TAB: BOND PARAMETERS

Bond terms

General parameters

Parameter	Value	Description
T	10.00	Term to maturity
dt	2.00	Time increment
principal	100.0	Bond principal amount
coupon-rate	5.0%	Coupon / dividend rate
coupon-frequency	1	Coupon payment frequency (measured in the # of tree periods)
n	6	Number of periods in the tree that measure the bond life

Interest deferral

Parameter	Value	Description
interest deferral period	0	The latest period until the bond coupon payments are deferred
is compounded	1	1 if deferred interest is compounded and zero otherwise

Bond amortization schedule

Parameter		Value	Description
	1	0%	% of bond amortization in period t=0
	3	0%	% of bond amortization in period t=3
	5	100%	% of bond amortization at maturity
amortization schedule	java.util.LinkedHas		Bond amortization schedule

Bond option parameters

Parameter	Value	Description
option	call	Option type

Bond redemption premium / discount

Parameter		Value	Description
	1	3.00%	Bond redemption premium in period t=0
	2	2.00%	Bond redemption premium in period t=3
	3	1.00%	Bond redemption premium at maturity
redemption premium	java.util.LinkedHas		Premium at which the bond is redeemed if option is exercised

TAB: INTEREST RATE TREE PARAMETERS

Interest rate tree and tree calculator parameters

General parameters

Parameter	Value	Description
Input parameters		
y_0	5.0%	Initial yield rate
μ	0.0%	Drift parameter
σ	1.07%	Standard deviation
Derived parameters		
$(\mu - \sigma^2/2) \times dt$	0.0%	Adjusted one-period drift parameter
$\sigma \times \sqrt{dt}$	1.5%	Size of upward / downward movement

Tree parameters

Parameter	Value	Description
States		
dx-down	4.00	Normalized downward change in state over dt period ($x_{min} = E\ x_T - \Sigma_T \times dx_{down}$)
dx-up	7.00	Normalized upward change in state over dt period ($x_{max} = E\ x_T + \Sigma_T \times dx_{up}$)
X-min	-0.30	Lower boundary on minimum state value
X-max	0.30	Upper boundary on maximum state value
X-count	13	Number of process discrete states $\{x_t\}$
iter-count	10	Number of iterations used to construct σ(T, x) - uniform set of states in period T
Diffusion tree parameter		

Calculator parameters

Parameter	Value	Description
Calculator option parameters		
option	call	Evaluated option
yield-min	-1%	Minimum yield bound in yield binary search estimation
yield-max	20%	Maximum yield bound in yield binary search estimation
yield-iter	10	Maximum number of yield iterations
npv-delta	0.1	Maximum difference between bond cash flow yield-based NPV and bond clean price
Calculator option executed methods		
value-option		Estimate the bond bullet prices and prices in the presence of the option
bond-yields		Estimate the bond bullet yields and yields in the presence of the option

Parameter objects

Parameter	Value	Description
Parameter mappings objects		
States mapping	java.util.Link	State mapping object
Calculator option parameter mapping	java.util.Link	Calculator parameter mapping object
Calculator option executed methods mapping	java.util.Arra	Calculator option executed methods list object

Transition probability functions

Function arguments

Parameter	Value	Description
Diffusion drift and volatility function arguments		
t	0.0	Time period
y	0.0	Process state action
x	0.0	Process state
mu	0.00%	Diffusion drift parameter
sigma	1.07%	Diffusion volatility parameter

Transition probability functions

Diffusion drift and volatility functions (used to construct transition probabilities function)

jkr.parser.lib.jmc.calculator.Calculator@Sun, 24 Jun 2018 12:54:38:608..113443318301897685

```
'mux'    = 'mu';
'sigmax' = 'sigma';

'Fmu'    = FX('mux',    VARS('t', 'y', 'x'));
'Fsigma' = FX('sigmax', VARS('t', 'y', 'x'));
```

