

## Ratthamnoon Prakitpong #63205165

1.

For both options, total profit is made up of 3 parameters:

Total profit (\$) = Total revenue (\$) – Production cost (\$) – Shipping cost (\$)

Option 1 equations for each parameters:

Production cost (\$) = Produce total (kg) \* Production cost (\$/kg)

Shipping cost (\$) = Produce total (kg) \* Shipping cost(\$/kg)

Total revenue (\$) = Caught outcome given uniform range of probability of getting caught \*  
Some sales price from normal distribution,  
looped by number of shipments  
$$= \sum \text{Number of shipments} = \text{Produce total (kg)} / \text{Cocaine per shipment (kg)} \text{ (IF(RAND() > RANDBETWEEN(Uniform chance caught, lower (%), Uniform change caught, upper (%)), 1, 0) * NORM.INV(RAND(), Sales price ($), Sale price stddev ($)))}$$

Option 2 equations for each parameters:

Production cost (\$) = Produce total (kg) \* Production cost (\$/kg)

Shipping cost (\$) = Produce total (kg) \* Shipping cost(\$/kg)

Total Revenue (\$) = Caught outcome given fixed probability of getting caught \*  
Some sales price from normal distribution,  
looped by number of shipments  
$$= \sum \text{Number of shipments} = \text{Produce total (kg)} / \text{Cocaine per shipment (kg)} \text{ (IF(RAND() > Chance caught (%)), 1, 0) * NORM.INV(RAND(), Sales price ($), Sale price stddev ($)))}$$

We will assume that shipment will be paid whether shipping is successful or not (we don't want a mutiny within ranks). We can put given information and derived formula into some sheet software and repeat it 250 times:

Option 1 simulation sample:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Given			Simulation																	
2	Produce total (kg)	5000		Shipment num	1			2													
3	Production cost (\$/kg)	2000		Simulation n	Failure proba	Success?	Sale price	Failure proba	Success?	Sale price	Failure proba	Success?	Sale price	Failure proba	Success?	Sale price	Failure proba	Success?	Sale price	Total revenue	Total profit (\$)
4	Cocaine per shipment (kg)	1000		1	11		114033.76091	15		19373.463389	14		115599.96243	6		111316.30595	6		112161.03331	62484526	49994526
5	Shipping cost (\$/kg)	500		2	11		112274.91001	7		111111.87704	13		119483.76882	10		116696.58035	8		116976.40998	76543546.2	64043546.2
6	Uniform chance caught (%), lower	5		3	11		114718.94075	7		0.12716.33182	15		114926.28197	5		118595.1275	12		113772.661	62013011.23	496513011.23
7	Uniform chance caught (%), upper	15		4	7		118543.07901	8		113656.79951	12		112465.62331	12		112642.63986	13		118187.00544	75505087.14	63005087.14
8	Sales price (\$)	14000		5	6		118512.22972	6		114411.49261	10		113414.57987	6		116057.64177	8		112511.60104	74907545	62407545
9	Sales price stddev (\$)	3000		6	6		116341.28911	14		112406.33448	6		113705.70416	13		119982.39796	13		110248.29506	72684020.77	60184020.77
10				7	13		110401.37495	10		111570.05117	11		117881.01127	7		118439.85891	5		113170.01002	71462306.32	58962306.32
11	Assumption			8	15		113398.55951	10		114643.11193	7		110507.32462	11		118362.81775	13		114616.63687	81528457	69028457
12	Pay for transport whether it's failed or succeeded.			9	5		0.8169.623192	5		117370.31578	6		110490.57664	11		113551.67642	10		115480.40765	65903312.48	53403312.48
13	Calculated			10	15		113166.64851	9		111937.92355	11		110269.1932	12		115198.28049	12		112992.3374	63564583.15	51064583.15
14	Production cost (\$)	10000000		11	7		114842.30343	5		113969.86507	5		116237.718	5		116780.45763	12		114036.82218	75867166.31	63367166.31
15	Shipping cost (\$)	2500000		12	14		112175.78446	12		0.14642.8829	12		119504.79691	7		115730.36609	14		114964.35814	71975305.59	59475305.59
16	Number of shipments	5		13	14		117227.823986	6		114088.76948	11		114614.34158	11		111879.74801	11		115333.89327	63244476.33	50744476.33
17	Total cost (\$)	12500000		14	8		111148.28657	7		114312.584	9		113727.9258	10		117045.52181	14		119027.413294	65261731.47	52761731.47
18				15	8		117446.90021	8		116236.03249	11		115191.91477	7		114782.48271	15		113013.88497	76671215.15	6471215.15
19				16	8		110338.32021	12		111214.9034	7		111777.76811	8		113503.29499	10		0.8825.19078	48834286.71	36334286.71
20				17	11		0.13302.01489	15		118504.782504	6		113465.77993	14		0.16964.97438	13		114205.40161	36175955.14	73675955.14

