



A DIVISION OF ANDREW KALOTAY ASSOCIATES, INC.

Creating a Live Yield Curve In the Illiquid Muni Market

- Andrew Kalotay -



Hutchins Center
on Fiscal & Monetary Policy
at BROOKINGS

BRANDEIS INTERNATIONAL
BUSINESS SCHOOL

Rosenberg Institute
of Global Finance



Washington University in St. Louis
OLIN BUSINESS SCHOOL



6th Annual Municipal Finance Conference
Washington, DC, July 17, 2017

Real-Time US Treasury Yields

US On/Off The Run Sovereign Curve

US On/Off The Run Sovereig Actions 98 Chart Setting

X-Axis Tenor Y-Axis Mid YTM Currency None PCS BGN

Specific mm/dd/yy Relative Last 1D 1W 1M Modify

● Values and Members ● Values ● Members ● Constituents

Export

Tenor	Description	Price	Yield	Source	Update
11) 1M	B 0 07/20/17 Govt	0.832	0.845	BGN	15:32
12) 3M	B 0 09/21/17 Govt	0.973	0.988	BGN	15:32
13) 6M	B 0 12/21/17 Govt	1.103	1.124	BGN	15:32
14) 1Y	B 0 06/21/18 Govt	1.190	1.218	BGN	15:33
15) 2Y	T 1 $\frac{3}{4}$ 05/31/19 Govt	99-25 $\frac{7}{8}$	1.350	BGN	15:33
16) 3Y	T 1 $\frac{1}{2}$ 06/15/20 Govt	100-00 $\frac{1}{8}$	1.499	BGN	15:33
17) 4Y	T 1 $\frac{3}{8}$ 05/31/21 Govt	98-27 $\frac{3}{4}$	1.673	BGN	15:33
18) 5Y	T 1 $\frac{3}{4}$ 05/31/22 Govt	99-28 $\frac{7}{8}$	1.771	BGN	15:33
19) 6Y	T 1 $\frac{5}{8}$ 05/31/23 Govt	98-14	1.904	BGN	15:33
20) 7Y	T 2 05/31/24 Govt	100-02 $\frac{3}{4}$	1.987	BGN	15:33
21) 8Y	T 2 $\frac{1}{8}$ 05/15/25 Govt	100-13	2.069	BGN	15:33
22) 9Y	T 1 $\frac{5}{8}$ 05/15/26 Govt	95-28+	2.135	BGN	15:33
23) 10Y	T 2 $\frac{3}{8}$ 05/15/27 Govt	101-29 $\frac{1}{4}$	2.159	BGN	15:33
24) 25Y	T 3 05/15/42 Govt	105-23	2.084	BGN	15:33
27) 30Y	T 3 05/15/47 Govt	105-17 $\frac{1}{4}$	2.728	BGN	15:33

Source: Bloomberg

Real-Time UST Yield Curve



Source: Bloomberg

How About the Muni Market?

Large but illiquid

Small issue sizes, little trading after issuance

Trades reported within 15 minutes to regulator MSRB/EMMA

Common structure: Serial issue of 5% bonds, callable at par after 10 years (5% NC-10)

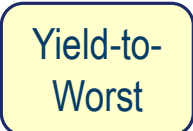
Issued at a significant premium

No live yield curve

Although needed for a wide range of purposes

Typical Recent Municipal Issue

\$78,265,000
STATE OF OREGON
OREGON FACILITIES AUTHORITY
REVENUE REFUNDING BONDS
(Samaritan Health Services Project)
2016 Series A

