1. Framing the portfolio selection problem

1-1) What is the mathematical formulation of the drug development portfolio selection problem?

Objective Function: max $\sum_{i=1}^{114} r_i\, x_i + \{\left(1{,}000 - \sum_{i=1}^{114} c_i\, x_i\right) \times (1 + 0.03)\}$
Decision Variables: $x_i,\ x_i \in \{0, 1\}$
Constraints:

- **Therapeutic area budget constraints**
  - $\sum_{i=1}^{16} \boldsymbol{c_i\, x_i} \leq \mathbf{100}$
  - $\sum_{i=17}^{36} \boldsymbol{c_i\, x_i} \leq \mathbf{200}$
  - $\sum_{i=37}^{53} \boldsymbol{c_i\, x_i} \leq \mathbf{150}$
  - $\sum_{i=54}^{63} \boldsymbol{c_i\, x_i} \leq \mathbf{100}$
  - $\sum_{i=64}^{85} \boldsymbol{c_i\, x_i} \leq \mathbf{300}$
  - $\sum_{i=86}^{103} \boldsymbol{c_i\, x_i} \leq \mathbf{100}$
  - $\sum_{i=104}^{114} \boldsymbol{c_i\, x_i} \leq \mathbf{50}$
- **Pipeline constraints**
  - $\sum \boldsymbol{x_{1year}} \geq \mathbf{0.15} \sum_{i=1}^{114} \boldsymbol{x_i}$
  - $\sum \boldsymbol{x_{2year}} + \sum \boldsymbol{x_{3year}} \geq \mathbf{0.2} \sum_{i=1}^{114} \boldsymbol{x_i}$
  - $\sum \boldsymbol{x_{4year}} + \sum \boldsymbol{x_{5year}} \geq \mathbf{0.25} \sum_{i=1}^{114} \boldsymbol{x_i}$
- where $\boldsymbol{x_i}\ is\ drugs, \boldsymbol{r_i}\ is\ return\ of\ each\ drug,\ and\ \boldsymbol{c_i}\ is\ cost\ for\ developing\ each\ drug$

1-2) Make a recommendation on which drugs to continue developing and which drugs to put on hold

- **Developing drugs:**
  - 3,4,6,13,15,17,18,20,21,22,24,25,27,28,29,30,39,40,42,43,44,47,48,50,57,58,62,66,69,72,76,77,78,86,91,98,99,101,102,104,105,106,109,110,111,112
- **On hold:** all the remaining 68 drugs

1-3) What percent of the overall budget is used for drug development?

- Total Cost: $874.48 M
- 87.448 % of the total budget is used for the drug development

2. Incorporating risk management in the analysis

2-1) How does the mathematical formulation for the drug development need to be appended to incorporate a constraint on the portfolio's variance?

Portfolio Variance: $x^T.COV.x$ $(= \sum_{i=1}^{114} \sum_{j=1}^{114} x_i\, \sigma_{ij} x_j)$
Add a constraint on variance: $x^T.COV.x \leq maximum\ allowed\ variance$

2-2) Illustrate an efficient frontier

- **(Figure1) in Appendix page**
- Minimum allowed variance: 0
- Maximum allowed variance: the possible maximum variance when developing all the 114 drugs

2-3) make a recommendation on how much risk to take and what drugs will be developed under this scenario

Steps for deriving a recommendation from the efficient frontier, the returns of which continuously go up as risks increase

I. Calculate the slope of the frontier curve (Figure 2) by each range of standard deviation

- a slope refers to the marginal increase in returns as risks increase
- **the slope graph (Figure 3)** shows that every slope of the frontier curve is positive
- the slope becomes exponentially steeper at the standard deviation of 737.895 and then the overall trend gradually decreases with multiple fluctuations

- the slope rebounds up at the point where the standard deviation is 3841.543 and goes up slightly more and then decreases again with big volatility
- It implies that it is hard to find a specific point where we can minimize the loss of returns reducing risks significantly since there's no range of standard deviation where the slope of frontier line turns to the negative direction or at least flatten

II. Create "peak_df" data frame (Figure 4) consisting of only the standard deviations where the slopes of the frontier curve increase (positive second derivative values).

