Forest management optimization

- *considering biodiversity, global warming and economics goals*

Workshop at: Gorgan University of Agricultural Sciences and Natural Resources (GUASNR), November 2017

Part 2: Optimal adaptive CCF under risk *Version 17-11-06 (Software table updates 171112)*

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Preparations before the workshop starts:

Lecture room preparations:

It is important that the lecture room has PC projector and necessary cables, screen etc.

It is also important that the lecture room has WiFi connection to the internet.

It is also important that the lecture room has a large whiteboard (at least 3 meters wide and one meter high) and pens with different colors. A large ruler (one meter length) makes the graphs and drawings better.

Preparations before the workshop starts:

Individual preparations:

Preparations to be made before the excercises:

During the excercices, we will use QB64.
It is important that the participants have access to laptops where QB64 has already been installed.
This software can be downloaded for free from this link: http://www.qb64.net/
It is also good if the participants have already installed Lingo.
Here is the link: http://www.lindo.com/index.php/products/lingo-and-optimization-modeling .
During the excecises, it is sufficient to have a simple version, which is free, of Lingo installed. Of course, for more advanced problems, a more advanced version is better. Advanced versions of Lingo can however be very expensive.

In the end of this document, you find the ”Workshop references”.
These references contain central theories and methods that will be discussed and used in the sessions. In the schedule, you find the references that are connected to the different sessions. All references may be downloaded from the internet. Please download the references as soon as possible and store them in your computer since internet disturbances may occur some days.

Workshop references of particular relevance to this presentation:

1,3,5,6,12,17,18,22,25,27,29

Background and theory of the

Optimal adaptive CCF under risk problem :

[1] Lohmander, P., **Continuous extraction under risk**, IIASA, International Institute for Applied Systems Analysis, Systems and Decisions Sciences, WP-86-16, March 1986
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[3] Lohmander, P., **Continuous extraction under risk**, SYSTEMS ANALYSIS - MODELLING - SIMULATION, Vol. 5, No. 2, 131-151, 1988
http://www.Lohmander.com/PL_SAMS_5_2_1988.pdf

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http://www.lohmander.com/Moscow_2010/Lohmander_Zazykina_Moscow_2010.ppt
http://www.lohmander.com/Moscow_2010/Programma-LE_10_01.doc

[18] Lohmander, P., Zazykina, L., **Dynamic economical optimization of sustainable forest harvesting in Russia with consideration of energy, other forest products and recreation**, SSAFR-2011, 14th Symposium for Systems Analysis in Forestry, Abstracts, Maitencillo, Chile, March 8-11, 2011,
http://www.lohmander.com/Chile_2011/Chile_2011_Dynamic_Lohmander.ppt

[22] Lohmander, P., **Optimal stochastic control of spatially distributed interdependent production units**, International Conference on Mathematics and Decision Science, International Center of Optimization and Decision Making & Guangzhou University, Guangzhou, China, September 12-15, 2016
http://www.Lohmander.com/PL_BEST_PAPER_AWARD_MATH_2016.jpg
http://www.Lohmander.com/PL_ICODM_2016_CCF.pptx
http://www.Lohmander.com/PL_ICODM_2016_CCF.pdf
http://www.Lohmander.com/PL_ICODM_2016_CCF_PAPER.pdf
http://www.Lohmander.com/PL_ICODM_2016_CCF_PAPER.docx
http://icodm2020.com/en/

[25] Lohmander, P., **Optimal stochastic control in continuous time with Wiener processes: - General results and applications to optimal wildlife management, KEYNOTE**, The 10th International Conference of Iranian Operations Research Society, Balbosar, Iran, May 3-5, 2017
http://www.Lohmander.com/PPT_OR10_PL_KEYNOTE_2017.pptx
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[27] Lohmander, P., Olsson, J.O., Fagerberg, N., Bergh, J., Adamopoulos, S., **High resolution adaptive optimization of continuous cover spruce forest management in southern Sweden**, SSAFR 2017, Symposium on Systems Analysis in Forest Resources, Clearwater Resort, Suquamish, Washington, (near Seattle), August 27-30, 2017
http://www.Lohmander.com/SSAFR_2017_Lohmander_et_al.pptx
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Case

The following model (in QB64) solves the Optimal adaptive CCF under risk problem.

We will investigate this model in every detail and learn to understand how to use QB64.