Variable name	Variable value	Variable description
Fmu	jkr.parser.lib.jmc.formu	Diffusion drift function object
Fsigma	jkr.parser.lib.jmc.formu	Diffusion dvolatility function object

Transition probability tree structure

Movement direction	a_i	p_i	Restrictions on the mapping coefficients
up	1.732	0.17	$\Sigma\ a_i^2 \times p_i = 1$
zero	0.000	0.67	$\Sigma\ p_i = 1$
down	-1.732	0.17	

Q tree structure: java.util.LinkedHashMa

TAB: INTERIOR RATE TREE MODELING

Controlled diffusion tree inputs and objects

Interest rate tree objects

Diffusion tree

Parameter	Value
T	10
dt	2.00
y_0	5.00%
states	java.util.LinkedHashMap@Sun, 24 Jun 2018 1
process-params	
Fmu	jkr.parser.lib.jmc.formula.objects.function.Co
Fsigma	jkr.parser.lib.jmc.formula.objects.function.Co
Q tree structure	java.util.LinkedHashMap@Sun, 24 Jun 2018 1
parameters	

jeconkr.finance.HW.Derivatives2003.lib.ch23_srm.ShortRateModel@Su

Tree output parameters

Tree keys:	Description
field	Markov tree field
state-value	State values (as a tree)
tree-states	State values (as a list)
Q	Transition probabilities (as array for period t)
P	State probabilities (as a tree)
path-stats	Tree statistics (mean, stdev, quantiles)
Q-drift	Transition probability drift parameter
Q-sigma	Transition probability sigma parameter

Calculator and tree parameter mapping

key	value
t	2
path-avg	
path-stdev	
path-pct	java.util.ArrayList@Sun, 24 Jun 2018 12:54:35:7
Lower percentile	0.25
Upper percentile	0.75

java.util.LinkedHashMa Calculator parameters mapping

Controlled diffusion tree output

Tree states

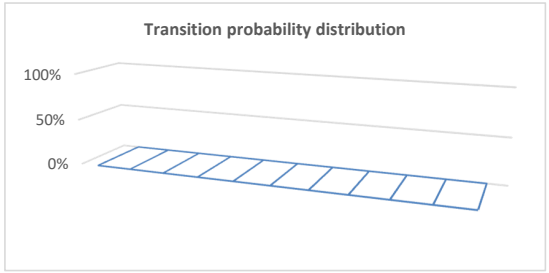
#			time period					
			0	1	2	3	4	5
1		-9.4%						-9.43%
2		-6.6%					-6.57%	-6.57%
3		-3.7%				-3.70%	-3.70%	-3.70%
4		-0.8%			-0.84%	-0.84%	-0.84%	-0.84%
5		2.0%		2.02%	2.02%	2.02%	2.02%	2.02%
6	state	4.9%	**4.89%**	**4.89%**	**4.89%**	**4.89%**	**4.89%**	**4.89%**
7		7.7%		7.75%	7.75%	7.75%	7.75%	7.75%
8		10.6%			10.61%	10.61%	10.61%	10.61%
9		13.5%				13.47%	13.47%	13.47%
10		16.3%					16.34%	16.34%
11		19.2%						19.20%
12		22.1%						
13		24.9%						