Option 2 simulation sample:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Given			Simulation																						
2	Produce total (kg)	5000		Shipment num	1																					
3	Production cost (\$/kg)	2000		Simulation n	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	Sale price	Success?	9				
4	Cocaine per shipment (kg)	500		1	1	10764.34487	1	8132.698229	1	15487.80056	1	15928.68304	1	12060.75853	1	16313.05038	1	14816.65206	1	11393.22243	1	18594.67561	69184502.43	6594502.43		
5	Shipping cost (\$/kg)	650		2	1	115584.36287	1	117645.20799	1	10345.66739	1	20354.27089	1	16376.99839	1	13524.09456	1	16711.93607	1	15435.1341	1	13501.99872	72601395.61	69351395.61		
6	Chance caught (%)	5		3	1	10246.62344	1	131174.30712	1	11243.43907	1	12552.07986	1	19938.52651	1	9918.802585	1	12251.61718	1	14782.52309	1	15374.95423	63297437.6	6004737.6		
7	Sales price (\$)	14000		4	1	15140.37602	1	13326.25044	1	11895.68679	1	7356.149583	1	11103.00497	1	13715.69571	1	14074.03463	1	15979.50829	1	14889.29522	58690000.83	55440000.83		
8	Sales price stddev (\$)	3000		5	1	16763.14717	1	1027.493692	1	13133.49419	1	16202.42042	1	0.13118.49115	1	11166.9424	1	15301.23077	1	16003.99445	1	9854.57349	61341540.76	58091540.76		
9	Assumption			6	1	13418.13059	1	12106.47415	1	11934.53899	1	16318.84249	1	18621.77952	1	13144.80164	1	11102.9694	1	15307.52745	1	18667.564878	11360.9693	6790736.76	6384736.76	
10	Pay for transport whether it's failed or succeeded.			7	1	11194.79843	1	11693.19905	1	13242.06001	1	10235.96813	1	10383.83154	1	14197.85059	1	13300.17069	1	15236.17407	1	12795.94208	115319.08678	66020540.69	62770540.69	
11	Calculated			8	1	13585.48189	1	1736.671096	1	16293.79149	1	17968.30964	1	9469.303321	1	11095.61943	1	16837.53822	1	18601.08011	1	12928.41466	18436.45277	6964537.81	61414537.81	
12	Production cost (\$)	10000000		9	1	13769.3698	0	14321.45033	1	10719.32401	1	13538.80237	1	12680.55862	1	11481.32901	1	13707.93075	1	13164.97652	1	10480.66445	13128.39453	56335676.04	53085676.04	
13	Shipping cost (\$)	2500000		10	1	14139.78125	1	14391.62088	1	14057.74712	1	16323.10099	1	16396.42303	1	14236.8188	1	10966.96664	1	15548.70447	1	15902.58071	13563.15919	6489099.31	6173999.31	
14	Total cost (\$)	13250000		11	1	10352.71812	1	9945.678377	1	9825.08769	1	5435.43688	1	13125.68614	1	9308.21094	1	10243.87952	1	12956.83211	1	9441.05408	15663.04785	5349478.48	4834478.48	
15				12	1	14475.69453	1	11269.23301	1	12290.58766	1	15494.25075	1	17106.22443	1	20467.02382	1	11831.80141	1	12876.47376	1	15890.87337	13524.33016	72632446.46	69413246.46	
16				13	1	10913.64157	1	14236.69845	1	11957.09927	1	12400.07955	1	12498.80329	1	12902.47909	1	16297.07761	1	14618.92287	1	11786.58639	10023.15983	55686730.16	52418730.16	
17				14	1	11685.8428	1	11468.94817	1	18025.04627	1	17252.94237	1	10025.49552	1	14315.78422	1	14270.10727	1	17231.39189	1	13556.86483	9097.32476	71894646.76	68644646.76	
18				15	1	12096.12172	0	12371.14281	1	10281.71323	1	12375.87887	1	13202.80962	1	19849.50153	1	12458.32155	1	18989.556082	0	12681.89243	10196.70856	50174805.59	46624805.59	
19				16	0	9651.0977	1	12485.72443	1	11063.73474	1	16618.17967	1	9600.521353	1	12400.96006	1	17098.12058	1	13060.59515	1	14177.21909	13626.17066	51516752.57	42626752.57	
20				17	0	16344.74479	1	16892.42388	1	11155.94681	1	11464.34072	1	18544.53202	1	11677.25073	1	8948.26357	1	14522.72281	1	10707.38135	18551.88322	63546937.05	5826937.05	
21				18	0	18571.97614	1	15830.4338	1	10001.62051	1	18232.00766	1	11514.72485	1	12490.7429	1	10734.85037	1	12445.3253	1	13878.35519	13338.7064	59232383.45	55982383.45	
22				19	0	8404.358437	1	14294.76459	1	17287.84725	1	14811.78931	1	11748.13996	1	12193.46062	1	12990.984	1	12234.48116	1	13286.61637	7635.948095	6244119.89	59194119.89	
23				20	1	14832.9437	1	11724.52148	1	18280.99578	1	11725.22123	1	15443.87953	1	18038.4912	1	18728.4756	1	15360.28858	1	12913.29036	7883.08216	76219944.81	72669444.81	