- such points can give more efficiencies in reducing the loss of returns when reducing risks compared to the points where the slopes decrease

III. Calculate the percentage changes from the risk neutral point to each point in peak_df

- risk neutral point (no variance constraint): Standard Deviation = 23142.146, Return = 4480.672
- calculate the percent change of risk and return from the risk neutral point to each of the points in peak_df

IV. Compare the efficiency of each point based on the marginal percent change of risk with respect to returns (Figure 5)

- percent change of risk / percent change of return.
- it represents how much percent of risks decrease at a specific point as returns decrease by 1% from the risk neutral point.
- when taking risk by about 4,463 standard deviation, we get the highest marginal percentage change of risk which 4.88.
- returns at the risk neutral - returns at the most efficient point = 23142.146 - 23122.969 = 19.177 which means $19.177M should be forgone.
- stdDev at the risk neutral - stdDev at the most efficient point = 4480.672 - 4463.391 = 17.281 (reduced).

V. Recommendation with summary

- the goal is to maximize returns, but the company should forgo some returns if the loss of returns reduces risks significantly.
- the term "significantly" is ambiguous, so I found a point that offers relatively more efficiency in a sense that more risks are reduced given the same reduction in returns compared to the risk neutral point.
- the standard deviation (risk) which the company should take is about 4463.391.
- the company should sacrifice returns by $19.177M then they can reduce risks by 17.281 (standard deviation).
- Developing drugs: 3,4,6,13,17,18,20,21,22,24,25,27,28,29,30,39,40,42,43,44,45,47,48,50,57,58,62,66,69,72,76,77,78,86,91,98,99,101,102,104,105,106,109,110,111,112

2-4) If the portfolio risk were to be minimized, what drugs would be chosen for development?

- **Objective Function:** min $x^T . COV . x$
- **Selected Drugs:** No drug is invested, and only risk-free return is earned ($1030M)
- **Portfolio Variance:** 0

2-5) Which therapeutic area you would recommend allocating the additional $50 million if the goal is to maximize return?

- Add an auxiliary variable $y_i, y \in \{0,1\},\ i \in \{0,1,2,3,4,5,6\}$
- Each budget constraint $\leq assigned\ budget + (50 \times y_i)$, $\sum_{i=0}^{6} y_i = 1$ (only one area must be selected)
- Recommending therapeutic area: y_0 = Oncology

2-6) How does the allocation of the additional $50 million depend on the willingness to take risk at Zinca? **(Figure 6)**

- when posing a variance constraint from minimum to maximum, the donation tends to be allocated to "Central nervous system", "Transplantation", and "Cardiovascular" at the very beginning.
- within the most part of the initial range of the allowed variance, the donation tends to be allocated to "Transplantation".
- as the variance constraint becomes looser, "Respiratory and dermatology" and "Rheumatology and hormone therapy" are more likely to be targeted for the additional donation.
- when the variance constraint is very close to (and even arrives at) the risk neutral point, "Oncology" is the optimal area to which the donation should be allocated.
- "Ophtalmics" has never been selected across all the range of the variance constraints.

3. Company-Wide budgeting

3-1) How does the mathematical formulation change when the therapeutic area budget constraints are replaced by the company-wide budget?

- The original budget constraint is replaced by: $\sum_{i=1}^{114} c_i\, x_i\ (= x^T.c\ where\ c\ is\ cost\ matrix) \leq 1000$

3-2) What changes does the company-wide budget imply in terms of

I. Selected projects

- Added drugs: 5, 11, 16, 26, 53, 68, 73, 74, 75
- Removed drugs: 15, 29

II. Portfolio's return

- $23142.1 M -> $24675.3 M
- Increased by $1533.2 M compared to the department-wide budget constraint

III. Standard Deviation of portfolio's return

- 4480.6722 -> 4742.2596
- Increased by 261.5874

IV. Percent of funds allocated on projects

- 87.448% -> 98.695%
- Increased by 11.247%

3-3) How does the efficient frontier change if the company-wide budget is used?

- the EF charts **(Figure 7)** have highly similar trend and patterns over the two models
- CW model can afford to take more risks earning more corresponding returns. In detail, when posing the same variance constraints, the DW model stops taking risks at the 75th constraint with 4480 stdDev and 23142 return, whereas the CW model keeps taking risks with more return and stops at the 84th constraint with 4742 stdDev and 24675 returns.

3-4) Would you recommend Zinca to use therapeutic area budgets or the company-wide budget? Explain your reasoning.