Later, we will marginally modify the model and investigate how the optimal results change.

```
REM
REM STDP_ex2
REM Peter Lohmander 171022
CLS

OPEN "PLEX2.txt" FOR OUTPUT AS #2

PRINT ""
PRINT " CCF harvest optimization via stochastic dynamic programming"
PRINT " Peter Lohmander Example 1 2017-11-12"
PRINT ""

PRINT #2, ""
PRINT #2, " CCF harvest optimization via stochastic dynamic programming"
PRINT #2, " Peter Lohmander Example 1 2017-11-12"
PRINT #2, ""
```

```
DIM f(100, 10, 15), u(100, 10, 15), DPProb(10), xlevel(15), deltaxlevel(15)
DIM harvset(15, 15)

REM Delta Price Probability distribution
DPProb(0) = .00
DPProb(1) = .03
DPProb(2) = .07
DPProb(3) = .10
DPProb(4) = .18
DPProb(5) = .24
DPProb(6) = .18
DPProb(7) = .10
DPProb(8) = .07
DPProb(9) = .03
DPProb(10) = .00
```

tmax = 5

deltat = 10
r = 0.03
p0 = 10
p1 = 0.3
p2 = 10
c = 50
Landv = 50

REM Transition matrix determination

REM

http://www.lohmander.com/Moscow_2010/Lohmander_Zazykina_Moscow_2010.ppt

REM dx/dt = alfa*x-beta*xx = (1/20)x-(1/8000)xx

a = 0.05

alfa = 1 / 20

beta = 1 / 8000

REM K = h = alfa / beta

K = alfa / beta

```
x0 = 30
xlevel(0) = x0
deltaxlevel(0) = 0

FOR level = 1 TO 15

    xlevel(level) = 1 / (1 / K + (1 / xlevel(level - 1) - 1 / K) * EXP(-a * deltat))

    deltaxlevel(level) = xlevel(level) - xlevel(level - 1)

NEXT level
```

```
REM GOTO 1
PRINT "     level    xlevel     deltaxlevel"
FOR level = 0 TO 15
   PRINT USING "##########"; level; xlevel(level); deltaxlevel(level)
NEXT level
INPUT zzz
1 REM
```

```
REM Harvest set determination
FOR stocklevel = 0 TO 15
    FOR harvlevel = 0 TO 15
        harvset(stocklevel, harvlevel) = 0
    NEXT harvlevel
NEXT stocklevel
```

```
FOR stocklevel = 1 TO 15
   FOR harvlevel = 0 TO stocklevel
      harvset(stocklevel, harvlevel) = xlevel(stocklevel) - xlevel(stocklevel - harvlevel)
   NEXT harvlevel
NEXT stocklevel
```

```
GOTO 2
FOR stocklevel = 1 TO 15
    PRINT "stocklevel = "; stocklevel; "stock = ";
xlevel(stocklevel)
    PRINT "Harvest alternatives = ";
    FOR harvlevel = 0 TO stocklevel
        PRINT USING "####"; harvset(stocklevel, harvlevel);
    NEXT harvlevel
    PRINT ""
    PRINT ""
NEXT stocklevel

INPUT zzz
2 REM
```

```
FOR t = 0 TO 100
    FOR pricelevel = 0 TO 9
        FOR stocklevel = 0 TO 15
            f(t, pricelevel, stocklevel) = 0
            u(t, pricelevel, stocklevel) = 0
        NEXT stocklevel
    NEXT pricelevel
NEXT t
```

```
REM boundary conditions at tmax
t = tmax * deltat

FOR pricelevel = 0 TO 9
    netp = p0 + p1 * t + p2 * (pricelevel - 5)
    FOR stocklevel = 0 TO 15
        vol = xlevel(stocklevel)
        f(tmax, pricelevel, stocklevel) = EXP(-r * t) * (netp * vol + Landv)
        u(tmax, pricelevel, stocklevel) = vol
        IF f(tmax, pricelevel, stocklevel) < 0 THEN u(tmax, pricelevel, stocklevel) = 0
        IF f(tmax, pricelevel, stocklevel) < 0 THEN f(tmax, pricelevel, stocklevel) = 0

    NEXT stocklevel
NEXT pricelevel
```

```
REM PRINT ""
REM PRINT " f(tmax,pricelevel (=column), stocklevel (=row))"
REM PRINT ""

REM FOR stocklevel = 1 TO 15
REM    FOR pricelevel = 1 TO 9
REM         PRINT USING "######"; f(tmax, pricelevel, stocklevel);
REM     NEXT pricelevel
REM     PRINT ""
REM NEXT stocklevel
REM INPUT zzz
```

```
REM Stochastic dynamic programming via backward recursion

FOR tindex = tmax - 1 TO 0 STEP -1
   t = tindex * deltat
   disc = EXP(-r * t)

   FOR stocklevel = 1 TO 15
      FOR pricelevel = 1 TO 9
         netp = p0 + p1 * t + p2 * (pricelevel - 5)

         fopt = -999999
         uopt = 0
         FOR harvlevel = 0 TO stocklevel
            stocklevel2 = stocklevel + 1 - harvlevel
            IF stocklevel2 > 15 THEN GOTO 1001
            harv = harvset(stocklevel, harvlevel)
            fnow = EXP(-r * t) * (netp * harv - c)
            ffut = 0
            FOR j = 1 TO 9
               ffut = ffut + DPProb(j) * f(tindex + 1, j, stocklevel + 1 - harvlevel)
            NEXT j
            fev = fnow + ffut
            IF fev > fopt THEN uopt = harv
            IF fev > fopt THEN fopt = fev
            1001 REM
         NEXT harvlevel
         f(tindex, pricelevel, stocklevel) = fopt
         u(tindex, pricelevel, stocklevel) = uopt
      NEXT pricelevel
   NEXT stocklevel

NEXT tindex
```