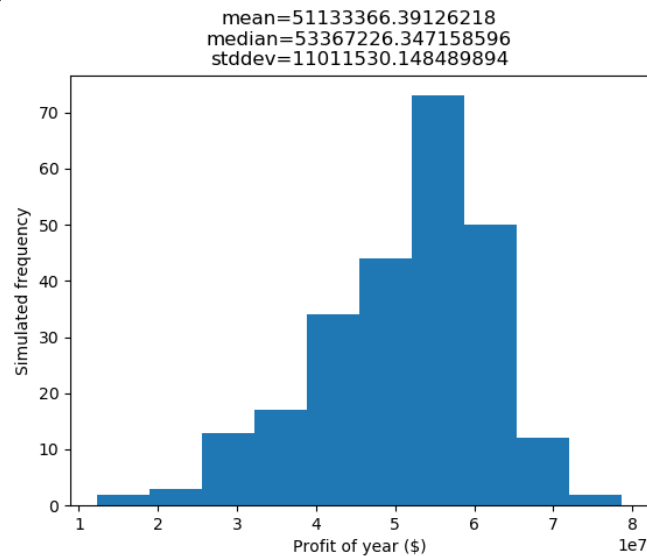
Sadly, the office software that I use can't plot frequency histogram. Therefore, I've ran a simulation (data from that simulation Appendix A), copied out total profit, and put it into a python script that I wrote. A benefit of using python is that we can trust that popular python libraries are robust and there's good internal logic for deciding bin size, number of bins, etc., so we can just plot our numbers with default settings. Also, we can make it calculate other values such as mean and standard deviation automatically for us:

```

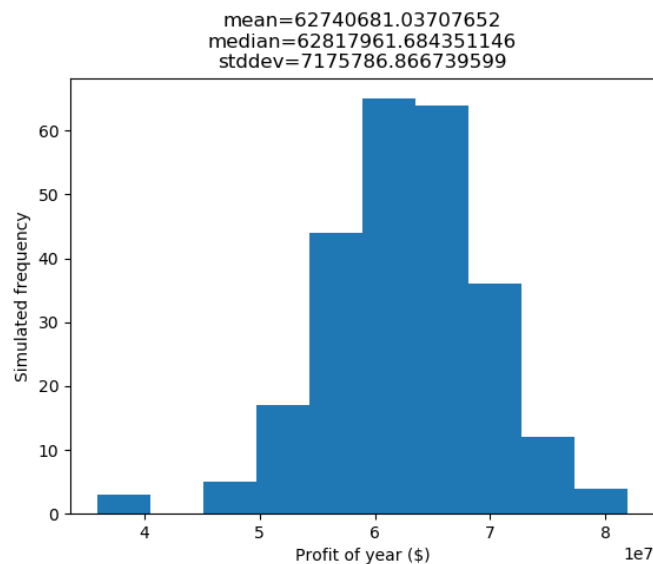
1 import matplotlib.pyplot as plt
2 import numpy as np
3 import os
4
5 cwd = os.getcwd()
6 print(cwd)
7
8
9 option1 = [53859542.9221536, 48068055.5568153, 39441099.9702173, 38197386.1471177, 59963575.1
10 plt.hist(option1)
11 plt.ylabel('Simulated frequency')
12 plt.xlabel('Profit of year ($)')
13 plt.title("Q1, option 1\nMean="+str(np.mean(option1))+", stddev="+str(np.std(option1)))
14 plt.savefig('q1-option1.png')
15 #plt.show()
16
17 plt.cla()
18 plt.clf()
19 plt.close()
20
21 option2 = [63720232.2927411, 56106540.2556289, 51092698.7740412, 61731076.4755671, 67029861.1
22 plt.hist(option2)
23 plt.ylabel('Simulated frequency')
24 plt.xlabel('Profit of year ($)')
25 plt.title("Q1, option 2\nMean="+str(np.mean(option2))+", stddev="+str(np.std(option2)))
26 plt.savefig('q1-option2.png')