Maturity Schedule						
Maturity Date (October 1)	Principal Amount	Interest Rates	Yield	Price	CUSIP [†]	
2024	\$1,155,000	5.000%	2.280%	119.503	68608JVU2	
2025	1,440,000	5.000	2.560	119.258	68608JVV0	
2026	3,580,000	5.000	2.720	119.625	68608JWV8	
2027	3,775,000	5.000	2.870	118.199*	68608JVX6	
2028	3,965,000	5.000	2.970	117.260*	68608JVY4	
2029	1,885,000	5.000	3.050	116.515*	68608JVZ1	
2030	1,975,000	5.000	3.130	115.776*	68608JWA5	
2031	7,430,000	5.000	3.200	115.133*	68608JWB3	
2032	7,970,000	5.000	3.260	114.586*	68608JWC1	
2036	1,095,000	5.000	3.390	113.411*	68608JWG2	

\$19,685,000, 5.000% Term Bonds due October 1, 2035, Yield 3.380%, Price 113.501*, CUSIP[†]68608JWF4

\$7,800,000, 5.000% Term Bonds due October 1, 2041, Yield 3.500%, Price 112.428*, CUSIP[†]68608JWH0

\$16,510,000, 5.000% Term Bonds due October 1, 2046, Yield 3.530%, Price 112.162*, CUSIP[†]68608JWJ6

Why 5% NC-10?

Issuers: Show large savings from refunding

- Call option at issuance is deep in the money

- Bonds are usually eligible for advance refunding

Institutional investors: Avoid undesirable mark-to-market treatment if rates rise

- Prices of bonds selling at a discount are further depressed by tax payable at maturity by marginal buyer

- Bonds issued at a high premium are unlikely to fall below par

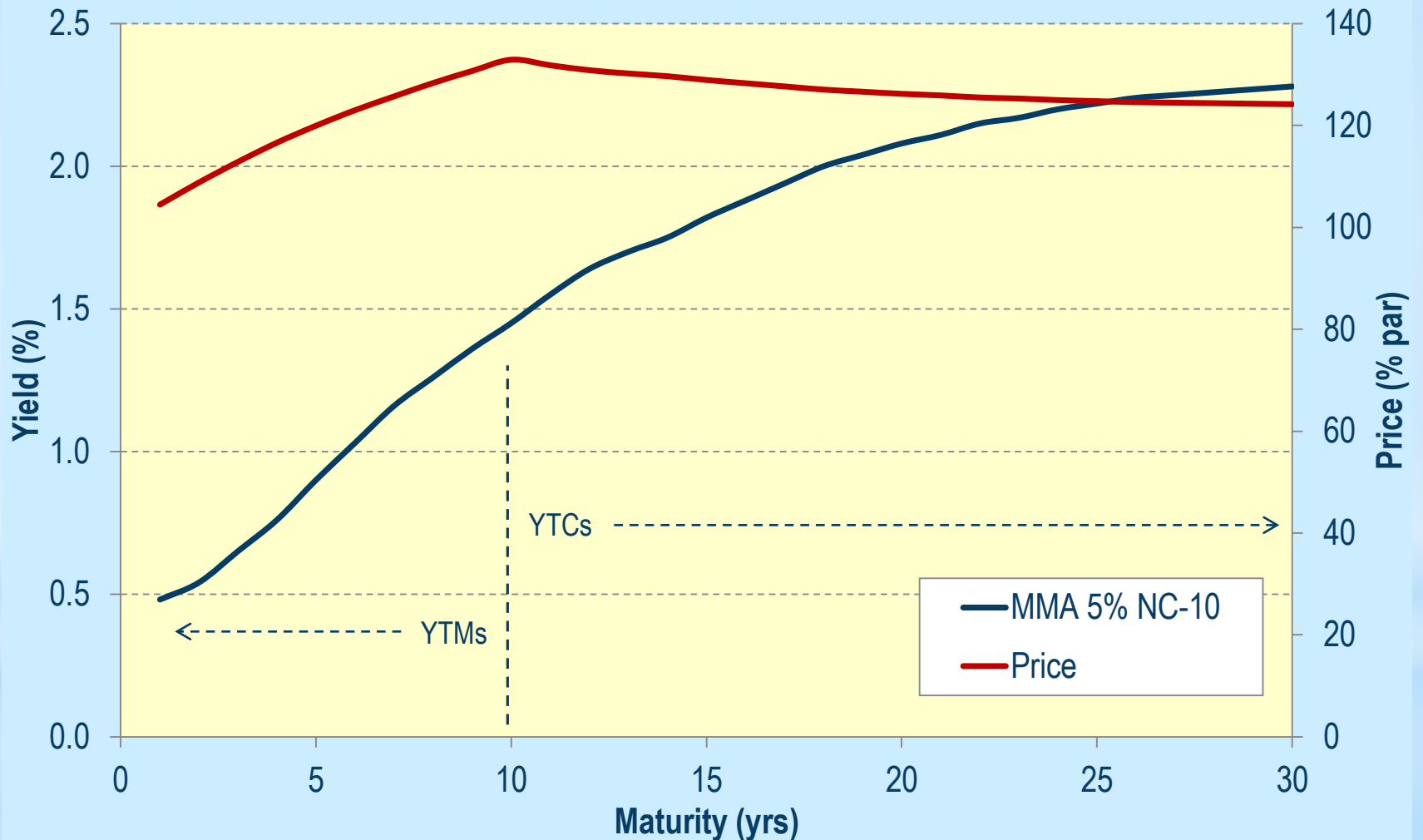
Benchmark Curves Represent Yields of 5% NC-10 Bonds

