used is 1; it will be held unchanged in all the calculation. The OCI is the change in market value rather than the market value itself. We expect the variance of OCI given different random seeds would be smaller. However, the model owner should be aware that the currently calculated OCI number could be different, if a different random seed is used. We also raised a recommendation that that the model owner performed Monte Carlo simulation test on the OCI results if time allowed.

5) Impact Analysis – Addressing Level 1 Issue on Credit Spread

In the process of the validation, there were several issues identified related with the Credit Spread:

- The credit pricing model is not fully activated
- The credit spreads were not defined correctly (as discussed in section 6.c)

As a result, the validator observed strange results on both the sensitivity test results and the stress test result on the first version of model that the model developer sent over (details could be found in Appendix B). Specially, huge gain is observed in first quarter for stress scenario which is designed by the model validator to approximate the severely adverse scenario. Thus, we raised a level 1 issue to the model owner. The model owner took immediate actions to address this issue. The credit spreads were redefined (as discussed in more details in section 6.c) and the credit pricing model was fully activated (as discussed in more details in section 6.b). A newer version of the model was delivered to the model validator. Table E.7 showed the comparison between the two versions of the models on Baseline scenario; because the first version of the model (before Level 1 issue addressed) was only done on Baseline, comparison on other scenarios are not available.

Table E.7 OCI on Baseline before vs. after Level 1 issue on Credit Spread addressed

$MM	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Before Credit Spread Level-1 Issue Addressed ($MM)	(324)	(259)	(225)	(258)	(76)	(181)	(169)	(99)	(150)
After Credit Spread Level-1 Issue Addressed ($MM)	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Diff ($MM)	116	(130)	(185)	(4)	(87)	(70)	115	(42)	(31)

From Table E.7, the differences are not very obvious. This is because that for Baseline scenario, the credit spread only decreased slightly. For scenarios with widened credit spread (e.g. severely stressed), the impact is most observe. From the stress test (in Appendix B), there is $1.4 Billion OCI gain in 4Q13 before this Level-1 issue is addressed, which is ridiculous. However, from the OCI results of the current model after Level-1 issue is addressed, there is a $1.8 Billion loss instead. We provided the current model results in table E.8.

We can see that the overall OCI loss for all nine quarters will be Adverse > BHC > Baseline > Severely Adverse. This is the same as the CCAR 2014 OCI model on BlackRock platform. Thus we can be comfortable that such order is due to the characteristic of BNY Mellon's investment portfolio.

Table E.8 Current OCI Results

a) OCI by Quarter

QRM OCI (ex CMBS)	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Supervisory Baseline	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Supervisory Adverse	(3,403)	(1,407)	(1,419)	(150)	493	416	757	483	108
Supervisory Severely Adverse	(1,811)	(421)	(336)	7	374	201	406	236	12
BHC Stress	(4,389)	(592)	92	565	543	41	393	127	97

b) OCI by Year and Total

	2013	2014	2015	Total
Supervisory Baseline	(208)	(1,224)	(628)	(2,060)
Supervisory Adverse	(3,403)	(2,483)	1,764	(4,122)
Supervisory Severely Adverse	(1,811)	(375)	856	(1,330)
BHC Stress	(4,389)	608	659	(3,122)

The sensitivity test (Test 3) showed that the yield curve and the credit spread (i.e. spread between corporate BBB rate and 10Y Treasury Rate) drive the OCI because these two macro-economic factors dominating the discount rates for the investment portfolio and the hedges.

- Baseline: The credit spread stays declined a little bit while the yield curve for this scenario keeps going up. In every quarter, the increase in yield curve (looking at 10Y treasury rate) is larger than the decrease in credit spread. Thus, the overall discount rates increased in every quarter. Hence, the baseline has losses in every quarter and the losses are relatively even distributed across the quarters.

- Adverse: The yield curve keeps increasing aggressively and the credit spread increased about 100bps. As a result, the discount rates increased sharply and leading to very large OCI loss in 2013 and 2014. Starting from 2015, the yield curve begins to go down and the spread narrows down. Thus, some OCI gains are observed then.

- Severely Adverse: The credit spread widened a lot for this scenario; however, the yield curve in this scenario is so low that it canceled out the effect of widened credit spread. As a result, overall, the severely stressed scenario is the scenario has the least OCI losses over the 9 quarters.

- BHC: The credit spread is the widest for this scenario and at the beginning; the yield curve is high as well. Thus, it has the largest loss at the front. However, later the yield curve of BHC is much lower than Adverse scenario. Hence, the OCI gains are observed earlier for BHC scenario and the overall OCI loss is smaller than Adverse.

Thus we conclude that the model results are reasonable after this Level-1 issue was addressed.