On the following pages, we find these rows in larger size.

```
REM Stochastic dynamic programming via backward recursion

FOR tindex = tmax - 1 TO 0 STEP -1
    t = tindex * deltat
    disc = EXP(-r * t)
```

```
FOR stocklevel = 1 TO 15

    FOR pricelevel = 1 TO 9

        netp = p0 + p1 * t + p2 * (pricelevel - 5)

        fopt = -999999
        uopt = 0
```

```
FOR harvlevel = 0 TO stocklevel
        stocklevel2 = stocklevel + 1 - harvlevel
        IF stocklevel2 > 15 THEN GOTO 1001
        harv = harvset(stocklevel, harvlevel)
        fnow = EXP(-r * t) * (netp * harv - c)
        ffut = 0
        FOR j = 1 TO 9
          ffut = ffut + DPProb(j) * f(tindex + 1, j, stocklevel + 1 - harvlevel)
        NEXT j
        fev = fnow + ffut
        IF fev > fopt THEN uopt = harv
        IF fev > fopt THEN fopt = fev
        1001 REM
      NEXT harvlevel
```

f(tindex, pricelevel, stocklevel) = fopt
u(tindex, pricelevel, stocklevel) = uopt

NEXT pricelevel

NEXT stocklevel

NEXT tindex

```
REM Result tables
PRINT "Optimal decision tables"
PRINT ""
PRINT ""

FOR tindex = 0 TO tmax
   t = tindex * deltat
   PRINT " u(.) when time = "; t
   PRINT ""
   PRINT "Stock     p1    p2    p3    p4    p5    p6    p7    p8    p9   "
   PRINT "------------------------------------------------------------"

   FOR stocklevel = 1 TO 15
      PRINT USING "#####"; xlevel(stocklevel);
      PRINT " _";
      FOR pricelevel = 1 TO 9
         PRINT USING "######"; u(tindex, pricelevel, stocklevel);
      NEXT pricelevel
      PRINT ""
   NEXT stocklevel
   PRINT ""
   PRINT ""
   INPUT z
NEXT tindex

PRINT ""
```

```
PRINT "Optimal result tables"
PRINT ""
PRINT ""
FOR tindex = 0 TO tmax
   t = tindex * deltat
   PRINT " f(.) when time = "; t
   PRINT ""
   PRINT "Stock     p1    p2    p3    p4    p5    p6    p7    p8    p9   "
   PRINT "-----------------------------------------------------------"

   FOR stocklevel = 1 TO 15
      PRINT USING "#####"; xlevel(stocklevel);
      PRINT " _";
      FOR pricelevel = 1 TO 9

         PRINT USING "######"; f(tindex, pricelevel, stocklevel);
      NEXT pricelevel
      PRINT ""
   NEXT stocklevel
   PRINT ""
   PRINT ""
   INPUT z
NEXT tindex
```

```
PRINT #2, "Optimal decision tables"
PRINT #2, ""
PRINT #2, ""

FOR tindex = 0 TO tmax
   t = tindex * deltat
   PRINT #2, " u(.) when time = "; t
   PRINT #2, ""
   PRINT #2, "Stock      p1    p2    p3    p4    p5    p6    p7    p8    p9   "
   PRINT #2, "-----------------------------------------------------------"

   FOR stocklevel = 1 TO 15
      PRINT #2, USING "#####"; xlevel(stocklevel);
      PRINT #2, " _";
      FOR pricelevel = 1 TO 9
         PRINT #2, USING "######"; u(tindex, pricelevel, stocklevel);
      NEXT pricelevel
      PRINT #2, ""
   NEXT stocklevel
   PRINT #2, ""
   PRINT #2, ""
   REM INPUT z
NEXT tindex
```

```
PRINT #2, "Optimal result tables"
PRINT #2, ""
PRINT #2, ""
FOR tindex = 0 TO tmax
   t = tindex * deltat
   PRINT #2, " f(.) when time = "; t
   PRINT #2, ""
   PRINT #2, "Stock     p1    p2    p3    p4    p5    p6    p7    p8    p9   "
   PRINT #2, "---------------------------------------------------------"

   FOR stocklevel = 1 TO 15
      PRINT #2, USING "#####"; xlevel(stocklevel);
      PRINT #2, " _";
      FOR pricelevel = 1 TO 9

         PRINT #2, USING "######"; f(tindex, pricelevel, stocklevel);
      NEXT pricelevel
      PRINT #2, ""
   NEXT stocklevel
   PRINT #2, ""
   PRINT #2, ""
   REM INPUT z
NEXT tindex
```