Tree state distribution

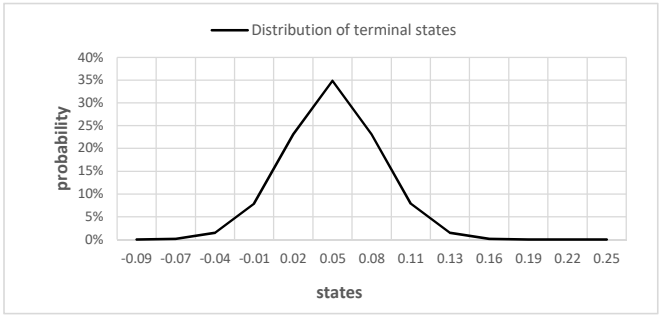
#			time period					
			0	1	2	3	4	5
1		-9.4%						0.000
2		-6.6%					0.000	0.001
3		-3.7%				0.003	0.008	0.014
4		-0.8%			0.020	0.042	0.062	0.078
5		2.0%		0.140	0.201	0.226	0.233	0.231
6	state	4.9%	**1.000**	**0.721**	**0.558**	**0.459**	**0.394**	**0.349**
7		7.7%		0.140	0.201	0.226	0.233	0.231
8		10.6%			0.020	0.042	0.062	0.078
9		13.5%				0.003	0.008	0.014
10		16.3%					0.000	0.001
11		19.2%						0.000
12		22.1%						
13		24.9%						

Transition probabilities

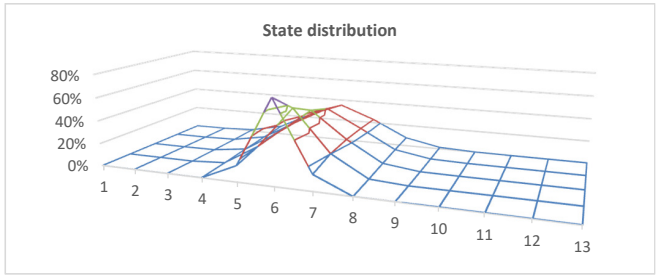
#		t = 2	1	2	3	4	5	6
			x_t					
			0:-0.008	0:0.02	0:0.049	0:0.077		
1		0:0.02			0.140			
2		0:0.049			0.721	0.140		
3		0:0.077			0.140	0.721		
4		0:0.106				0.140		
5		0:0.135						
6	x_{t+1}	1:-0.001	1.000	1.000				
7								
8								
9								
10								
11								



Distribution of terminal states



mean	4.89%
variance	0.114%
standard deviation	3.38%



TAB: INTERIOR RATE TREE CALCULATOR OUTPUT

Interest rate tree output

Interest rate tree calculator objects

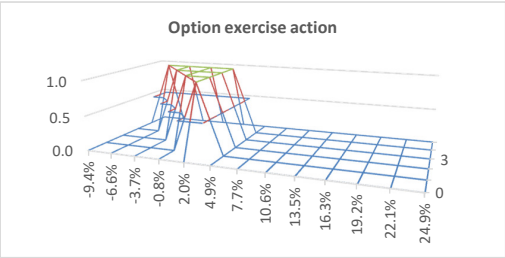
Markov tree calculator

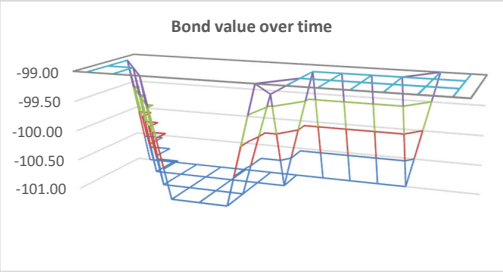
Parameter	Value
Interest rate tree model	jeconkr.finance.HW.Derivatives2003.lib.ch23_srm.Sho
bond cash flows	java.util.LinkedHashMap@Sun, 24 Jun 2018 13:22:19:2
parameters	java.util.LinkedHashMap@Sun, 24 Jun 2018 12:54:35:2
executed methods	java.util.ArrayList@Sun, 24 Jun 2018 12:54:35:739..64

jeconkr.finance.HW.Derivatives2003.lib.ch23_srm.calculator.CalculatorSRM@Sun, 2

Tree calculator output parameters

Tree keys:	Description
field	*Markov tree calculator field*
bond-price	The full (dirty) price of the bond
bond-price-bullet	The full (dirty) bullet price of the bond (option-adjuste
bond-ytm	The bond yield to maturity (based on bond clean price
bond-ytm-bullet	The bond bullet yield to maturity
mode-action	Optimal mode action estimated for the tree
objective	Objective function defined on tree states
discount	Discount function defined on tree states