6) Impact Analysis – face vs. book

The current model uses quarter-to-quarter book value change to remove the change in market value due to outstanding balance changes (called 'normalization of market value). However, in the forecasting procedure, the changes of the book value do not only arise from the outstanding balance change (i.e. amortization, prepayment, new purchase, reinvestment, etc.); the amortization or depreciation of premium / discount also contributes to the book value change. Hence, we recommend that the change of face amount to be used in the market value normalization, instead of book value.

In this test, we assessed the impact of using face amount instead book value for the investment portfolio for all four scenarios.

Table E.9 shows the test results, as we can see if we used face amount instead of book value to normalize the market value change, the total before tax OCI would have an additional about $600MM loss. We raised this as a level 2 issue.

Table E.9: Impact Analysis – Book Value vs. Face Amount to Normalize Market Value Change

Baseline	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
OCI with Book Value ($MM)	**(2,059)**	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
OCI with Face Amount ($MM)	**(2,636)**	(320)	(528)	(515)	(283)	(180)	(287)	(104)	(194)	(226)
Diff ($MM)	**(576)**	(112)	(140)	(106)	(21)	(16)	(36)	(50)	(53)	(44)
Adverse	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
OCI with Book Value ($MM)	**(4,123)**	(3,403)	(1,407)	(1,419)	(150)	493	416	757	483	108
OCI with Face Amount ($MM)	**(4,670)**	(3,519)	(1,827)	(1,875)	(217)	635	569	878	557	129
Diff ($MM)	**(547)**	(116)	(420)	(455)	(67)	142	152	121	74	21
Severely Adverse	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
OCI with Book Value ($MM)	**(1,331)**	(1,811)	(421)	(336)	7	374	201	406	236	12
OCI with Face Amount ($MM)	**(1,985)**	(1,909)	(751)	(636)	(63)	406	240	439	250	38
Diff ($MM)	**(655)**	(97)	(330)	(300)	(71)	32	39	33	14	26
BHC	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
OCI with Book Value ($MM)	**(3,123)**	(4,389)	(592)	92	565	543	41	393	127	97
OCI with Face Amount ($MM)	**(3,687)**	(4,506)	(663)	24	502	484	(4)	348	70	56
Diff ($MM)	**(564)**	(116)	(70)	(68)	(63)	(59)	(45)	(45)	(57)	(41)

7) Impact Analysis – Investment Portfolio Valued at Discount

Currently, OCi is calculated as

$$OCI_t = [MarketValue_t - MarketValue_{t-1}] - [BookValue_t - BookValue_{t-1}]$$
$$= [MarketValue_t - BookValue_t] - [\, MarketValue_{t-1} - BookValue_{t-1}] \quad (2)$$

In equation (2), the component $[BookValue_t - BookValue_{t-1}]$ is to exclude the market price changes caused by the change of outstanding balance, i.e. it is used as an approximation for $Market\ Value_{Outstanding\ Balance\ Change\ from\ t-1\ to\ t}$. This approximation is less accurate when the market value is far away from par.

As we stated in section 6.a, we could observe that for Adverse and BHC scenarios, there are situations when 1 dollar in book value is less than 95 cents in market value; i.e. under stressed scenarios, the investment portfolio will be valued at discount. Thus, we think it is better to calculate OCI as follows:

$$OCI_t = \sum_K OCI_{t,account\ K} \quad (5)$$

Where,

$$OCI_{t,account\ K} = \left[MarketValue_{t,account\ K} - MarketValue_{t-1,account\ K}\right] - \left[BookValue_{t,account\ K} - BookValue_{t-1,account\ K}\right] \times \frac{MarketValue_{t,account\ K}}{BookValue_{t,account\ K}}$$

Table E.12 summarized the impact for each scenario. We can see that for all scenarios, the OCI loss will decrease if equation (5) is used instead of equation (2). This is because right now, in most cases $[BookValue_t - BookValue_{t-1}]$ is positive; thus in equation (2), the current approximation overestimate the OCI losses by ignoring the fact that the investment portfolio will be valued at discount given stressed scenarios. We raised this as a level 3 issue.

Table E.12: Impact Analysis – Investment Portfolio Valued at Discount

Baseline	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Current ($MM)	**(2,059)**	(208)	(389)	(410)	(262)	(163)	(251)	(54)	(141)	(181)
Adjust with Ratio ($MM)	**(1,961)**	(176)	(383)	(380)	(255)	(159)	(247)	(52)	(137)	(173)
Diff ($MM)	**98**	32	6	30	7	4	5	2	4	8
Adverse	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Current ($MM)	**(4,123)**	(3,403)	(1,407)	(1,419)	(150)	493	416	757	483	108
Adjust with Ratio ($MM)	**(3,635)**	(3,081)	(1,245)	(1,220)	(122)	442	365	688	439	99
Diff ($MM)	**488**	323	162	199	28	(51)	(51)	(69)	(43)	(9)
Severely Adverse	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Current ($MM)	**(1,331)**	(1,811)	(421)	(336)	7	374	201	406	236	12
Adjust with Ratio ($MM)	**(1,166)**	(1,615)	(418)	(299)	(9)	362	184	393	225	11
Diff ($MM)	**165**	196	3	37	(17)	(13)	(17)	(13)	(11)	(0)

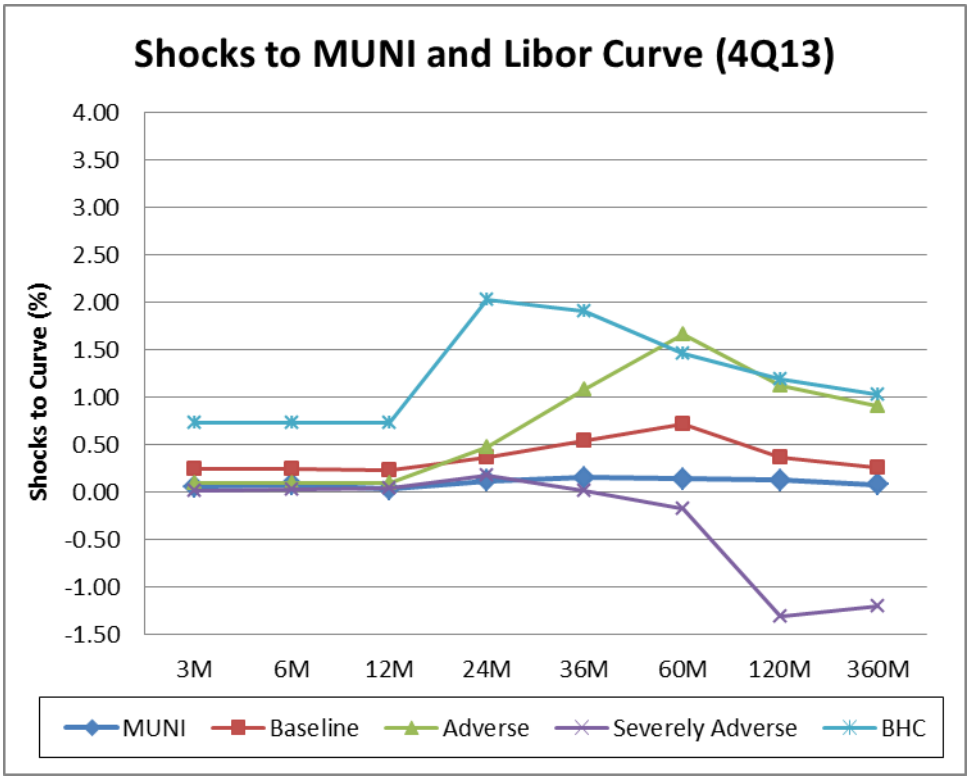
BHC	**Total**	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Current ($MM)	**(3,123)**	(4,389)	(592)	92	565	543	41	393	127	97
Adjust with Ratio ($MM)	**(2,820)**	(3,994)	(542)	100	522	497	31	365	114	87
Diff ($MM)	**302**	395	50	8	(43)	(46)	(10)	(28)	(14)	(10)