CLOSE #2

END

CCF harvest optimization via stochastic dynamic programming

Peter Lohmander Example 2 2017-11-12

Optimal decision tables

u(.) when time = 0

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	0	0	0	0	0	17	17
72	_	0	0	0	0	0	0	25	42	42
107	_	0	0	0	0	0	0	59	77	77
150	_	0	0	0	0	0	43	103	120	120
199	_	0	0	0	0	0	92	152	169	169
248	_	0	0	0	0	0	141	201	218	218
291	_	0	0	0	0	0	185	244	261	261
326	_	0	0	0	0	0	220	279	296	296
352	_	0	0	0	0	26	245	305	322	322
369	_	0	0	0	0	43	263	322	339	339
381	_	0	0	0	0	55	274	334	351	351
388	_	0	0	0	0	62	282	341	358	358
393	_	0	0	0	0	66	286	346	363	363
396	_	0	0	0	0	69	289	348	366	366
397	_	2	2	2	2	71	291	350	367	367

u(.) when time = 10

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	0	0	0	0	0	17	17
72	_	0	0	0	0	0	0	25	42	42
107	_	0	0	0	0	0	0	59	77	77
150	_	0	0	0	0	0	43	103	120	120
199	_	0	0	0	0	0	92	152	169	169
248	_	0	0	0	0	0	141	201	218	218
291	_	0	0	0	0	44	185	244	261	261
326	_	0	0	0	0	78	220	279	296	296
352	_	0	0	0	0	104	245	305	322	322
369	_	0	0	0	0	121	263	322	339	339
381	_	0	0	0	0	133	274	334	351	351
388	_	0	0	0	0	140	282	341	358	358
393	_	0	0	0	0	145	286	346	363	363
396	_	0	0	0	0	148	289	348	366	366
397	_	2	2	2	2	149	291	350	367	367

u(.) when time = 20

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	0	0	0	0	0	17	17
72	_	0	0	0	0	0	0	25	42	42
107	_	0	0	0	0	0	0	59	77	77
150	_	0	0	0	0	0	43	103	120	120
199	_	0	0	0	0	0	92	152	169	169
248	_	0	0	0	0	0	141	201	218	218
291	_	0	0	0	0	44	185	244	261	261
326	_	0	0	0	0	78	220	279	296	296
352	_	0	0	0	0	104	245	305	322	322
369	_	0	0	0	0	121	263	322	339	339
381	_	0	0	0	0	133	274	334	351	351
388	_	0	0	0	0	140	282	341	358	358
393	_	0	0	0	0	145	286	346	363	363
396	_	0	0	0	0	148	289	348	366	366
397	_	2	2	2	2	149	291	350	367	367

u(.) when time = 30

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	0	0	0	0	17	17	17
72	_	0	0	0	0	0	0	42	42	42
107	_	0	0	0	0	0	34	77	77	77
150	_	0	0	0	0	0	78	120	120	120
199	_	0	0	0	0	0	127	169	169	169
248	_	0	0	0	0	49	176	218	218	218
291	_	0	0	0	0	93	219	261	261	261
326	_	0	0	0	0	128	254	296	296	296
352	_	0	0	0	0	153	280	322	322	322
369	_	0	0	0	0	171	297	339	339	339
381	_	0	0	0	0	182	309	351	351	351
388	_	0	0	0	0	189	316	358	358	358
393	_	0	0	0	0	194	320	363	363	363
396	_	0	0	0	0	197	323	366	366	366
397	_	2	2	2	2	199	325	367	367	367

