QuIC Mechanics FD Test Cases

(HSBC Edition)

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TERMS OF USE

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1 INTRODUCTION

This document describes a series of test procedures that were carried out to verify that the pricing of instruments by QuIC Mechanics FD is accurate. While the tests are not exhaustive, they do represent a series of necessary checks of the framework.

The FD results were compared to analytic calculations for instruments where an analytic solution is available. Range accrual trades were tested in the limit of large ranges and for consistency between varying ranges. Bermudan callability was tested through checking for consistent changes in the instrument prices as call dates are adjusted. Consistency between Bermudan callable swaps and Bermudan swaptions was tested.

The remainder of this document outlines the test instruments to price in QuIC Mechanics FD and how the prices should compare to demonstrate success. The results from all tests and the demonstration of the pass criteria are presented in a separate Excel workbook.

All tests were carried out with the market data for 2005/05/05 (found in the package). The external scenarios for 2005/05/05 were used to obtain MTM values on all PFE dates specified in that data. These external scenarios are generated by running `GenerateExternalBKScenarios.mds` in the `MarketData` directory.

For all trades set up below, we assumed that the trades start 5 days before the valuation date, that is 2005/05/01. When needed, historical rates for dates 2005/05/01 to 2005/05/04 were taken to be 3.21938%. The notional was taken to be $1,000,000 for all tests.

2 GENERAL TRENDS WHEN ADDING CALL DATES

The test cases in this section consider a fixed rate bond. For these test cases, set the funding leg notional to zero so that there are no funding leg payments. Use QFDEventNotionalCashFlow to add a payment at the end of the trade. Enter a redemption amount of -1000000 in the call event. Set up trades to evaluate the test cases in Table 1.

Table 1: Fixed rate bond test cases

Test Case Number	Description	Comments
1.00	*Item removed. Ignore this test case.*	
1.01	5y, quarterly, fixed rate bond paying a coupon of 6%.	Test need only consider MTM value on calibration date (2005/05/05).
1.02	*Item removed. Ignore this test case.*	
1.03	*Item removed. Ignore this test case.*	
1.04	5y, quarterly, fixed rate bond paying a coupon of 6%. Callable at 6m intervals, starting from the 6m point out to the last coupon period (a total of 9 possible exercise dates)	
1.05	5y, quarterly, fixed rate bond paying a coupon of 6%. Callable at 6m intervals, starting from the 1y point out to the last coupon period (a total of 8 possible exercise dates).	See Test Case 1.01 comment.
1.06	As above. Callable at 6m intervals, starting from the 1y6m point out to the last coupon period (a total of 7 possible exercise dates).	See Test Case 1.01 comment.
1.07	As above. Callable at 6m intervals, starting from the 2y point out to the last coupon period (a total of 6 possible exercise dates).	See Test Case 1.01 comment.
1.08	As above Callable at 6m intervals, starting from the 2y6m point out to the last coupon period (a total of 5 possible exercise dates).	See Test Case 1.01 comment.
1.09	As above. Callable at 6m intervals, starting from the 3y point out to the last coupon period (a total of 4 possible exercise dates).	See Test Case 1.01 comment.

Test Case Number	Description	Comments
1.10	As above. Callable at 6m intervals, starting from the 3y6m point out to the last coupon period (a total of 3 possible exercise dates).	See Test Case 1.01 comment.
1.11	As above. Callable at 6m intervals, starting from the 4y point out to the last coupon period (a total of 2 possible exercise dates).	See Test Case 1.01 comment.
1.12	As above. Callable at the 4y6m point (1 possible exercise date).	See Test Case 1.01 comment.
1.13	As above. Callable at the 4y point (1 possible exercise date).	See Test Case 1.01 comment.
1.14	As above. Callable at the 3y6m point (1 possible exercise date).	See Test Case 1.01 comment.
1.15	As above. Callable at the 3y point (1 possible exercise date).	See Test Case 1.01 comment.
1.16	As above. Callable at the 2y6m point (1 possible exercise date).	See Test Case 1.01 comment.
1.17	As above. Callable at the 2y point (1 possible exercise date).	See Test Case 1.01 comment.
1.18	As above. Callable at the 1y6m point (1 possible exercise date).	See Test Case 1.01 comment.
1.19	As above. Callable at the 1y point (1 possible exercise date).	See Test Case 1.01 comment.
1.20	As above. Callable at the 6m point (1 possible exercise date).	See Test Case 1.01 comment.
1.21	As above. Callable at 6m intervals, starting from the 6m point out to the 4y point (a total of 8 possible exercise dates).	See Test Case 1.01 comment.
1.22	As above. Callable at 6m intervals, starting from the 6m point out to the 3y6m point (a total of 7 possible exercise dates).	See Test Case 1.01 comment.

Test Case Number	Description	Comments
1.23	As above. Callable at 6m intervals, starting from the 6m point out to the 3y point (a total of 6 possible exercise dates).	See Test Case 1.01 comment.
1.24	As above. Callable at 6m intervals, starting from the 6m point out to the 2y6m point (a total of 5 possible exercise dates).	See Test Case 1.01 comment.
1.25	As above. Callable at 6m intervals, starting from the 6m point out to the 2y point (a total of 4 possible exercise dates).	See Test Case 1.01 comment.
1.26	As above. Callable at 6m intervals, starting from the 6m point out to the 1y6m point (a total of 3 possible exercise dates).	See Test Case 1.01 comment.
1.27	As above. Callable at 6m intervals, starting from the 6m point out to the 1y point (a total of 2 possible exercise dates).	See Test Case 1.01 comment.

Expected results

We expect to see the bond get successively cheaper as we add call points. Thus we expect the following conditions to hold (where [n.nn] means the result of Test Case n.nn):

- [1.12] ≥ [1.11] ≥ [1.10] ≥ [1.09] ≥ [1.08] ≥ [1.07] ≥ [1.06] ≥ [1.05] ≥ [1.04]
- min([1.12],…,[1.20]) ≥ [1.04]
- min([1.12],…,[1.19]) ≥ [1.05]
- min([1.12],…,[1.18]) ≥ [1.06]
- min([1.12],…,[1.17]) ≥ [1.07]
- min([1.12],…,[1.16]) ≥ [1.08]
- min([1.12],…,[1.15]) ≥ [1.09]
- min([1.12],…,[1.14]) ≥ [1.10]
- min([1.12], [1.13]) ≥ [1.11]
- [1.20] ≥ [1.27] ≥ [1.26] ≥ [1.25] ≥ [1.24] ≥ [1.23] ≥ [1.22] ≥ [1.21] ≥ [1.04]
- min([1.13],…,[1.20]) ≥ [1.21]
- min([1.14],…,[1.20]) ≥ [1.22]
- min([1.15],…,[1.20]) ≥ [1.23]
- min([1.16],…,[1.20]) ≥ [1.24]
- min([1.17],…,[1.20]) ≥ [1.25]
- min([1.18],…,[1.20]) ≥ [1.26]
- min([1.19], [1.20]) ≥ [1.27]

Verify all test cases above for the MTM value on the first date (2005/05/05).

3 EUROPEAN SWAPTION PRICES VERSUS ANALYTIC RESULTS

This test compares European swaption prices found by the finite difference solution to prices found by an analytic approach. For these test cases, enter a funding leg paying 3-month USD LIBOR. Set up trades to evaluate the test cases in Table 2.

Table 2: European callable swap test cases

Test Case Number	Description	Comments
2.01	As above. Callable at the 4y6m point (1 possible exercise date).	Test need only consider MTM value on calibration date (2005/05/05).
2.02	As above. Callable at the 4y point (1 possible exercise date).	See Test Case 2.01 comment.
2.03	As above. Callable at the 3y6m point (1 possible exercise date).	See Test Case 2.01 comment.
2.04	As above. Callable at the 3y point (1 possible exercise date).	See Test Case 2.01 comment.
2.05	As above. Callable at the 2y6m point (1 possible exercise date).	See Test Case 2.01 comment.
2.06	As above. Callable at the 2y point (1 possible exercise date).	See Test Case 2.01 comment.
2.07	As above. Callable at the 1y6m point (1 possible exercise date).	See Test Case 2.01 comment.
2.08	As above. Callable at the 1y point (1 possible exercise date).	See Test Case 2.01 comment.
2.09	As above. Callable at the 6m point (1 possible exercise date).	See Test Case 2.01 comment.

For all test cases above, show that the FD value converges to the analytic value as the number of grid points increases. Analytic solutions can be obtained from the calibrated G2++ model.

4 FIXED RANGE ACCRUAL TESTS

For these test cases, enter a funding leg with zero notional so that the funding leg is nonexistent, and add a notional payment at the end of the trade (range accrual bond trade). Set up trades to value the test cases in Table 3.

Table 3: Fixed range accrual test cases

Test Case Number	Description	Comments
3.00	5y, quarterly, 'open' range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is below -3 %.	MTM prices on all PFE dates should be calculated and compared. These tests should hold for all dates.
3.01	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between-3 to 0 %.	See Test Case 3.00 comment.
3.02	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between 0 to 3 %.	See Test Case 3.00 comment.
3.03	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between 3 to 6 %.	See Test Case 3.00 comment.
3.04	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between 6 to 9 %.	See Test Case 3.00 comment.
3.05	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between 9 to 12 %.	See Test Case 3.00 comment.
3.06	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between 12 to 30 %.	See Test Case 3.00 comment.
3.06a	5y, quarterly, 'open' range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is above 30 %.	See Test Case 3.00 comment.
3.07	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between –3 to 3 %.	See Test Case 3.00 comment.
3.08	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between –3 to 6 %.	See Test Case 3.00 comment.
3.09	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between –3 to 9 %.	See Test Case 3.00 comment.