Bond value in the presence of the option (full value including accrued interest)

#			time period 0	1	2	3	4	5
1		-9.4%						-110.00
2		-6.6%					-111.00	-110.00
3		-3.7%				-111.00	-111.00	-110.00
4		-0.8%			-112.00	-111.00	-111.00	-110.00
5		2.0%		-113.00	-112.00	-111.00	-111.00	-110.00
6	state	4.9%	**-95.67**	**-106.74**	**-107.88**	**-109.00**	**-109.76**	**-110.00**
7		7.7%		-91.52	-95.09	-99.29	-104.21	-110.00
8		10.6%			-82.96	-90.07	-98.97	-110.00
9		13.5%				-81.83	-94.01	-110.00
10		16.3%					-89.34	-110.00
11		19.2%						-110.00
12		22.1%						
13		24.9%						

Option exercise action function

#			time period 0	1	2	3	4	5
1		-9.4%						0
2		-6.6%					1	0
3		-3.7%				1	1	0
4		-0.8%			1	1	1	0
5		2.0%		1	1	1	1	0
6	state	4.9%	**0**	**0**	**0**	**0**	**0**	**0**
7		7.7%		0	0	0	0	0
8		10.6%			0	0	0	0
9		13.5%				0	0	0
10		16.3%					0	0
11		19.2%						0
12		22.1%						
13		24.9%						

Bond bullet value (full value including accrued interest)

#			time period 0	1	2	3	4	5
1		-9.4%						-110.00
2		-6.6%					-135.44	-110.00
3		-3.7%				-148.39	-128.46	-110.00
4		-0.8%			-146.47	-133.98	-121.87	-110.00
5		2.0%		-131.88	-126.49	-121.10	-115.64	-110.00
6	state	4.9%	**-100.01**	**-109.67**	**-109.54**	**-109.59**	**-109.76**	**-110.00**
7		7.7%		-91.76	-95.16	-99.29	-104.21	-110.00
8		10.6%			-82.96	-90.07	-98.97	-110.00
9		13.5%				-81.83	-94.01	-110.00
10		16.3%					-89.34	-110.00
11		19.2%						-110.00
12		22.1%						
13		24.9%						

Option value

#			time period 0	1	2	3	4	5
1		-9.4%						0.000
2		-6.6%					24.439	0.000
3		-3.7%				37.394	17.458	0.000
4		-0.8%			34.474	22.985	10.866	0.000
5		2.0%		18.880	14.486	10.103	4.640	0.000
6	state	4.9%	**4.338**	**2.931**	**1.664**	**0.588**	**0.000**	**0.000**
7		7.7%		0.242	0.070	0.000	0.000	0.000
8		10.6%			0.000	0.000	0.000	0.000
9		13.5%				0.000	0.000	0.000
10		16.3%					0.000	0.000
11		19.2%						0.000
12		22.1%						
13		24.9%						

Objective function (bond cash flow or bond redemption price)

#			time period 0	1	2	3	4	5
1		-9.4%						-220.00
2		-6.6%					-111.00	-220.00
3		-3.7%				-111.00	-111.00	-220.00
4		-0.8%			-112.00	-111.00	-111.00	-220.00
5		2.0%		-113.00	-112.00	-111.00	-111.00	-220.00
6	state	4.9%	**0.00**	**-10.00**	**-10.00**	**-10.00**	**-10.00**	**-220.00**
7		7.7%		-10.00	-10.00	-10.00	-10.00	-220.00
8		10.6%			-10.00	-10.00	-10.00	-220.00
9		13.5%				-10.00	-10.00	-220.00
10		16.3%					-10.00	-220.00
11		19.2%						-220.00
12		22.1%						
13		24.9%						

Discount function

#			time period 0	1	2	3	4	5
1		-9.4%						
2		-6.6%					1.140	
3		-3.7%				1.077	1.077	
4		-0.8%			1.017	1.017	1.017	
5		2.0%		0.960	0.960	0.960	0.960	
6	state	4.9%	**0.907**	**0.907**	**0.907**	**0.907**	**0.907**	
7		7.7%		0.856	0.856	0.856	0.856	
8		10.6%			0.809	0.809	0.809	
9		13.5%				0.764	0.764	
10		16.3%					0.721	
11		19.2%						
12		22.1%						
13		24.9%						

TAB: BOND YIELD RATES AND OPTION PREMIUM

Parameters

principal	100
T	10.00
coupon-rate	5.0%
coupon-frequency	0
dt	2.00

Bond value in the presence of the option

			time period					
#			0	1	2	3	4	5
1		-9.4%						
2		-6.6%					4.46%	
3		-3.7%				4.71%	4.46%	
4		-0.8%			4.60%	4.71%	4.46%	
5		2.0%		4.54%	4.60%	4.71%	4.46%	
6	state	4.9%	**5.59%**	**5.52%**	**5.43%**	**5.29%**	**5.13%**	
7		7.7%		8.34%	8.35%	8.36%	8.39%	
8		10.6%			9.99%	9.99%	9.99%	
9		13.5%				9.99%	9.99%	
10		16.3%					9.99%	
11		19.2%						
12		22.1%						
13		24.9%						

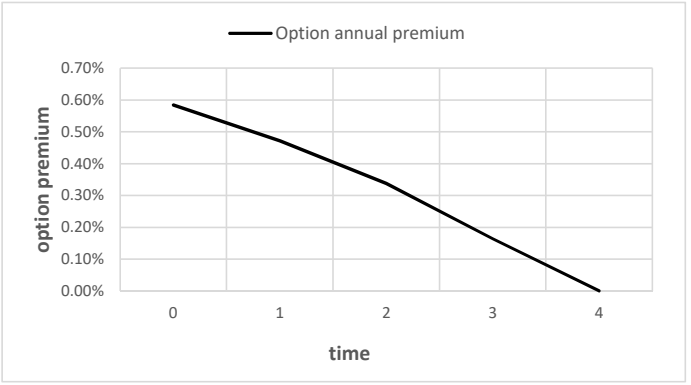
Option annual premium

			time period					
#			0	1	2	3	4	5
1		-9.4%						
2		-6.6%					4.95%	
3		-3.7%				5.21%	4.95%	
4		-0.8%			5.10%	5.21%	4.95%	
5		2.0%		2.55%	2.57%	2.67%	2.39%	
6	state	4.9%	**0.58%**	**0.47%**	**0.34%**	**0.16%**	**0.00%**	
7		7.7%		0.05%	0.01%	0.00%	0.00%	
8		10.6%			0.00%	0.00%	0.00%	
9		13.5%				0.00%	0.00%	
10		16.3%					0.00%	
11		19.2%						
12		22.1%						
13		24.9%						

Bond bullet value

			time period					
#			0	1	2	3	4	5
1		-9.4%						
2		-6.6%					-0.49%	
3		-3.7%				-0.49%	-0.49%	
4		-0.8%			-0.49%	-0.49%	-0.49%	
5		2.0%		1.99%	2.03%	2.05%	2.07%	
6	state	4.9%	**5.00%**	**5.05%**	**5.09%**	**5.12%**	**5.13%**	
7		7.7%		8.29%	8.34%	8.36%	8.39%	
8		10.6%			9.99%	9.99%	9.99%	
9		13.5%				9.99%	9.99%	
10		16.3%					9.99%	
11		19.2%						
12		22.1%						
13		24.9%						

Option premium / discount term structure



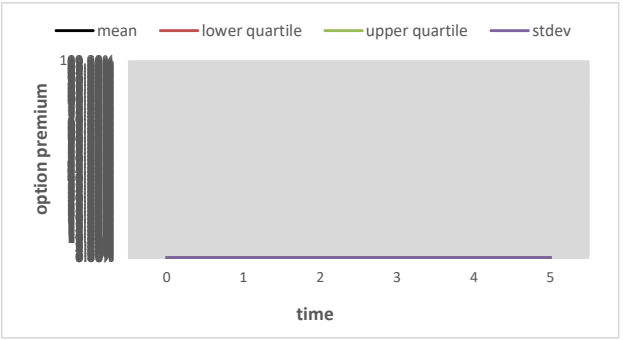
TAB: INTEREST TREE STATISTICS

Parameters

Interest rate tree	jeconkr.finance.H
Tree output parameters	
Field key	path-stats
Parameters	java.util.LinkedHa
Q output parameters	
Q drift field parameter	Q-drift
Q sigma field parameter	Q-sigma

Interest rate tree statistics

Statistics	Parameter	time period					
		0	1	2	3	4	5
mean		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
stdev		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
lower quartile	0.25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
upper quartile	0.75	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%



Interest rate transitional probability statistics

Interest process drift parameter

			time period					
#			0	1	2	3	4	5
1	state	-9.4%	0.00%	0.00%	0.00%	0.00%	0.00%	
2		-6.6%	0.00%	0.00%	0.00%	0.00%	0.00%	
3		-3.7%	0.00%	0.00%	0.00%	0.00%	0.00%	
4		-0.8%	0.00%	0.00%	0.00%	0.00%	0.00%	
5		2.0%	0.00%	0.00%	0.00%	0.00%	0.00%	
6		4.9%	0.00%	0.00%	0.00%	0.00%	0.00%	
7		7.7%	0.00%	0.00%	0.00%	0.00%	0.00%	
8		10.6%	0.00%	0.00%	0.00%	0.00%	0.00%	
9		13.5%	0.00%	0.00%	0.00%	0.00%	0.00%	
10		16.3%	0.00%	0.00%	0.00%	0.00%	0.00%	
11		19.2%	0.00%	0.00%	0.00%	0.00%	0.00%	
12		22.1%	0.00%	0.00%	0.00%	0.00%	0.00%	
13		24.9%	0.00%	0.00%	0.00%	0.00%	0.00%	

Interest process volatility parameter

			time period					
#			0	1	2	3	4	5
1	state	-9.4%	0.00%	0.00%	0.00%	0.00%	0.00%	
2		-6.6%	0.00%	0.00%	0.00%	0.00%	0.00%	
3		-3.7%	0.00%	0.00%	0.00%	0.00%	0.00%	
4		-0.8%	0.00%	0.00%	0.00%	0.00%	0.00%	
5		2.0%	0.00%	0.00%	0.00%	0.00%	0.00%	
6		4.9%	0.00%	0.00%	0.00%	0.00%	0.00%	
7		7.7%	0.00%	0.00%	0.00%	0.00%	0.00%	
8		10.6%	0.00%	0.00%	0.00%	0.00%	0.00%	
9		13.5%	0.00%	0.00%	0.00%	0.00%	0.00%	
10		16.3%	0.00%	0.00%	0.00%	0.00%	0.00%	
11		19.2%	0.00%	0.00%	0.00%	0.00%	0.00%	
12		22.1%	0.00%	0.00%	0.00%	0.00%	0.00%	
13		24.9%	0.00%	0.00%	0.00%	0.00%	0.00%	

TAB: BOND INTEREST AND PRINCIPAL PAYMENTS CASH FLOWS

Bond cash flows inputs

Parameter	Value	Description
first period	0	
bond maturity period	5	
last period	5	Bond principal amount
principal	100.0	Coupon rate
coupon-rate	5.00%	Coupon payment frequency
coupon-frequency	1	
dt	2.00	
interest deferral period	0	Indicator of compounded interest
is compounded	1	Bond amortization schedule
amortization schedule	java.util.LinkedHashMap@Sun, 24 Jun 2018 12:54:35:752..6	
bond redemption premiums	java.util.LinkedHashMap@Sun, 24 Jun 2018 12:54:35:738..5	
bond default redemption premium	0.00%	

java.util.LinkedHashMap@Sun, 24 Jun 2018 13:22:19:205..2304287379002258535

bullet interest payment	10
Discount rate	0.909
	100

Bond cash flows output

period	principal outstanding	principal paid	interest accrued	interest paid	**Total amount paid**	**Redemption value**
0	100.0	0.0	0.00	0.00	**0.00**	**100.00**
1	100.0	0.0	10.00	10.00	**10.00**	**113.00**
2	100.0	0.0	10.00	10.00	**10.00**	**112.00**
3	100.0	0.0	10.00	10.00	**10.00**	**111.00**
4	100.0	0.0	10.00	10.00	**10.00**	**111.00**
5	100.0	100.0	10.00	10.00	**110.00**	**111.00**

TAB: TESTING CODE EXECUTION

Parameter testing

Testing mapping and list input parameters

State mapping

key	value
java.lang.ClassCastExcept	java.lang.ClassCastExc
java.lang.ClassCastExcept	java.lang.ClassCastExc
java.lang.ClassCastExcept	java.lang.ClassCastExc
java.lang.ClassCastExcept	ast to java.util.Map
java.lang.ClassCastExcept	java.lang.ClassCastExc
java.lang.ClassCastExcept	java.lang.ClassCastExc

Calculator methods list object

value-option

Test of state uniform distribution

State	Change in state	Parameter	Value
-0.094		Σ	0.17%
-0.066	2.86%	μ_T	0.00%
-0.037	2.86%	x_0	5.00%
-0.008	2.86%	x_{min}	4.32%
0.020	2.86%	x_{max}	6.18%
0.049	2.86%		
0.077	2.86%		
0.106	2.86%		
0.135	2.86%		
0.163	2.86%		
0.192	2.86%		
0.221	14.91%		
0.249	12.98%		

Testing function input parameters

Probability transition function Q(x)

#	t	y	x	FT(x)
1	0	0	-2	#NAME?
2	1	0	-1	#NAME?
3	1	0	0	#NAME?
4	0	0	1	#NAME?
5	0	0	2	#NAME?
6	0	0	3	#NAME?
7	0	0	4	#NAME?

Testing backward recursion

Tested bond value function

#			5	4	3	2	1	0
1		-9.43%	-110.00					
2		-6.57%	-110.00	-135.44				
3		-3.70%	-110.00	-128.46				
4		-0.84%	-110.00	-121.87				
5		2.02%	-110.00	-115.64				
6	state	4.89%	-110.00	-109.76				
7		7.75%	-110.00	-104.21				
8		10.61%	-110.00	-98.97				
9		13.47%	-110.00	-94.01				
10		16.34%	-110.00	-89.34				
11		19.20%	-110.00					
12		22.06%						
13		24.93%						

Discount rates

4	3	2	1	0
1.140				
1.077				
1.017				
0.960				
0.907				
0.856				
0.809				
0.764				
0.721				

bond cash flow	110.00	10.00	10.00	10.00	10.00	10.00	0.00
bond redemption value	111.00	111.00	111.00	112.00	113.00	100.00	

Difference between calculated and tested values

#			5	4	3	2	1	0
1		-9.43%	-110.00					
2		-6.57%	-110.00	-111.00				
3		-3.70%	-110.00	-111.00				
4		-0.84%	-110.00	-111.00				
5		2.02%	-110.00	-111.00				
6	state	4.89%	-110.00	-109.76				
7		7.75%	-110.00	-104.21				
8		10.61%	-110.00	-98.97				
9		13.47%	-110.00	-94.01				
10		16.34%	-110.00	-89.34				
11		19.20%	-110.00					
12		22.06%						
13		24.93%						