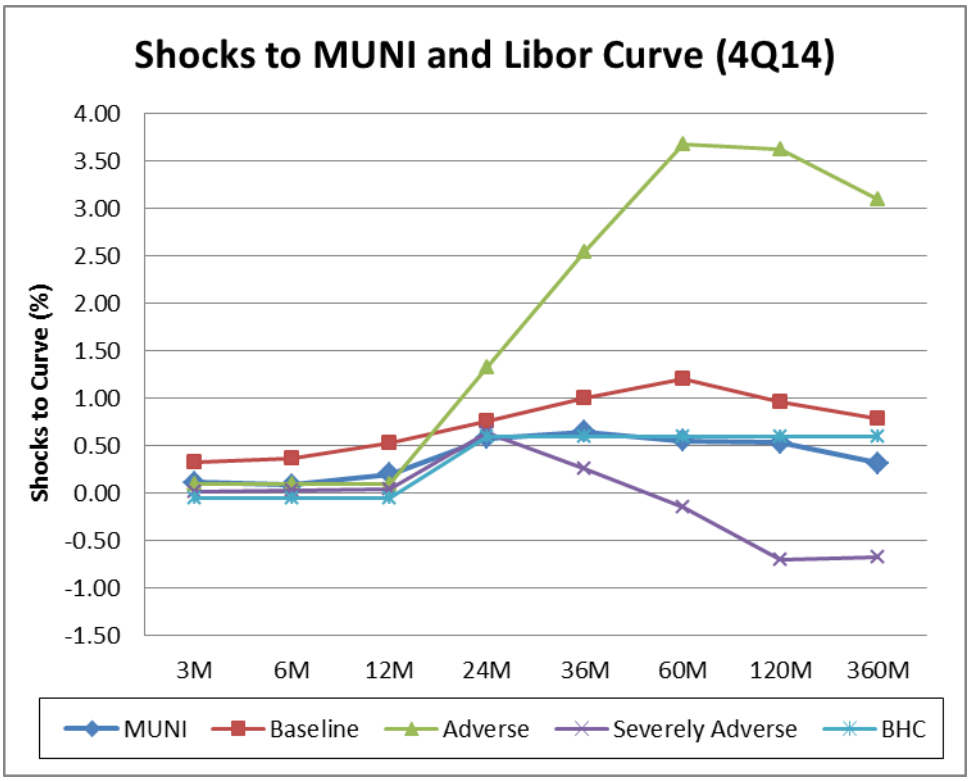
8) Curve comparison – Muni vs. Libor

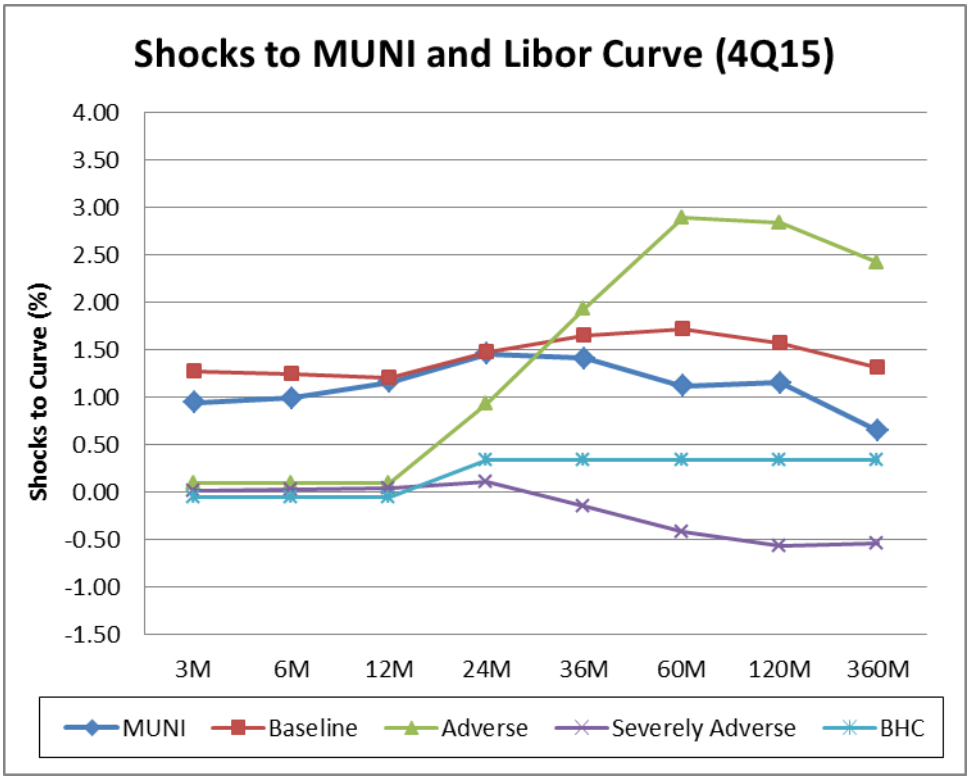
As we stated in section 6.c 'Accuracy and Appropriateness of Input Data, Data Cleaning and Verification', currently the forecasting of the MUNI curve is based on 'implied forward method'. This is because CCAR QRM OCI inherits the market curve setup from CCAR QRM NII forecasting. However, MUNI curve is not used in CCAR NII calculation since all these positions are fixed-rate and the interest income rate is input rather than derived from the MUNI curve. However, the OCI calculation would use the MUNI curve since it is a discount curve and the OCI is based on market value change.

As we know, the implied forward curve will usually be pretty steep thus generate high rates. We are to compare the MUNI curve shocks (based on implied forward) with the Libor curve shock under each scenario at 4Q13, 4Q14 and 4Q15 under each scenario. The results are shown in Figure E.1 below. As we can see, the Muni curve shocks are smaller than all curves except for Severely Adverse in 4Q13, Severely Adverse and BHC in 4Q14 and 4Q15.