- **I would recommend Zinca takes the company-wide budget constraint.**
  - according to the diff_df **(Figure 8)**, from the 6th constraint, the CW model always makes higher returns taking bigger or smaller risks than the DW model within the same range of variance constraints.
  - the CW model tends to make increasingly higher returns as the variance constraint becomes looser.

4. Managing extreme risks

4-1) Assess the maximum risk at the 95% VAR (if the portfolio is selected using a risk-neutral approach) and the minimum possible risk attainable at the 95% VAR for the drug portfolio. What are the expected returns of these portfolios? Compare these results to the 95% VAR and expected return obtained from model "drug1.ipynb"

- Maximum risk (variance): 20076423.45
  - The maximum risk is the variance of the portfolio created by the minimum r.
  - Min r ranges from 0 to 15771.4398 which is the 95% VaR of the selected portfolio.
    - h can exceed the standard deviation of the portfolio, as h is an auxiliary variable where $h^2 \geq \sum_{i=1}^{114} \tau_i^2$
    - It results in the min r can be stretched to 0 from the 95% Var of the highest risk portfolio.
  - Expected return: $23,142 (M)
  - 95% VaR = $15,771.4398 (M)

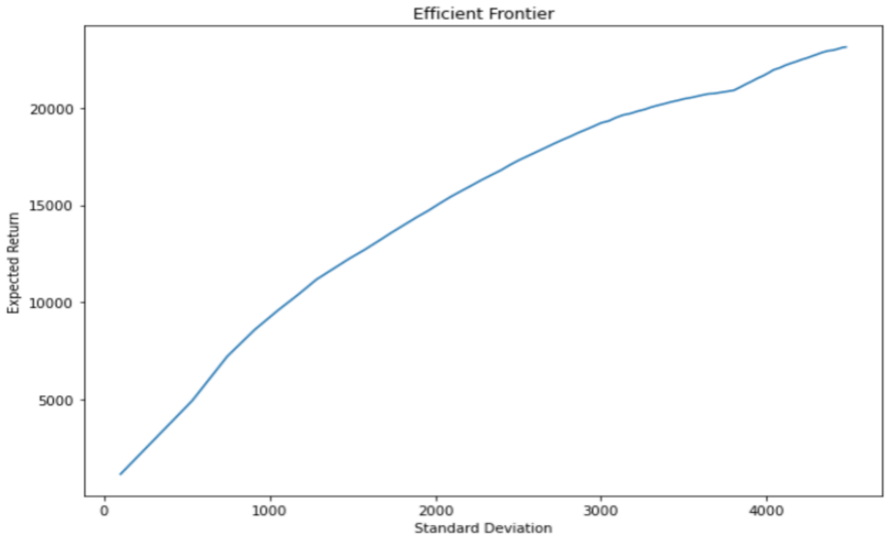
- Minimum risk (variance): 19921861.5
  - The minimum risk is the variance of the portfolio created by the possible maximum r.
  - Max r = 15780.69028 which is the 95% VaR of the lowest risk portfolio
  - Expected return: $23,123 (M)
  - 95% VaR = $15,780.6903 (M)

- The maximum risk portfolio selected based on the possible minimum r is the as the one selected in "drug1".
  - As the exact same drugs are selected, the variance, expected return of the two models are the same
  - the 95% VaR of the two models (drug1 & max risk portfolio): $Expected\ return$ – 1.645(4480.6722) = 15771.44

4-2) Explain whether Zinca should be concerned about the extreme risk of its drug development portfolio?

- I would recommend that Zinca incorporates the constraint on the 95% VaR because they are willing to sacrifice some returns if it reduces risks. Even though it is only 5% confidence that they get the return at the extreme risk range, it will enable them to reduce the overall risk at an efficient point when it comes to the extreme risk. And the resulting portfolio with the largest return at the 95% VaR is equal to the portfolio I recommend in "drug2", which implies that the portfolio is composed at the most efficient point in terms of the reduction in the marginal percent change of risk with respect to reduction of returns.