4	3	2	1	0
0.000				
0.000				
0.000				
0.000				
0.000				
0.000				
0.000				
0.000				
0.000				

dt 2.00

#		
1		-9.43%
2		-6.57%
3		-3.70%
4		-0.84%
5		2.02%
6	state	4.89%
7		7.75%
8		10.61%
9		13.47%
10		16.34%
11		19.20%
12		22.06%
13		24.93%

4	3	2	1	0
1.151				
1.080				
1.017				
0.961				
0.911				
0.866				
0.825				
0.788				
0.754				

TAB: CONFIGURATION FILE **Calculation enabled** **TRUE**

Test connection host: home-pc; user: Konstantin Rybakov; key: null

Output array sizes

Maximum size

Object	number of rows	number of cols
Tree dimension	13	6
Transition probabilities	12	7

T	10.00
dt	2.00
n_T	6
X-count	13

Array formula cell address	number of rows	number of cols	Description
'tree'!$H$10	13	6	Tree states
'tree'!$G$10	13	1	Tree list of states
'tree'!$R$10	13	6	Tree probabilities
'tree'!$G$28	6	5	Transition probabilities
'calc'!$H$10	13	6	Option value function
'calc'!$R$10	13	6	Option exercise action value
'yield'!$H$8	13	5	Yields
'yield'!$H$26	13	5	Bullet yields
'calc'!$H$46	13	6	Asset cash flows
'calc'!$R$46	13	5	Discount function
'stats'!$H$8	4	6	Interest tree statistics (mean, stdev, lower and upper quartiles)
'stats'!$H$27	13	5	Interest tree drift parameters
'stats'!$H$45	13	5	Interest tree volatility parameter
'cf'!$H$7	6	6	Bond cash flows

Package: SRM

Interest rate process modelling

The objective of the model is to analyze fixed income securities, specifically bonds. The template allows to set generic parameters for the interest rate tree but generally assumes specific inputs for the calculated bond prices and related interest rate options.

Modelling bond prices

The bond prices are modelled as follows:

1. **The bond terminal value**. The terminal value is generally assumed to be equal to the sum of the outstanding principal value and the accrued interest. The outstanding principal value depends on the (i) time period; (ii) applied amortization schedule; (iii) and exercised options. The accrued interest depends on the (i) time period; (ii) interest payment schedule; and (iii) outstanding balances used as a base for interest calculations.

2. **The bond coupon payments**. The bond coupon payments depend on time period and interest payment terms. Fixed interest payments are assumed (will be extended to variable interest rate).

3. **Redemption price**. The redemption price models the penalty that is applied in the case of bond option exercise. Generally, both call (early prepayment) and put (pay-on-demand) options nvolve a penalty that determines the bond redemption price.

4. **Amortization schedule**. The schedule determines the timing of bond principal repayments. Based on the amortization schedule, the outstanding principal balances are calculated.

Package: SRM

Note: to resize the output arrays, press Ctrl+R

Markov tree objects and output

IMarkovTreeR1 tree = Markov.tree(int T, double x_0, Map states, Object Q);

Construct Markov tree object using the following paarmeters:
T - number of periods
x_0 - initial state,
states - Map: *X-min* - minimum state value, *X-max* - maximum state value; *X-count* - number of states; and *X-type* which is set either to *uniform* or *log-uniform* to describe how the states are generated within the range;
Q - object that describes transition probabilities (typically in the form of a function: (t, x) => {xi => pi} that mapps given period and state (t, x) into a mapping {xi => pi} between next period states and probabilities;

Object[][] out = Markov.get(IMarkovTreeR1 tree, String key, Map<String, Object> params);

Return the value of a given field (referred to bya given key) of the Markov tree using the given set of parameters (if necessary). Keys include:
state-values - an array[][] that describes tree structure (contains a state value in a given cell if the cell belong to the tree or zero otherwise);
Q - returns an array of transition probabilities $Q(x_t, x_{t+1})$ for a given period t;
P - return an array of tree state probabilites