Because 5% NC-10 is the standard structure
Used to be par NC-10

Curves distributed by several vendors, once or twice daily
MMA and MMD are best known
Bloomberg curve represents yields of 5% *optionless* bonds

Yields obtained by surveying major market participants
and using trade data from EMMA
Process not transparent

Typical 5% NC-10 Yield Curve And Corresponding Prices



Problems with Callable Benchmark Curves

Fail to be arbitrage free: *Prices of 5% callable bonds should decline with maturity*

Increasing yields do not assure declining prices

Implied optionless (NCL) curve not credible: Smooth callable curve implies *kink in optionless curve*

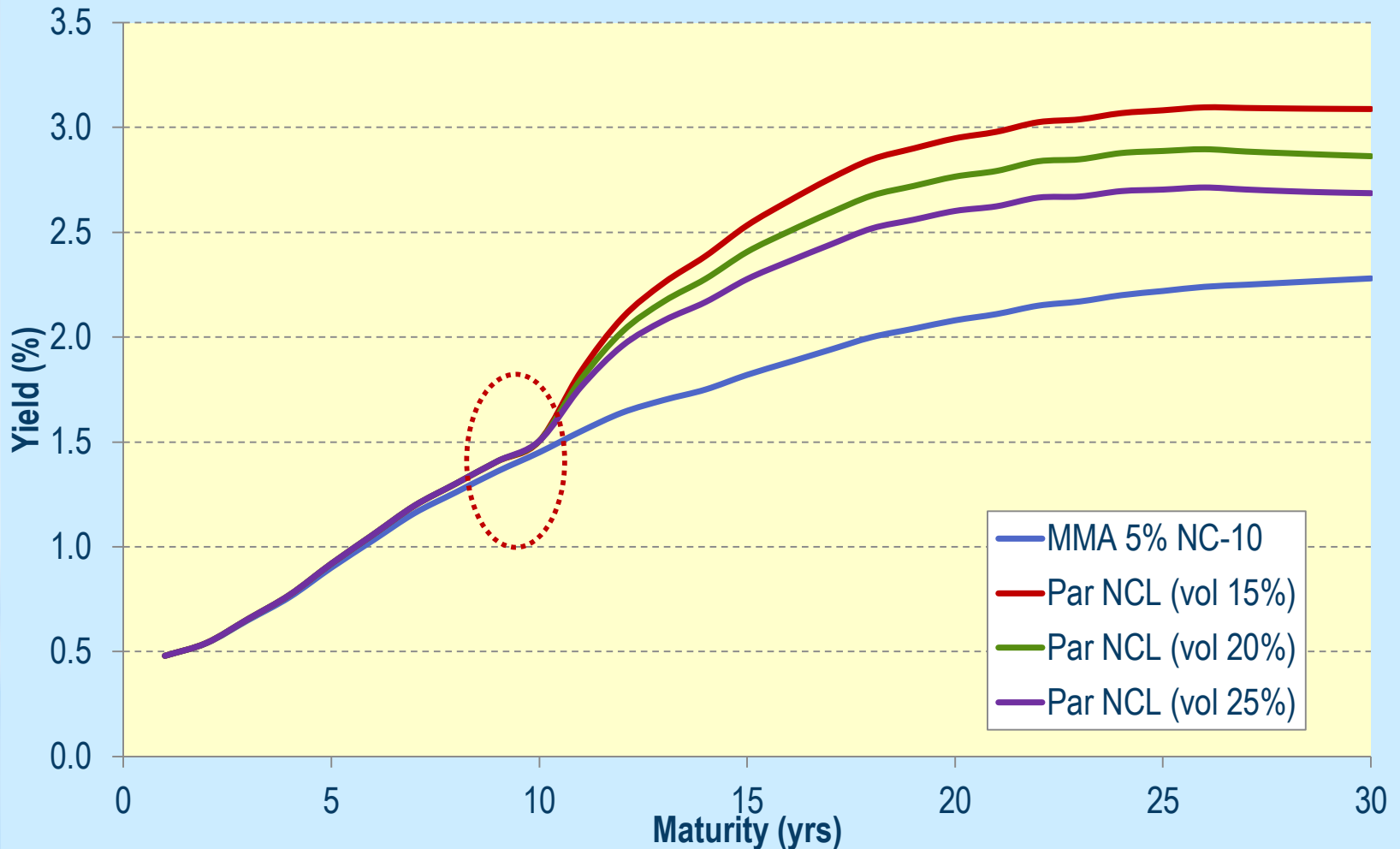
Usage: Analysts fail to 'strip out' call option