```

Option 1 frequency histogram:



Option2 frequency histogram:



We can see that in 250 simulations, none of them lost money, so both options are at least viable. Comparing option 1 to option 2, option 1 has comparatively lower mean profit (by approx. \$1mil) and higher standard deviation (by approx \$4mil), which means that it's the riskier option (smaller mean profit, but more potential to earn more, but also more potential to earn less).

Truck shipment is recommended, since it'll make more money on an average year, and drug operations are often already very risky, so an obvious chance to lower risk is appreciated.

2.

There are four possible outcomes. We can put them in a spreadsheet to calculate outcomes:

	A	B	C	D	E	F	G	H
1	Scenario	Demand	Probability	Confiscated	Probability	Net probability	EAUB	Variance
2		1 High	40.00%	Yes	20.00%	8.00%	600000	28800000000
3		2 Low	60.00%	Yes	20.00%	12.00%	400000	19200000000
4		3 High	40.00%	No	80.00%	32.00%	3000000	2.88E+12
5		4 Low	60.00%	No	80.00%	48.00%	2000000	1.92E+12
6								
7						Expected EAUB	2016000	
8								
9							STDDEV	885293.1718

Calculating IRR:

PV of benefits – PV of costs = 0

\$2016000(P/A, i, 5) - \$2000000 = 0

$[(1+i)^5 - 1] / [i(1+i)^5] - 2000000/2016000 = [(1+i)^5 - 1] / [i(1+i)^5] - 125/126 = 0$

After interpolating in some sheet software:

0.95	0.023234189
0.955	0.018390987
0.96	0.013591078
0.965	0.008833914
0.97	0.004118957
0.975	-0.000554321
0.98	-0.005186442
0.985	-0.009777919
0.99	-0.014329257
0.995	-0.018840951
1	-0.023313492

IRR = i = 0.9725 = 97.25%

This rate of return is very high.

Per rule of thumb ("If the expected present worth is at least double the standard deviation of the present worth, then the project is relatively safe."), we can see that  $2 \times \text{STDDEV} = 1770586.344 < 2016000$ , therefore our expected value is at least double the standard deviation and our risk passes the rule of thumb test.

Therefore, we can see that the rate of return is very high, and the risk is acceptable, so moving forward with this investment is recommended.

Bonus:

Medellín Cartel

Appendix A in following pages: