

CS522

Problem Set 4

Due date: Friday May 1st, 1998

This problem set has three parts: the first two require the use of the RiskWatch software (please see Yohan Kim if you have not yet received an account to access the software from either the Computer Science or Theory Center Unix systems). You will need the file cs522. (two files) to complete the first two parts. Details on how to start RiskWatch and on file location are being sent by separate email.*

1. Data specification in RiskWatch

Add the following to the cs522 file:

- (a) Create two models to price a European bond option and an American bond option using the lattice pricing functions supplied with the software (there are two such functions based on the Cox-Ross-Rubinstein model, an extension of the binomial lattice method). Print the models you have just created.
Hint: you may want to use the following models as templates: American Bond Option (clean) and European Bond Option (clean), and modify the pricing functions accordingly.
- (b) Construct a zero coupon bond with the following specifications:
Name: ZCB 1999/11/01
Type: zero coupon bond
Currency: USD
Notional: 100 USD
Maturity date: 1999/11/01
Discount Curve: IRUSD-Govt
State procedure: @zero coupon bond
*Theoretical Model: PV Bond Zero (annual)
- (c) Next, construct a coupon-paying bond with the following specifications:
Name: FRB 6% 1999/11/01
Type: fixed rate bond
Currency: USD
Coupon Rate: 6% semi actual/actual
Notional: 100 USD
Maturity date: 1999/11/01

Discount Curve: IRUSD-Govt
State procedure: @regular fixed day
*Theoretical Model: PV Bond Zero semi-annual

- (d) Next, construct two European call options, one for each bond defined before. Use the following parameters:
Type: European
Currency: USD
Maturity Date: 1998/11/01
Call Option: True
Underlying: “choose the appropriate one”
Strike Price: 100.00 USD
Discount Curve: IRUSD-Govt
Volatility: 10 % CONT actual/actual
Volatility Type: yield vol
*Theoretical Model: European Bond Option (clean)
- (e) Compute (i.e., read off) the present value (i.e., theoretical value) of each of these instruments (you may need to recalculate your results after you enter new data).
- (f) What does an American call option on a zero coupon bond reduce to? You may want to (but do not have to) use the software, and the many instruments the sample file contains for guidance. Give a brief justification for your answer (Hint: think of the possibility of early exercise of the American option in that case).

2. Use of the scenario and optimization modules

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a) Look up the instrument called S&P500 (hint: to view all instruments in the file -shift click the entire filter list, and sort), and briefly describe what this instrument is based on the attributes attached to it (use the Help command liberally!).

(b) Create and name a set of 150 scenarios using a single step Monte Carlo generator, and taking the IRUSD Govt curve as a variable. Use a non-parallel shift type of scenario generation. Plot the scenario set you have just created and print it.

(c) Solve the minimum absolute error tracking problem using the scenario optimization method with the l_1 norm, taking the scenario set just created, together with the following:

target: S&P500 target

Tradeable instruments: S&P500 options.

(d) Find the optimal tracking portfolio (one vector of positions).

(e) Modify the problem by replacing the portfolio optimization method by the risk/reward method (in max(K)/mr(K) mode). Generate the risk/reward curve (you may need to abort the curve generation process if necessary), and analyze it according to the following guidelines: what do points lying on, and on either side of, the frontier represent? By inspection, find the excess profit for the optimal risk-adjusted portfolio(s) on this curve. What is the interpretation of the curve segment lying on the x-axis? Modify the error

definition by using a negative (downside) error only. Recalculate and regenerate the risk/reward curve, and find the optimal portfolio.

3. Optimization model specifications (does not require the software)

Given the following description of the scenario optimization (index tracking) problem,

Input	Variables
n : instruments (scalar)	x^+ : long position vector ($n \times 1$)
m : generated scenarios (scalar)	x^- : short position vector ($n \times 1$)
f : maximum initial cash flow (scalar)	y^+ : positive tracking error vector ($m \times 1$)
τ : value vector of target portfolio ($m \times 1$)	y^- : negative tracking error vector ($m \times 1$)
D : matrix of forecast values ($m \times n$)	
a : ask price vector ($n \times 1$)	
b : bid price vector ($n \times 1$)	
l : lower trading limit vector (non-positive) ($n \times 1$)	
u : upper trading limit vector (non-negative) ($n \times 1$)	
p : scenario probability vector ($n \times 1$)	

(a) Write the scenario optimization problem using minimum regret with the norm l_1 and absolute tracking errors as a linear programming model in vector form. The formulation must include all information in the table above. In particular, it must contain the tracking constraints, it should capture the fact that no more than f units of currency are available to purchase the replicating portfolio, and it should also specify lower and upper bounds l and u on the positions of the instruments. Specify clearly the number of constraints of each type.

(b) We now impose an additional condition on this problem: we must have no more than N instruments in our optimal portfolio ($N \leq n$). Modify the model in (a) to include this condition by using an additional set of variables represented by the $n \times 1$ binary vector z (i.e., each element has a value which is either zero or one, depending on whether or not the instrument is included in the portfolio). Identify the type of optimization problem we now have. What numerical method(s) would you use to solve it ?