Figure E.1: Yield Curve Shocks – Libor (each CCAR Scenario) vs. Muni







Because the MUNI is used as the discount, the less the shock leads to the less decrease in market value; the OCI for the muni positions could be underestimated. We think it is better that the shock to the MUNI is derived from CCAR scenarios as all other curves. Because there are only

$5.76 Billion muni positions (7.7% of the total investment portfolio), we raised this as a level 3 issue. The validator did an analysis based using data from 2008 to 2013, using the rate level as well as the rate quarterly change for 3M, 5Y and 10Y respectively. The test results are shown in table E.10 below. We can see that for the short-end (i.e. 3M) of the curve, the Muni curve's quarterly change has a stronger relationship with the quarterly Libor rate change. For 5Y and 10Y, the relationships are stronger for the rate level. The model developer might consider building some similar statistic relationship between Muni and Libor.

Table E.10: Fitting Muni to Libor Curves

	Quarterly Muni Rate Change			Muni Rate		
	3M	5Y	10Y	3M	5Y	10Y
R-squared	86.7%	54.5%	47.0%	54.4%	80.3%	78.3%
Intercept	-0.0020	-0.0379	-0.0391	0.0558	0.3368	0.7519
Coefficient to Libor/Libor Quarterly Change	0.5003	0.6046	0.5530	0.3116	0.5863	0.7149

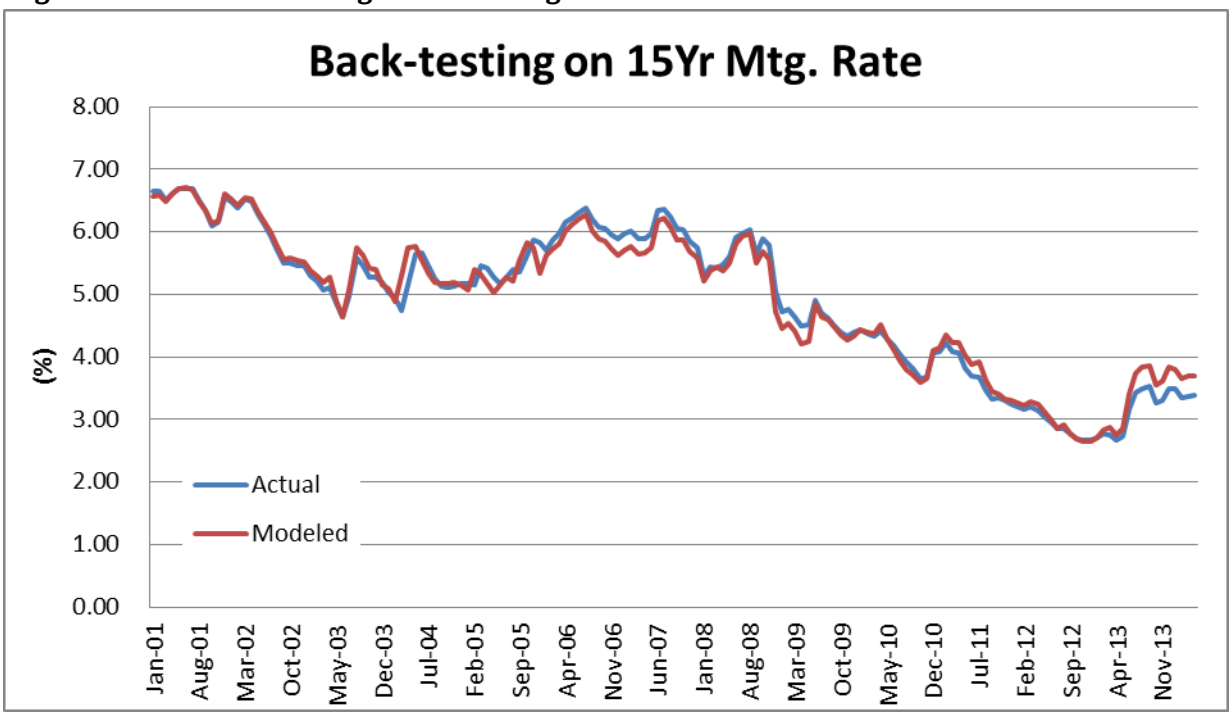
9) Back-testing on 15Yr Mtg. Rate

The model owner used an equation provided by ADCo to model 15Yr mortgage rate from 30Yr mortgage rate. The test is performed to review the back-testing on this equation. We used Freddie Mac PMMS rate as the mortgage rates. The modeled 15Yr mortgage rates were compared with the actual 15Yr mortgage rate from Jan. 2001 to Apr. 2014. The comparison chart is shown below in Figure E.2. We also summarized the statistics on the difference in table E.11. Overall, we think the modeled rate follow the trend of the actual rate and the differences are relatively small. Hence, we think the function is satisfactory.