Should use optionless curve

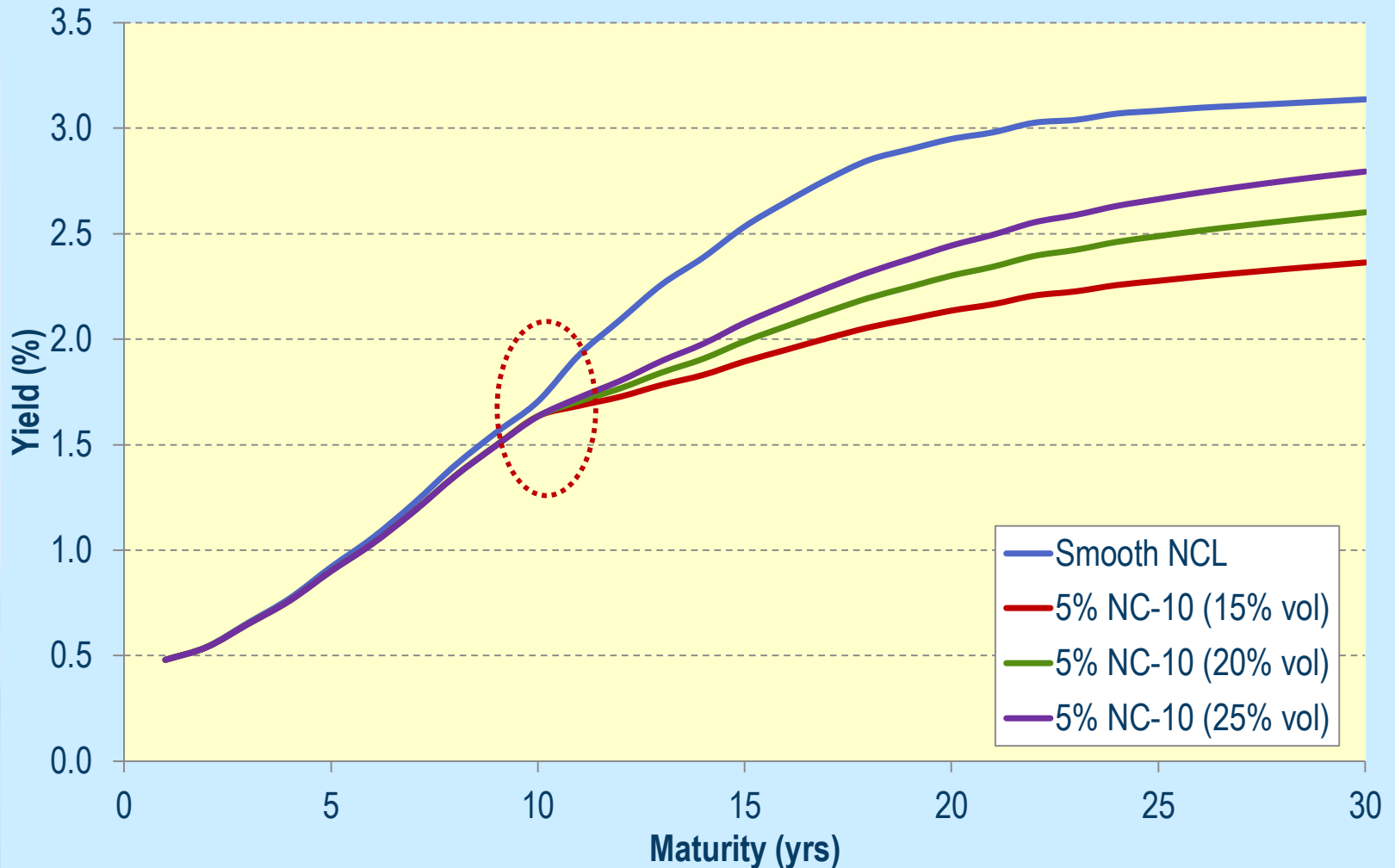
Results based on callable benchmark are misleading