Appendix



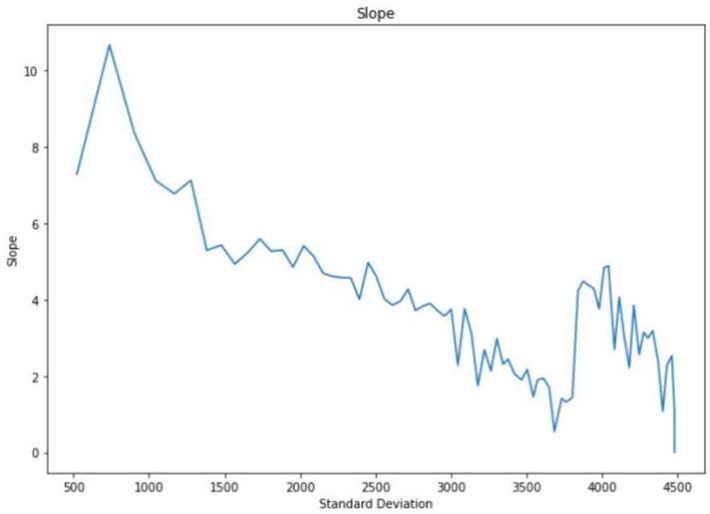
[Figure 1]

Efficient Frontier for Part2

	Std_Dev	slope	row_id
1	522.670	7.290661	1
2	737.895	10.672696	2
3	903.597	8.359314	3
4	1045.013	7.118162	4
5	1168.382	6.774814	5
6	1277.815	7.129988	6
7	1382.789	5.292568	7
8	1478.662	5.429412	8
9	1568.332	4.933724	9
10	1653.177	5.227073	10
11	1733.906	5.591448	11
12	1810.692	5.269646	12
13	1884.823	5.298485	13
14	1954.274	4.851608	14
15	2024.090	5.412183	15
16	2089.814	5.138184	16
17	2154.794	4.685596	17
18	2217.542	4.606920	18
19	2278.857	4.575406	19
20	2335.860	4.571970	20
21	2393.987	4.008413	21
22	2451.998	4.973626	22
23	2506.038	4.603516	23
24	2559.954	4.014467	24
25	2613.818	3.853613	25
26	2665.610	3.960901	26
27	2716.559	4.273666	27
28	2765.254	3.714468	28
29	2814.017	3.829256	29
30	2863.148	3.901773	30
31	2908.500	3.722680	31
32	2957.032	3.568615	32
33	3002.531	3.744478	33
34	3046.278	2.285322	34
35	3091.248	3.765332	35
36	3135.370	3.125085	36
37	3178.489	1.745912	37
38	3222.179	2.686267	38
39	3264.606	2.131001	39
40	3304.496	2.980120	40
41	3345.922	2.306305	41
42	3378.595	2.440302	42
43	3420.541	2.059219	43
44	3467.177	1.897182	44
45	3506.001	2.169612	45
46	3545.840	1.452521	46
47	3573.204	1.891025	47
48	3611.842	1.943294	48
49	3651.064	1.701086	49
50	3685.622	0.543637	50
51	3733.346	1.412036	51
52	3761.595	1.316755	52
53	3804.541	1.432892	53
54	3841.543	4.231285	54
55	3875.819	4.482728	55
56	3909.727	4.386575	56
57	3946.942	4.288378	57
58	3981.317	3.755375	58
59	4014.686	4.839552	59
60	4044.302	4.886649	60
61	4083.263	2.691974	61
62	4114.735	4.067361	62
63	4147.238	3.047719	63
64	4181.931	2.216672	64
65	4211.597	3.851244	65
66	4246.157	2.560822	66
67	4277.662	3.144231	67
68	4305.326	2.989734	68
69	4336.401	3.187772	69
70	4372.473	2.394517	70
71	4403.330	1.075023	71
72	4430.666	2.278973	72
73	4463.391	2.525134	73
74	4480.672	1.109716	74
75	4480.672	0.000000	75
76	4480.672	0.000000	76
77	4480.672	0.000000	77
78	4480.672	0.000000	78
79	4480.672	0.000000	79
80	4480.672	0.000000	80
81	4480.672	0.000000	81
82	4480.672	0.000000	82
83	4480.672	0.000000	83
84	4480.672	0.000000	84
85	4480.672	0.000000	85
86	4480.672	0.000000	86
87	4480.672	0.000000	87
88	4480.672	0.000000	88
89	4480.672	0.000000	89
90	4480.672	0.000000	90
91	4480.672	0.000000	91
92	4480.672	0.000000	92
93	4480.672	0.000000	93
94	4480.672	0.000000	94
95	4480.672	0.000000	95
96	4480.672	0.000000	96
97	4480.672	0.000000	97
98	4480.672	0.000000	98
99	4480.672	0.000000	99

[Figure 2]

Table for the slopes of the efficient frontier by its standard deviation



[Figure 3]

Chart for the slopes of the efficient frontier (first derivative)

[Figure 4]

Peak df:
Data frame for the standard deviation the slope of which increases (second derivative is positive value)

	row_id	Peak_Std_Dev
0	2	737.895
1	6	1277.815
2	8	1478.662
3	10	1653.177
4	11	1733.906
5	13	1884.823
6	15	2024.090
7	22	2451.998
8	26	2665.610
9	27	2716.559
10	29	2814.017
11	30	2863.148
12	33	3002.531
13	35	3091.248
14	38	3222.179
15	40	3304.496
16	42	3378.595
17	45	3506.001
18	47	3573.204
19	48	3611.842
20	51	3733.346
21	53	3804.541
22	54	3841.543
23	55	3875.819
24	59	4014.686
25	60	4044.302
26	62	4114.735
27	65	4211.597
28	67	4277.662
29	69	4336.401
30	72	4430.666
31	73	4463.391

	row_id	Peak_Std_Dev	return_prct_chng	risk_prct_chng	marginal_risk_change_ratio
0	2	737.895	-69.16	-83.53	1.21
1	6	1277.815	-51.84	-71.48	1.38
2	8	1478.662	-47.19	-67.00	1.42
3	10	1653.177	-43.36	-63.10	1.46
4	11	1733.906	-41.41	-61.30	1.48
5	13	1884.823	-37.96	-57.93	1.53
6	15	2024.090	-34.88	-54.83	1.57
7	22	2451.998	-26.26	-45.28	1.72
8	26	2665.610	-22.47	-40.51	1.80
9	27	2716.559	-21.53	-39.37	1.83
10	29	2814.017	-19.94	-37.20	1.87
11	30	2863.148	-19.11	-36.10	1.89
12	33	3002.531	-16.89	-32.99	1.95
13	35	3091.248	-15.73	-31.01	1.97
14	38	3222.179	-14.30	-28.09	1.96
15	40	3304.496	-13.40	-26.25	1.96
16	42	3378.595	-12.64	-24.60	1.95
17	45	3506.001	-11.52	-21.75	1.89
18	47	3573.204	-11.05	-20.25	1.83
19	48	3611.842	-10.72	-19.39	1.81
20	51	3733.346	-10.06	-16.68	1.66
21	53	3804.541	-9.64	-15.09	1.57
22	54	3841.543	-8.96	-14.26	1.59
23	55	3875.819	-8.30	-13.50	1.63
24	59	4014.686	-5.71	-10.40	1.82
25	60	4044.302	-5.08	-9.74	1.92
26	62	4114.735	-4.08	-8.17	2.00
27	65	4211.597	-2.82	-6.01	2.13
28	67	4277.662	-2.01	-4.53	2.25
29	69	4336.401	-1.23	-3.22	2.62
30	72	4430.666	-0.44	-1.12	2.55
31	73	4463.391	-0.08	-0.39	4.88

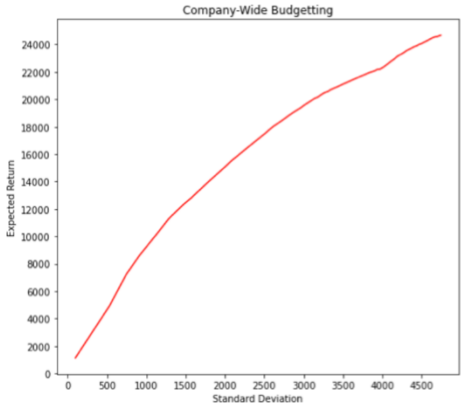
[Figure 5]

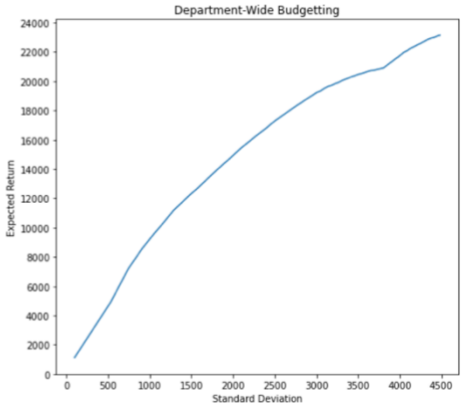
Table for the percentage change of returns and stdDev from the risk neutral point to each point the slope of which increases and the marginal percent change of stdDev with respect to returns

	return	stdDev	num_project	allocated_area
0	1081.500	0.000	0	Oncology
1	4892.110	522.670	20	Central nervous system
2	7189.141	737.895	20	Cardiovascular
3	8574.296	903.597	20	Central nervous system
4	9580.918	1045.013	26	Central nervous system
5	10485.143	1166.710	26	Transplantation
6	11291.296	1280.250	33	Transplantation
7	11875.298	1382.887	40	Transplantation
8	12384.037	1478.584	40	Transplantation
9	12831.172	1568.397	40	Transplantation
10	13274.616	1652.933	40	Transplantation
11	13717.432	1733.289	40	Transplantation
12	14124.635	1810.791	40	Transplantation
13	14510.280	1884.326	40	Transplantation
14	14872.101	1956.112	46	Transplantation
15	15241.893	2024.770	46	Transplantation
16	15582.177	2091.016	46	Transplantation
17	15877.032	2155.174	46	Transplantation
18	16165.467	2216.813	46	Transplantation
19	16450.209	2278.777	46	Transplantation
20	16710.360	2337.339	46	Transplantation
21	16952.575	2395.338	46	Transplantation
22	17232.129	2451.963	46	Transplantation
23	17484.165	2505.520	53	Transplantation
24	17699.799	2561.035	53	Respiratory and dermatology
25	17945.024	2612.676	53	Respiratory and dermatology
26	18154.026	2664.928	53	Respiratory and dermatology
27	18353.134	2716.234	53	Respiratory and dermatology
28	18560.452	2766.412	53	Respiratory and dermatology
29	18758.219	2813.823	53	Respiratory and dermatology
30	18944.433	2863.516	53	Respiratory and dermatology
31	19122.322	2909.604	53	Respiratory and dermatology
32	19292.180	2956.959	53	Respiratory and dermatology
33	19476.767	3002.192	53	Respiratory and dermatology
34	19642.710	3045.475	53	Respiratory and dermatology
35	19814.845	3092.780	53	Respiratory and dermatology
36	19934.490	3134.778	53	Respiratory and dermatology
37	20091.403	3178.818	53	Respiratory and dermatology
38	20250.417	3222.387	53	Respiratory and dermatology
39	20362.300	3263.687	53	Respiratory and dermatology
40	20452.831	3306.427	53	Respiratory and dermatology
41	20585.311	3342.426	53	Respiratory and dermatology
42	20684.371	3382.359	53	Respiratory and dermatology
43	20764.592	3427.945	53	Respiratory and dermatology
44	20864.986	3466.919	53	Respiratory and dermatology
45	20964.046	3505.434	53	Respiratory and dermatology
46	21062.470	3545.754	53	Respiratory and dermatology
47	21142.839	3583.088	53	Respiratory and dermatology
48	21234.097	3615.863	53	Respiratory and dermatology
49	21320.472	3659.045	53	Respiratory and dermatology
50	21368.818	3690.895	53	Respiratory and dermatology
51	21422.921	3730.095	53	Respiratory and dermatology
52	21495.513	3767.279	53	Respiratory and dermatology
53	21551.669	3805.338	53	Respiratory and dermatology
54	21562.779	3824.782	53	Respiratory and dermatology
55	21562.779	3824.782	53	Respiratory and dermatology
56	21583.408	3911.294	46	Rheumatology and hormone therapy
57	21751.653	3941.895	46	Rheumatology and hormone therapy
58	21875.154	3974.987	46	Rheumatology and hormone therapy
59	22037.498	4012.803	46	Rheumatology and hormone therapy
60	22176.213	4049.501	46	Rheumatology and hormone therapy
61	22320.013	4079.642	46	Rheumatology and hormone therapy
62	22407.732	4116.244	53	Respiratory and dermatology
63	22542.064	4147.633	53	Respiratory and dermatology
64	22665.299	4181.161	53	Respiratory and dermatology
65	22782.896	4214.532	53	Respiratory and dermatology
66	22881.956	4246.271	53	Respiratory and dermatology
67	22959.123	4272.362	53	Respiratory and dermatology
68	23039.768	4310.694	53	Respiratory and dermatology
69	23157.724	4342.568	53	Respiratory and dermatology
70	23262.267	4373.838	53	Respiratory and dermatology
71	23343.685	4402.943	53	Respiratory and dermatology
72	23413.508	4435.230	53	Respiratory and dermatology
73	23494.862	4466.631	53	Respiratory and dermatology
74	23587.386	4494.734	53	Respiratory and dermatology
75	23647.138	4522.033	53	Respiratory and dermatology
76	23732.266	4554.963	53	Respiratory and dermatology
77	23780.612	4580.588	53	Respiratory and dermatology
78	23780.612	4580.588	53	Respiratory and dermatology
79	23780.612	4580.588	53	Respiratory and dermatology
80	23812.454	4671.304	53	Oncology
81	23841.842	4695.807	53	Oncology
82	23847.983	4705.990	53	Oncology
83	23847.983	4705.990	53	Oncology
84	23847.983	4705.990	53	Oncology
85	23847.983	4705.990	53	Oncology
86	23847.983	4705.990	53	Oncology
87	23847.983	4705.990	53	Oncology
88	23847.983	4705.990	53	Oncology
89	23847.983	4705.990	53	Oncology
90	23847.983	4705.990	53	Oncology
91	23847.983	4705.990	53	Oncology
92	23847.983	4705.990	53	Oncology
93	23847.983	4705.990	53	Oncology
94	23847.983	4705.990	53	Oncology
95	23847.983	4705.990	53	Oncology
96	23847.983	4705.990	53	Oncology
97	23847.983	4705.990	53	Oncology
98	23847.983	4705.990	53	Oncology
99	23847.983	4705.990	53	Oncology