u(.) when time = 40

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	0	0	0	17	17	17	17
72	_	0	0	0	0	0	42	42	42	42
107	_	0	0	0	0	0	77	77	77	77
150	_	0	0	0	0	43	120	120	120	120
199	_	0	0	0	0	92	169	169	169	169
248	_	0	0	0	0	141	218	218	218	218
291	_	0	0	0	0	185	261	261	261	261
326	_	0	0	0	0	220	296	296	296	296
352	_	0	0	0	0	245	322	322	322	322
369	_	0	0	0	0	263	339	339	339	339
381	_	0	0	0	0	274	351	351	351	351
388	_	0	0	0	7	282	358	358	358	358
393	_	0	0	0	12	286	363	363	363	363
396	_	0	0	0	15	289	366	366	366	366
397	_	2	2	2	16	291	367	367	367	367

u(.) when time = 50

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	47	47	47	47	47	47	47
72	_	0	0	72	72	72	72	72	72	72
107	_	0	0	107	107	107	107	107	107	107
150	_	0	0	150	150	150	150	150	150	150
199	_	0	0	199	199	199	199	199	199	199
248	_	0	0	248	248	248	248	248	248	248
291	_	0	0	291	291	291	291	291	291	291
326	_	0	0	326	326	326	326	326	326	326
352	_	0	0	352	352	352	352	352	352	352
369	_	0	0	369	369	369	369	369	369	369
381	_	0	0	381	381	381	381	381	381	381
388	_	0	0	388	388	388	388	388	388	388
393	_	0	0	393	393	393	393	393	393	393
396	_	0	0	396	396	396	396	396	396	396
397	_	0	0	397	397	397	397	397	397	397

Optimal result tables

f(.) when time = 0

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	1988	1988	1988	1988	1988	1988	1988	2075	2247
72	_	2705	2705	2705	2705	2705	2705	2741	3078	3500
107	_	3505	3505	3505	3505	3505	3505	3772	4453	5219
150	_	4330	4330	4330	4330	4330	4370	5069	6183	7381
199	_	5101	5101	5101	5101	5101	5349	6536	8139	9827
248	_	5751	5751	5751	5751	5751	6330	8008	10101	12280
291	_	6257	6257	6257	6257	6257	7202	9317	11847	14461
326	_	6621	6621	6621	6621	6621	7899	10362	13240	16203
352	_	6869	6869	6869	6869	6876	8409	11127	14260	17478
369	_	7030	7030	7030	7030	7051	8759	11653	14961	18354
381	_	7132	7132	7132	7132	7166	8989	11998	15421	18929
388	_	7196	7196	7196	7196	7239	9136	12217	15714	19295
393	_	7233	7233	7233	7233	7285	9228	12355	15897	19524
396	_	7250	7250	7250	7250	7314	9284	12440	16010	19666
397	_	7198	7215	7233	7250	7331	9319	12492	16080	19753

f(.) when time = 10

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	1426	1426	1426	1426	1426	1426	1426	1509	1636
72	_	1993	1993	1993	1993	1993	1993	2039	2308	2621
107	_	2637	2637	2637	2637	2637	2637	2880	3403	3970
150	_	3306	3306	3306	3306	3306	3374	3937	4780	5668
199	_	3933	3933	3933	3933	3933	4207	5133	6338	7589
248	_	4471	4471	4471	4471	4471	5043	6332	7901	9515
291	_	4890	4890	4890	4890	4891	5786	7398	9291	11228
326	_	5192	5192	5192	5192	5226	6380	8250	10401	12596
352	_	5397	5397	5397	5397	5472	6814	8874	11213	13597
369	_	5531	5531	5531	5531	5641	7113	9302	11771	14285
381	_	5616	5616	5616	5616	5751	7309	9583	12137	14736
388	_	5669	5669	5669	5669	5822	7434	9762	12371	15024
393	_	5700	5700	5700	5700	5866	7512	9874	12517	15204
396	_	5715	5715	5715	5715	5893	7560	9943	12607	15315
397	_	5681	5694	5706	5719	5910	7590	9986	12662	15383