Test Case Number	Description	Comments
3.10	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between –3 to 12 %.	See Test Case 3.00 comment.
3.11	5y, quarterly, range accrual, accruing at a fixed rate of 6% each day when 3m LIBOR is between –3 to 30 %.	See Test Case 3.00 comment.

Expected results

We expect to see that the coupons of Test Cases 3.00 to 3.06a add up to the coupons from 1.01, and we expect to see that the cumulative sum of 3.01 to 3.06 adds up to 3.07, 3.08, and so on.

That is, in equation form, check the following conditions:

[3.00] + [3.01] + [3.02] + [3.03] + [3.04] + [3.05] + [3.06] + [3.06a] = [1.01]

[3.01] + [3.02] = [3.07]

[3.01] + [3.02] + [3.03] = [3.08]

[3.01] + [3.02] + [3.03] + [3.04] = [3.09]

[3.01] + [3.02] + [3.03] + [3.04] + [3.05] = [3.10]

[3.01] + [3.02] + [3.03] + [3.04] + [3.05] + [3.06] = [3.11]

Perform this comparison for the MTM prices on all PFE dates.

5 CALLABLE RANGE ACCRUAL TESTS

Use the range accrual bond as above, and add a redemption value to the call event. Set up trades to value the test cases in Table 4.

Table 4: Callable range accrual test cases

Test Case Number	Description	Comments
4.01	5y, quarterly, range accrual, accruing at a fixed rate of 6% when 3m LIBOR is between 3 to 6 %. Callable at 6m intervals, starting from the 6m point out to the last coupon period (a total of 9 call points).	Test need only consider MTM value on calibration date (2005/05/05).
4.02	As above. Callable at 6m intervals, starting from the 1y point out to the last coupon period (a total of 8 call points).	See Test Case 4.01 comment.
4.03	As above. Callable at 6m intervals, starting from the 1y6m point out to the last coupon period (a total of 7 call points).	See Test Case 4.01 comment.
4.04	As above. Callable at 6m intervals, starting from the 2y point out to the last coupon period (a total of 6 call points).	See Test Case 4.01 comment.
4.05	As above. Callable at 6m intervals, starting from the 2y6m point out to the last coupon period (a total of 5 call points).	See Test Case 4.01 comment.
4.06	As above. Callable at 6m intervals, starting from the 3y point out to the last coupon period (a total of 4 call points).	See Test Case 4.01 comment.
4.07	As above. Callable at 6m intervals, starting from the 3y6m point out to the last coupon period (a total of 3 call points).	See Test Case 4.01 comment.
4.08	As above. Callable at 6m intervals, starting from the 4y point out to the last coupon period (a total of 2 call points).	See Test Case 4.01 comment.
4.09	As above. Callable at 6m intervals, starting from the 4y6m point out to the last coupon period (a total of 1 call point).	See Test Case 4.01 comment.

Expected results

We expect to see the bond get successively cheaper as we add call points. Thus we expect the following condition to hold:

[3.03] ≥ [4.09] ≥ [4.08] ≥ [4.07] ≥ … ≥ [4.01]

For these test cases, consider the MTM prices only on the calibration date, 2005/05/05.

Perform Test Cases 3.*nn* and 4.*nn* for both the analytic and daily stepping range accrual events. Compare the value obtained for each test case with the two events. We expect the difference in the prices to be <0.3% of the notional.

6 SWAPTION VERSUS CALLABLE SWAP AND MTM VALUATION

For the following test, assume a quarterly funding leg that pays 3-month USD LIBOR. Value the trades in Table 5 with no call and with the call to show that the difference between the two is equivalent to the value of the opposite swaption. To value the opposite swaption, set `strPayReceive` to `Receive` and `strOptionType` to `Swaption` in the trades file.

Table 5: Swaption versus callable swap test cases

Test Case Number	Description	Comments
5.01	5y, quarterly, range accrual, accruing at a fixed rate of 6% when 3m LIBOR is between 3 to 6 %. Callable at 6m intervals, starting from the 6m point out to the last coupon period (a total of 9 call points).	MTM prices on all PFE dates should be calculated and compared. These tests should hold for all dates.
5.02	5y, quarterly, fixed rate bond paying a coupon of 6%. Callable at 6m intervals, starting from the 6m point out to the last coupon period (a total of 9 possible exercise dates).	See Test Case 5.01 comment.
5.03	5y, quarterly, floating rate bond paying a coupon of 9%-3month libor. Callable at 6m intervals, starting from the 6m point out to the last coupon period (a total of 9 possible exercise dates).	See Test Case 5.01 comment.

Check the equivalence for MTM prices on all PFE dates.

APPENDIX A. ABBREVIATIONS

FD	Finite difference
LIBOR	London interbank offer rate
MTM	Mark to market
PFE	Potential future exposure