[Figure 6]

Therapeutic areas to which the additional $50M donations assigned by different variance constraints





[Figure 7]
Efficient frontier charts for the two different constraints on budget

	CW_return	CW_stdDev	DW_return	DW_stdDev	return_diff	stdDev_diff
0	1030.000	0.000	1030.000	0.000	0.000	0.000
1	4840.610	522.670	4840.610	522.670	0.000	0.000
2	7137.641	737.895	7137.641	737.895	0.000	0.000
3	8522.796	903.597	8522.796	903.597	0.000	0.000
4	9529.418	1045.013	9529.418	1045.013	0.000	0.000
5	10433.643	1166.710	10365.220	1168.382	68.423	-1.672
6	11239.796	1280.250	11145.476	1277.815	94.320	2.435
7	11832.162	1383.182	11701.058	1382.789	131.104	0.393
8	12341.065	1476.366	12221.592	1478.662	119.473	-2.296
9	12785.568	1568.080	12663.999	1568.332	121.569	-0.252
10	13234.413	1652.773	13107.490	1653.177	126.923	-0.404
11	13670.095	1732.866	13558.882	1733.906	111.213	-1.040
12	14082.708	1810.959	13963.517	1810.692	119.191	0.267
13	14475.821	1884.546	14356.299	1884.823	119.522	-0.277
14	14841.737	1955.846	14693.248	1954.274	148.489	1.572
15	15191.380	2024.759	15071.105	2024.090	120.275	0.669
16	15551.813	2090.810	15408.807	2089.814	143.006	0.996
17	15850.100	2154.090	15713.277	2154.794	136.823	-0.704
18	16156.335	2217.833	16002.352	2217.542	153.983	0.291
19	16432.172	2278.500	16282.893	2278.857	149.279	-0.357
20	16707.453	2337.118	16543.509	2335.860	163.944	1.258
21	16986.442	2395.304	16776.506	2393.987	209.936	1.317
22	17238.578	2451.901	17065.031	2451.998	173.547	-0.097
23	17489.770	2507.264	17313.805	2506.038	175.965	1.226
24	17764.073	2560.847	17530.249	2559.954	233.824	0.893
25	18015.394	2613.949	17737.820	2613.818	277.574	0.131
26	18208.718	2664.494	17942.963	2665.610	265.755	-1.116
27	18422.790	2715.483	18160.702	2716.559	262.088	-1.076
28	18616.279	2763.472	18341.578	2765.254	274.701	-1.782
29	18828.589	2814.540	18528.304	2814.017	300.285	0.523
30	19014.754	2862.544	18720.002	2863.148	294.752	-0.604
31	19191.808	2909.633	18888.833	2908.500	302.975	1.133
32	19354.028	2957.217	19062.025	2957.032	292.003	0.185
33	19547.137	3002.542	19232.395	3002.531	314.742	0.011
34	19714.206	3047.191	19332.371	3046.278	381.835	0.913
35	19880.178	3092.775	19501.698	3091.248	378.480	1.527
36	20050.788	3136.737	19639.583	3135.370	411.205	1.367
37	20163.057	3179.991	19714.865	3178.489	448.192	1.502
38	20324.111	3220.461	19832.228	3222.179	491.883	-1.718
39	20478.837	3262.935	19922.640	3264.606	556.197	-1.671
40	20566.216	3305.306	20041.517	3304.496	524.699	0.810
41	20707.486	3346.540	20137.058	3345.922	570.428	0.618
42	20813.324	3387.393	20216.790	3378.595	596.534	8.798
43	20911.019	3427.625	20303.166	3420.541	607.853	7.084
44	21019.801	3467.454	20391.643	3467.177	628.158	0.277
45	21119.661	3504.060	20475.876	3506.001	643.785	-1.941
46	21223.992	3545.712	20533.743	3545.840	690.249	-0.128
47	21319.228	3582.530	20585.489	3573.204	733.739	9.326
48	21416.924	3620.476	20660.574	3611.842	756.350	8.634
49	21505.814	3656.502	20727.294	3651.064	778.520	5.438
50	21588.768	3689.563	20746.081	3685.622	842.687	3.941
51	21693.463	3731.030	20813.469	3733.346	879.994	-2.316
52	21777.696	3767.973	20850.666	3761.595	927.030	6.378
53	21870.214	3803.382	20912.203	3804.541	958.011	-1.159
54	21954.447	3837.509	21068.769	3841.543	885.678	-4.034
55	22018.130	3873.939	21222.419	3875.819	795.711	-1.880
56	22093.144	3910.915	21371.159	3909.727	721.985	1.188
57	22175.765	3933.699	21530.751	3946.942	645.014	-13.243
58	22194.552	3968.636	21659.842	3981.317	534.710	-12.681
59	22352.235	4015.750	21821.333	4014.686	530.902	1.064
60	22494.534	4048.599	21966.056	4044.302	528.478	4.297
61	22646.580	4082.580	22070.938	4083.263	575.642	-0.683
62	22796.014	4116.032	22198.946	4114.735	597.068	1.297
63	22930.528	4148.807	22298.006	4147.238	632.522	1.569
64	23093.448	4181.987	22374.909	4181.931	718.539	0.056
65	23200.542	4209.207	22489.160	4211.597	711.382	-2.390
66	23309.558	4246.804	22577.662	4246.157	731.896	0.647
67	23425.556	4277.547	22676.721	4277.662	748.835	-0.115
68	23543.118	4311.055	22759.429	4305.326	783.689	5.729
69	23641.508	4340.544	22858.489	4336.401	783.019	4.143
70	23734.375	4372.174	22944.864	4372.473	789.511	-0.299
71	23828.431	4404.994	22978.036	4403.330	850.395	1.664
72	23899.427	4435.318	23040.334	4430.666	859.093	4.652
73	23998.486	4465.488	23122.969	4463.391	875.517	2.097
74	24060.132	4496.258	23142.146	4480.672	917.986	15.586
75	24153.037	4526.692	23142.146	4480.672	1010.891	46.020
76	24237.270	4557.026	23142.146	4480.672	1095.124	76.354
77	24323.092	4585.580	23142.146	4480.672	1180.946	104.908
78	24417.617	4614.260	23142.146	4480.672	1275.471	133.588
79	24501.850	4644.022	23142.146	4480.672	1359.704	163.350
80	24556.645	4669.212	23142.146	4480.672	1414.499	188.540
81	24583.307	4701.347	23142.146	4480.672	1441.161	220.675
82	24642.820	4724.724	23142.146	4480.672	1500.674	244.052
83	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
84	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
85	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
86	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
87	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
88	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
89	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
90	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
91	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
92	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
93	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
94	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
95	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
96	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
97	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
98	24675.271	4742.260	23142.146	4480.672	1533.125	261.588
99	24675.271	4742.260	23142.146	4480.672	1533.125	261.588

[Figure 8]

Diff_df:
Differences in return and stdDev between Company-Wide budget constraint and Department-Wide budget constraint