Examples follow

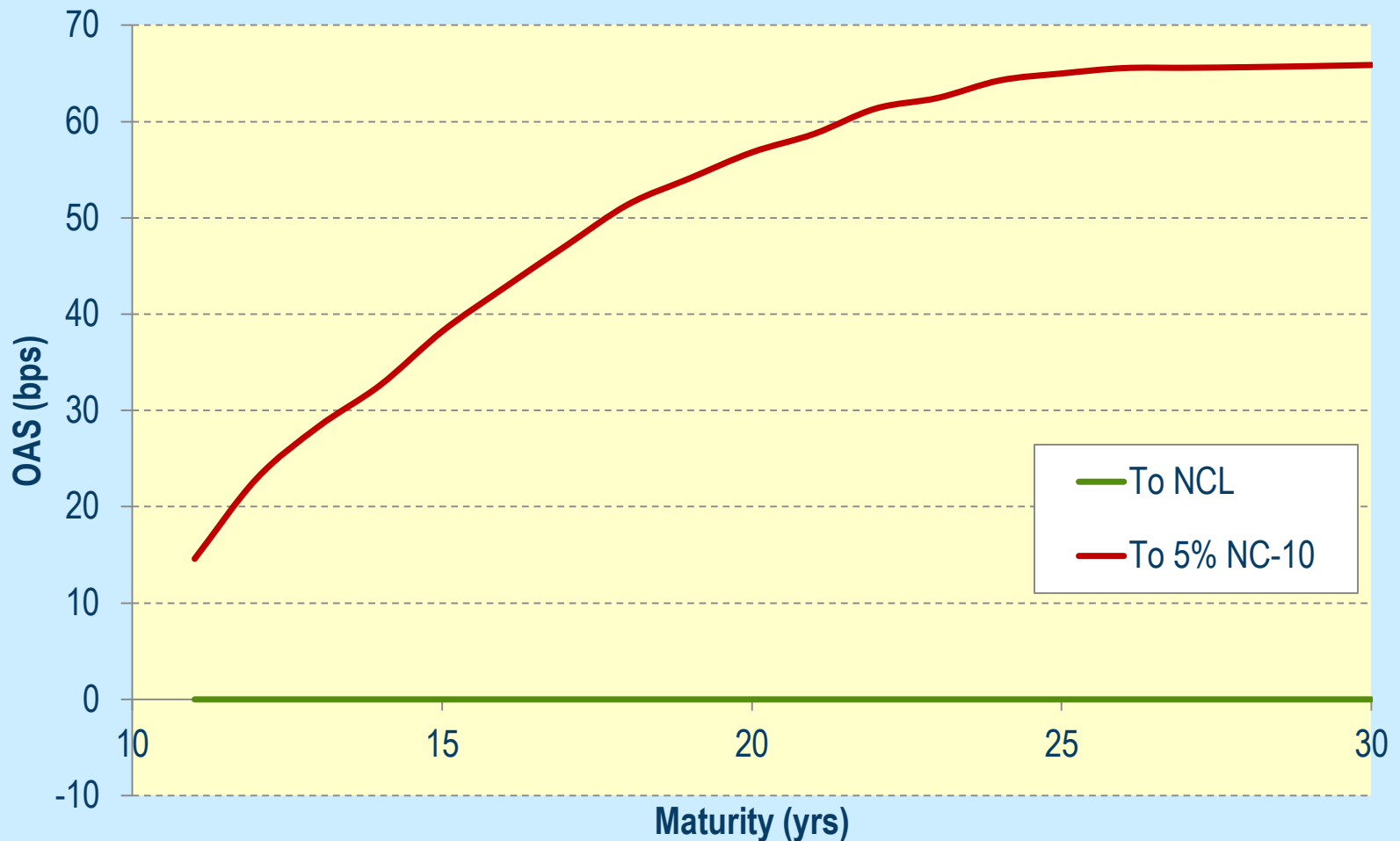
Smooth Callable Curve Implies Kink in Optionless Curve



Smooth Optionless Curve Implies Kink In Callable Curve



Spreads of Benchmark Bonds to Callable Curve Are Nonsensical



The AP/MBIS Yield Curves

Benchmark curve derived from 'ask' prices posted by several dealers for roughly 4,000 investment-grade bonds

Bonds updated monthly

Selection, prices, and curve construction fully documented

Rigorous, automated process; uses CurviLinear™ methodology

Credit-specific and optionless curves also reported

Calculated and disseminated hourly

Plans call for greater frequency

Distributed to financial institutions, the press, and to the public (by AP, via third party tools)

CurviLinear™ Methodology

- ① Solve for *optionless par yield* curve that prices bonds as closely as possible to the input prices
Multidimensional nonlinear regression using Google's open source Ceres Solver
- ② Derive 5% NC10 curve from optionless par curve
YTW's of fairly priced 5% NC10 bonds

All prices, including call option values, computed using standard bond analytics (Black-Karasinski process with 15% vol, tax-neutral OAS)

Work in progress:

Improve fit by solving for par curve and volatility simultaneously

Build volatility surface – by maturity and lock-out

E.g. Vol of 5% bond maturing in 15 years callable in 8 years is 17.3%

AP Municipal Benchmark Curve

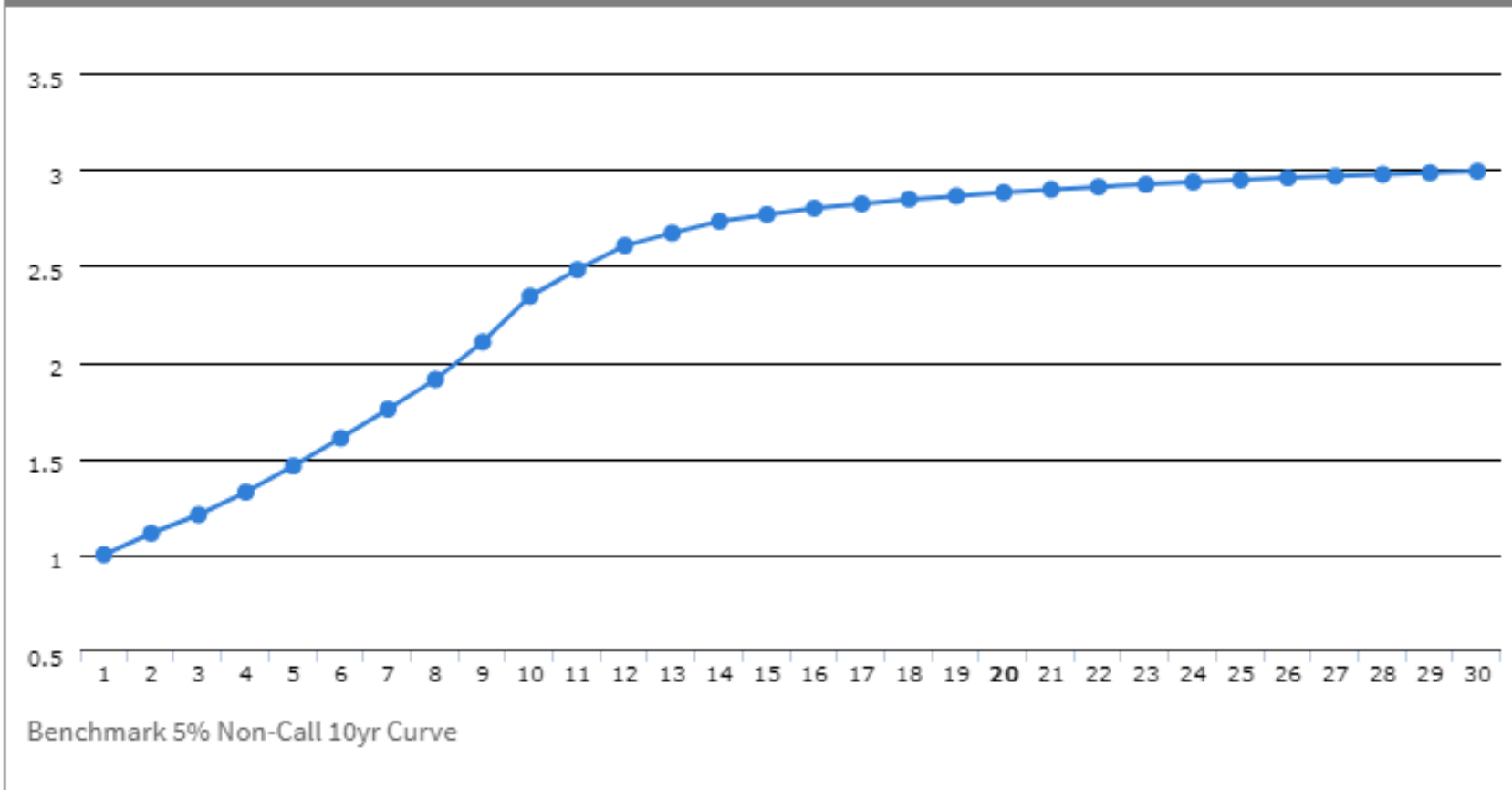
Powered by MBIS and Kalotay Analytics

Date: 07/06/2017

Curve: Benchmark

Rates as of 01:00 PM

AP Tax Exempt Municipal Benchmark Yields



AP Municipal AAA N/C Curve

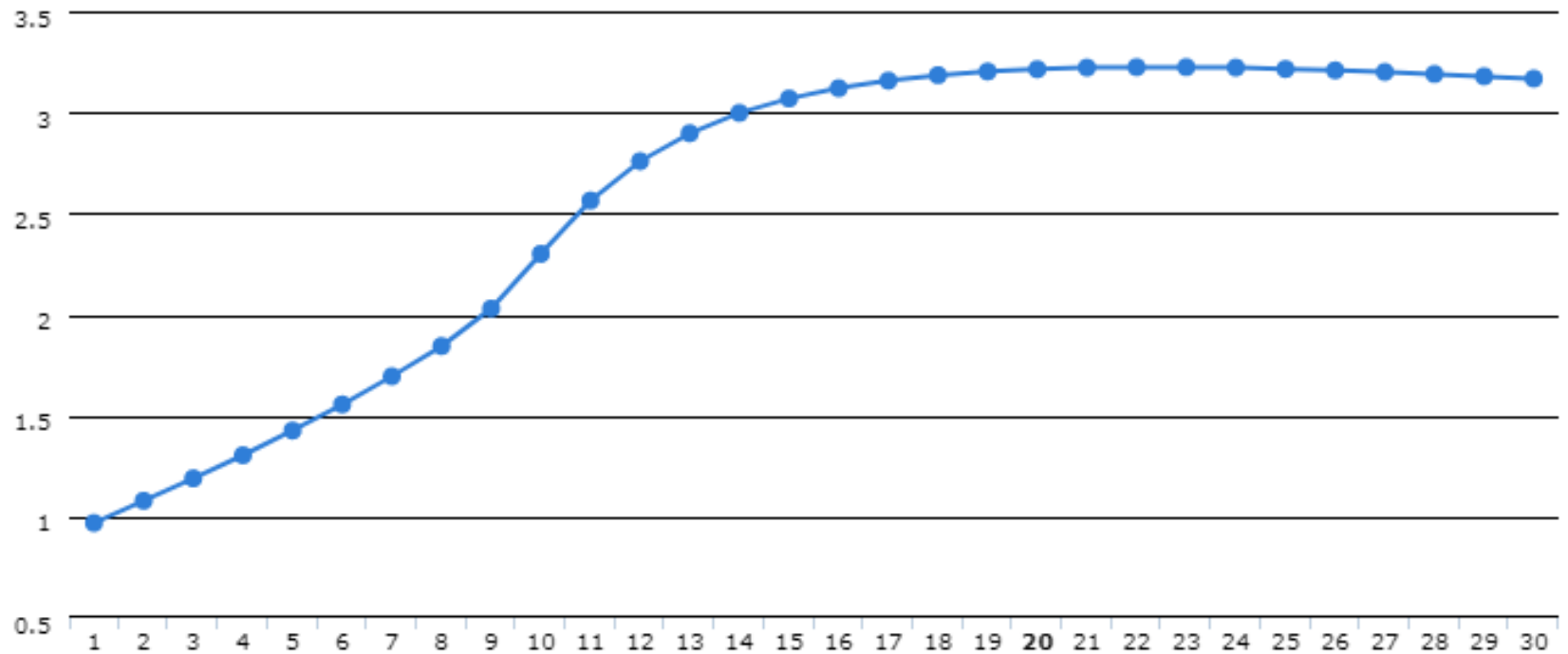
Powered by MBIS and Kalotay Analytics

Date: 07/06/2017

Curve: AAA N/C

Rates as of 01:00 PM

AP Tax Exempt Municipal AAA N/C Yields



AAA N/C Par Equivalent Non-Call Curve

In Summary

Muni market has lacked a live benchmark yield curve

Standard curves represent yields of hypothetical 5% callable bonds

Opaque process, often defective and misused

New AP/MBIS curves are derived from ask prices of selected bonds across maturity spectrum

Methodology transparent

Currently updated hourly

Approach allows for ongoing enhancements

More frequent updates

Interest rate volatility surface

Contact Information

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