Table E.11: Statistics of Model Residuals

Residual	**bps**
Mean	0
Max	59
90 Percentile	19
75 Percentile	8
Median	0
25 Percentile	-10
10 Percentile	-22
Min	-48

Figure E.2: Back-Testing on 15Yr Mtg. Rate



f. References

[1]: CCAR OCI Valdiation Report_20131230_V2.2.docx
[2]: QRM Validation Repost_Final After MVRC.docx
[3]: (QRM Validation Report) Addendum 1_ Addendum 1_QRM CCAR NII_v1.0.docx
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[5]: Future Market Value Comparision.xlsx
[6]: CCAR - 2013 OCI Analysis_FINAL(new12162013).xlsx
[7]: BNYM CCAR 2014 Feedback Letter 4_21_2014_FINAL
[8]: BK vs. QRM OCI.xlsx
[9]: CCAR Metrics Spreads revided.xlsx
[10]: Future MV Baseline May13 credit shocks with new vol Spreads.xlsm
[11]: Future MV Adverse May13 credit shocks with new vol Spreads.xlsm
[12]: Future MV Severe May13 credit shocks with new vol Spreads.xlsm
[13]: Future MV BHC Stress May13 credit shocks with new vol Spreads.xlsm
[14]: 2014 CCAR OCI Documentation_121613v2.doc
[15]: Modeling Documentation for CCaR ao121613.docx

Appendix A: QRM Guidance on Future Market Value Calculation Setup

Calculating Future Market Value in the Framework

Follow these steps to calculate future market value in the Framework.

1. Before logging into the Framework, navigate to the client folder associated with the database that this test will be run in. If there is an analysis.sys already in the client folder, please add the line below to the file. If an analysis.sys file does not exist, please open a text file and insert the following line and save the text file to the client folder (ensuring that a .sys file extension is used in place of a .txt file extension).

   DISTRIBUTEDFUTUREMARKETVALUEPROCESSMULTIPLE = 40

   This setting will trigger the Framework to distribute the FMV calculation to 40 processors. We will use the log file generated from this run to determine whether it is appropriate to use more of your CPUs or fewer for your production FMV runs.

(Note from validator: the code review does not cover this step; it is to be covered by IT support.)

2. Verify that there is a strategy created in **Enterprise Model/Portfolio/Earnings Forecasting/Strategies**.

   This can be one of your regular production strategies.

(Note from validator: the strategy reviewed is 'Test (FMV) CCAR Fed Baseline'.)

(Update on 5/21/2014: revisit this given the new set of model. The strategies reviewed are 'New Vol MTM Test Baseline/Adverse/Severe/BHC Stress'.)

3. Navigate to **Properties/Analytics Options** in the Strategy tree.
4. Click **Edit**.
5. Select **Calculate future market values.**

   You might want to change the strategy name to indicate that this is a future market value type strategy.

6. Navigate to **Properties/Output Options/Balance Sheet and Income**
7. Select **Future market value** to output future market value results.

   If this option is not selected, future market value analysis will still take place (e.g. gain/losses will be accurately captured), but FMV results will not be output.

8. Click **Save**.
9. Navigate to **Processing/Current Run Parameters/Modes of Analysis** in the toolbar.

   Select **Analytics Settings** under Future Valuation.

(Note from validator: the Analytics Settings reviewed is 'IRR FMV Test'.)

10. Click **Edit**.
11. Specify the frequency of the future value calculation.

    For CCAR purposes, the typical setting is "Quarterly until horizon."

(Note from validator: the Analytics Settings reviewed is 'Quarterly until horizon' is used.)

12. Click **Save**.
13. Navigate to **Processing/Current Run Parameters/Yield Curve Models** in the toolbar.
14. Select **Future Valuation** under Monte Carlo Settings for Pricing and Currency.

    Verify that you've made the appropriate yield curve modeling selections. Select the number of monte carlo paths you wish to use for your analysis. Clients with large Intex positions typically choose something between 10 and 50.

(Note from validator: the paths used is 30.)

15. Navigate to **Processing/Current Run Parameters/Modes of Analysis** in the toolbar.
16. Select **Scenario Selection** under Future Valuation.
17. Click **Edit**.
18. Select the **Market Shocks** that you want to include in future market valuation.

For CCAR purposes, you do not need to select any shocks. For BPV and convexity calculations, toggle to None and then de-select the shocks so that no valuation shocks are selected.

(Note from validator: the Market Shocks used is 'Base', 'Up10' and 'Down10'.)

19. Click **Save**.
20. Navigate to **Processing / Process Control Panel** in the Toolbar to run the planning process.
21. Verify that the strategy with future market value activated is included in the run.

    For purposes of this test, please ensure to only select ONE strategy and scenario combination to process at first. This will provide us with our baseline memory usage.
22. Once analysis is completed, please send us the monitor log file from the run. You can also navigate to **Reporting / Export Report Books** and export the **Planning / Future Market Value** report to view and confirm the quarterly WAL calculation.