f(.) when time = 20

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	988	988	988	988	988	988	988	1077	1171
72	_	1421	1421	1421	1421	1421	1421	1483	1710	1941
107	_	1929	1929	1929	1929	1929	1929	2162	2577	2998
150	_	2463	2463	2463	2463	2463	2546	3016	3669	4327
199	_	2972	2972	2972	2972	2972	3244	3983	4904	5830
248	_	3411	3411	3411	3411	3411	3944	4952	6142	7338
291	_	3754	3754	3754	3754	3794	4567	5814	7244	8679
326	_	4000	4000	4000	4000	4100	5064	6502	8123	9749
352	_	4168	4168	4168	4168	4324	5428	7006	8767	10533
369	_	4278	4278	4278	4278	4478	5678	7352	9209	11071
381	_	4347	4347	4347	4347	4579	5842	7579	9499	11425
388	_	4391	4391	4391	4391	4643	5946	7724	9684	11650
393	_	4417	4417	4417	4417	4683	6012	7815	9800	11791
396	_	4430	4430	4430	4430	4708	6052	7871	9872	11878
397	_	4407	4417	4426	4436	4723	6077	7905	9916	11931

f(.) when time = 30

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	655	655	655	655	655	655	688	758	827
72	_	969	969	969	969	969	969	1085	1257	1429
107	_	1347	1347	1347	1347	1347	1375	1630	1942	2253
150	_	1759	1759	1759	1759	1759	1885	2316	2803	3291
199	_	2161	2161	2161	2161	2161	2461	3092	3778	4464
248	_	2510	2510	2510	2510	2540	3040	3869	4755	5641
291	_	2784	2784	2784	2784	2877	3554	4561	5624	6687
326	_	2981	2981	2981	2981	3146	3965	5114	6318	7523
352	_	3116	3116	3116	3116	3343	4266	5518	6826	8135
369	_	3204	3204	3204	3204	3479	4472	5796	7175	8555
381	_	3259	3259	3259	3259	3568	4608	5978	7404	8831
388	_	3294	3294	3294	3294	3624	4694	6094	7550	9006
393	_	3316	3316	3316	3316	3660	4748	6167	7642	9116
396	_	3327	3327	3327	3327	3681	4781	6212	7698	9184
397	_	3312	3320	3327	3334	3695	4802	6239	7733	9226

f(.) when time = 40

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	411	411	411	411	411	432	484	535	587
72	_	609	609	609	609	609	674	801	928	1055
107	_	858	858	858	858	858	1005	1236	1466	1697
150	_	1139	1139	1139	1139	1144	1422	1783	2144	2505
199	_	1422	1422	1422	1422	1468	1893	2401	2910	3418
248	_	1673	1673	1673	1673	1793	2366	3022	3678	4334
291	_	1873	1873	1873	1873	2083	2786	3574	4361	5149
326	_	2020	2020	2020	2020	2313	3122	4015	4907	5799
352	_	2121	2121	2121	2121	2482	3368	4337	5307	6276
369	_	2187	2187	2187	2187	2598	3537	4559	5581	6603
381	_	2229	2229	2229	2229	2675	3648	4704	5761	6817
388	_	2256	2256	2256	2256	2723	3718	4797	5876	6954
393	_	2272	2272	2272	2272	2754	3762	4855	5947	7040
396	_	2282	2282	2282	2283	2772	3790	4891	5992	7093
397	_	2273	2278	2283	2289	2784	3807	4913	6019	7125

f(.) when time = 50

Stock		p1	p2	p3	p4	p5	p6	p7	p8	p9
47	_	0	0	64	169	274	380	485	590	695
72	_	0	0	92	253	414	575	736	898	1059
107	_	0	0	130	368	606	844	1082	1320	1557
150	_	0	0	178	513	847	1182	1516	1850	2185
199	_	0	0	233	676	1120	1563	2007	2450	2894
248	_	0	0	288	841	1394	1947	2500	3053	3605
291	_	0	0	336	987	1637	2287	2938	3588	4238
326	_	0	0	375	1103	1831	2559	3287	4015	4744
352	_	0	0	404	1189	1974	2759	3544	4328	5113
369	_	0	0	423	1247	2071	2895	3719	4543	5367
381	_	0	0	436	1286	2135	2985	3835	4684	5534
388	_	0	0	444	1310	2176	3042	3908	4774	5640
393	_	0	0	449	1326	2202	3078	3954	4831	5707
396	_	0	0	452	1335	2218	3100	3983	4865	5748
397	_	0	0	454	1341	2227	3114	4000	4887	5773

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