Appendix B: Sensitivity Test and Stress Test on Model Before Level 1 Issue on Credit Spread Addressed

In April 2014, the model owner delivered the first version of the QRM based OCI model under the baseline scenario. In the sensitivity Test result, the model validator noticed that the sensitivity of the model to credit spread is much smaller than the sensitivity to the yield curve, as shown in Table B.1 below. This looks unreasonable because both the yield curve and the credit spread works mostly on the discount rate, their impacts on the OCI should be close.

Table B.1: Sensitivity to Yield Curve and Credit Spread before Level 1 Issue on Credit Spread Addressed

	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Baseline OCI ($MM)	(324)	(259)	(225)	(258)	(76)	(181)	(169)	(99)	(150)
Difference on OCI ($MM)									
Yield Curve Up 50bps	(792)	(28)	(23)	(28)	(13)	(24)	(7)	(6)	2
Credit Spread Up 50bps	(139)	(53)	(28)	(39)	(39)	(34)	(33)	(29)	(29)

This further raised a concern that given the sensitivity observed in table B.1, for severely adverse scenario there could be large OCI gains. This is because in severely adverse scenario, the yield curves are very low while the credit spread widen. Back then, the other three CCAR scenarios results are not yet available; thus the model validator created a stressed scenario to approximate the severely adverse scenario to input into QRM. We called this as an approximation because all yield curves are shocked based on USD Libor/Swap shocks.

The results of the stress test are shown below in Table B.2. As expected, huge gain are observed in the first quarter. We concluded that such results are not reasonable and OCI as such are not acceptable at all. Combined with the finding of credit spread definition, we raised a level 1 issue on the credit spread and notified the model owner.

Table B.2: Stress Test before Level 1 Issue on Credit Spread Addressed

OCI ($MM)	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Baseline	(324)	(259)	(225)	(258)	(76)	(181)	(169)	(99)	(150)
Stressed Scenario	1,350	(89)	(121)	(53)	(301)	(81)	(71)	(129)	(67)

The model owner took actions immediately. With several rounds of conversation with QRM, it was found that the credit pricing function in QRM is not fully activated. The following changes are made in the QRM setup:

- Activate 'Credit Spread - Credit Pricing Model' in the definition of each product;
- Activate 'Enable spreads during analysis cycles' in Run Parameters definition;
- Activate 'Include OAS in call decision' in Run Parameters definition.

These setups are not listed in QRM guidance (Appendix A) because they are more related with credit spread modeling, rather than the future market value.

The model developer also changed the method used to define the credit spread to be used in the OCI model (detailed in section 6.c).

After both changes were made, the model results now look reasonable (as shown in Test 5).

Appendix C: Validation Log

#	Area	Items	Details	Status	Notification Time	Response & Time
1	Accounts	Municipal Bonds - Callable - HTM	This position is HTM; should not be in the OCI calculation	Addressed	13-Apr	4/14: The account is excluded from the OCI calculation. 4/24: new results sent by Akshat.
2	Accounts	CMBS	(Identified by MO) Currently, this account has issue in FMV calculation. The model owner is waiting for	Level 2	n.a.	5/1: Until we get a new release from QRM, CMBS will be a problem for OCI. So far, no resoluation yet. QRM new release is likely to be in May (QRM does not firm up a date)
4	Setup	OAS in Callable	QRM notified that in the run parameters, the item 'include OAS in call decision' need to be checked. But there are few callable bonds, the impact should be small (Currently doing impact analysis)	Addressed	n.a.	Changed.
5	Final results	All four CCAR scenarios	Currently, only the baseline scenario is performed. We think it is necessary to do on all scenarios and compare with the previous method. This is not only to assess the change introduced by the new method. This could also help exclude the model change impact from year to year diff. in 2015 CCAR .	Addressed	23-Apr	5/1 Akshat: should be able to give you other results by next Monday 5/20: Results provided.
6	Macrr-economic factors	Credit Spread	Based on the current sensitivity test, the results are not sensitive to the credit spread?	Addressed	1-May	5/1 Akshat: The run parameters should be checked to include the credit spread calcualtion. 5/2 validator: re-do the sensitivity test now. 5/6 validator: Done.

#	Area	Items	Details	Status	Notification Time	Response & Time
7	Macrr-economic factors	Sensitivity to Yield Curve	Currently, the OCI will be driven mostly by yield curve; the higher the interest rate, the more negative OCI is. The HPI /mortgage rate/strategy hardly affects the OCI, because these three affects the balance only, while the yield curve directly affects the discounting. As a result, I am suspecting that given the severely stressed scenario, the OCI will be much positive than the baseline; because severely adverse scenario has much lower interest rate.	Addressed	2-May	5/2 Akshat: Currently running other scenarios. Should be available next Monday (5/5). 5/14 Akshat: this is related with the credit spread implementation. Please wait till the new implementation for Credit Spread. 5/20: Results provided. The OCI results looks reasonable. The order of losses given different scenarios are the same given current model on QRM and previous model on BlackRock.
8	Calculation Function	Face amount vs. Book amount	Currently, book value is used to approximate the market value change due to the change of outstanding balance. I invested a little bit more into the book value vs. face value. The face value change will be more preferable to the book value change. This is because that the book value change also includes the 'AFS gains' and 'amortization of premium'. However, I think for Security hedge, the book value should be used, because the face value seems to be notional amount.	Level 2	2-May	Need to think through for this item.

#	Area	Items	Details	Status	Notification Time	Response & Time
11	Macrr-economic factors	Credit Spread	The current setup of the credit spread is incorrect; it has an component of the initial spread. After Taras's feed back, there are still issue, either way the setup is: 1) If the credit spread does not replace MTM spread/OAS spread, the current implementation method (of applying the absolute level of spread) would have double counting, because the MTM spread is currently calculated on underlying curve (which are mostly Libor); 2) If the credit spread DOES replace MTM spread, then the change in market value in the 1st quarter will arise mostly from the switch from MTM spread to credit spread. MTM spread is particular to each position, and usually it will be pretty difference from credit spread, especially on MBS positions.	Addressed	6-May	5/6 Akshat: The current setup of the credit spread changed; and we are currently looking into it. 5/6 Akshat (after discussion): will get back to you either today or tomorrow. 5/6 Taras: We had another discussion with Tyler and he confirmed that there is a miscommunication and our previous (initial) thoughts are correct. ========== 5/7 Akshat:Yes. previously we thought we need this initial spread. However, now we know that the initial spread is not needed. We will reset the credit spread and rerun everything. Would send the results once rerun. 5/14 Taras: After another conversation with QRM, there as another option that needed to be checked at the product level for credit spreads to be used properly. We are reviewing the results now. Unfortunately, there is not FMV manual from QRM and we keep getting updates on the implementation in QRM. Maybe please halt testing anything credit related until we review the latest results and will update you as soon as possible. The rates and mortgage side is still OK. 5/20: Results provided. The OCI results looks reasonable. The order of losses given different scenarios are the same given current model on QRM and previous model on BlackRock.

#	Area	Items	Details	Status	Notification Time	Response & Time
12	MTM spread	MTM Spread	The investment portfolio positions have market price; hence MTM spreads are generated for existing positions. These MTM spread will held constant in the FMV positions. But for the new volume, there will be no MTM spread.	Addressed	6-May	5/7 Akshat: we talked with QRM; what we currently plan to do is add another 'credit spread' for new volume. We are to add these spread based on the current MTM spreads for each of the large product type (e.g. ABS, Agency MBS, etc.) After another conversation with QRM, there as another option that needed to be checked at the product level for credit spreads to be used properly. We are reviewing the results now. Unfortunately, there is not FMV manual from QRM and we keep getting updates on the implementation in QRM. Maybe please halt testing anything credit related until we review the latest results and will update you as soon as possible. The rates and mortgage side is still OK. 5/20: Results provided. The OCI results looks reasonable. The order of losses given different scenarios are the same given current model on QRM and previous model on BlackRock. Follow up: Is this spread applied for MBS only; or for all large products?
14	Market risk factor	MUNI	The CCAR scenario does not covers for MUNI curve, because it is not used in NII calculation (fixed rate instruments). However, this curve is used for OCI purpose in discounting. Hence, it should be developed	Level 3	9-May	Will work on it.

#	Area	Items	Details	Status	Notification Time	Response & Time
15	Model Developmentment	Sensitivity Test	Based on the recent letter from regulators, the model developer should perform sensitivity tests on their own, rather than depend on the model validation group. I did limited sensitivity Test, given the resource (of QRM processor). Need to expend on this.	Level 2	14-May	Will work on it.
16	Documentation	Documentation	On OCI as well as mtg&credit implementation	Level 2	1-Apr	Will work on it.
17	Calculation Function	market value vs. book value/face amount ratio	Currently, the OCI is calculated as (market t – market t-1) – (book t – book t-1). However, such approximation only is more accurate when the investment portfolio is close to par (i.e. market/book close to 1). However, in the scenarios (especially for Adverse), the ratio will be close to 0.9, meaning a dollar volume change contribute to about 90 cents change in market value. Hence, I am think whether it would make more sense to change the equation to (market t – market t-1) – market t-1/ book t-1 *(book t – book t-1). The same conclusion holds if face value is used. I redo the calculation using this updated equation; the OCI loss is smaller. Please let me know your thought.	Level 3	20-May	