Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Trinity Business School

Operations Analytics

Tutorial #3: Newsvendor model

Konstantinos Stouras[1]

[1]Please refer to "Recipe 3" for a review of the formulas used.

Exercise 1: Matt Herron

Matt Herron is the chief buyer at Investment Clothiers, a retail store known for excellence in apparel. It is time to order merchandise for the Christmas season. During a recent trip to Hong Kong, Matt spotted a particular men's overcoat that he expects will sell very well. Based on past experience, Matt expects demand to range from 100 to 400 overcoats, with probabilities that are as follows:

Estimated demand	Probability
100	0.1
200	0.4
300	0.4
400	0.1

The total cost to Investment Clothiers would be $60 per overcoat, and the retail price is estimated at $110 per overcoat. Any overcoat left over after the Christmas season is expected to be sold at $40 each.

(1a) Calculate the expected profits for each of the following four cases: when Matt buys 100, 200, 300 or 400 overcoats. How many overcoats should Matt buy if he wishes to maximize expected profits over the coming Christmas season?

(1b) Now solve (1a) again using marginal analysis.

(1c) The assumption of a discrete demand distribution is a bit artificial. Solve the problem using a normal distribution for demand (with the same mean and standard deviation as the discrete distribution of the original problem description). Does this change make much difference?

Exercise 2: Incentive Conflicts in a Supply Chain

Consider the situation by a manufacturer of PlayStations, SUNNY, who is facing Christmas demand. SUNNY sells the PlayStations through a large retail chain, TOYS-are-MINE, at a manufacturer (wholesale) price of 500€ per PlayStation. SUNNY's unit manufacturing cost is 350€ per PlayStation.

TOYS-are-MINE offers the PlayStations for sale at its retail stores at the retail price of 800€ per PlayStation. Its demand forecast for the upcoming Christmas season is for 200,000 PlayStations, with a standard deviation of 50,000. The retail chain has to order ahead of the season.

Any PlayStations ordered will be delivered in time for the Christmas sales season, but no re-supply is possible during the sales season. Any PlayStation that will not be sold during the upcoming Christmas will be sold after the season at a discount, for a price of 300€ per PlayStation.

(2a.i) What is the optimal order quantity for TOYS-are-MINE, and what are its expected profits on this item?

(2a.ii) What is the expected profit of the manufacturer, SUNNY?

(2b) What is the optimal order quantity on this item, if the retailer and the manufacturer were integrated into a single company?

(2c) Compare the expected profits generated by the integrated supply chain (which you computed in your answer to (b)), with that of the chain formed by the two independent firms, SUNNY and TOYS-are-MINE (in the latter case, we have assumed in (a) that the order quantity was determined by the retailer). Which arrangement generates the highest expected profits for the supply chain? Why? What other major differences do you observe between these two inter-organisational arrangements?

Exercise 3: Banking Crisis

Nwankwo Kanu is Chief Investment Officer at a leading hedge fund in Africa. While his fund has been performing well, the contagion and fear in capital markets is getting to his investors. This is leading to huge redemptions from his fund. He must plan to meet these redemptions at the lowest costs. Kanu, a TCD Alum, recalls some quantitative methods he learned at Operations Analytics, his favorite TCD module, and suggests this method to his economic team to estimate these redemptions and predict that over the course of the next month, the expected redemptions will be US$ 300m. The coefficient of variation of this estimate is 0.333. Unfortunately, all Kanu's hedge fund assets are illiquid and cannot be disposed for the next year. He must thus go to the capital markets to raise additional funds. He has two sources of financing that he is planning to use simultaneously:

Source 1*:* Borrow from the government sponsored TARP (The-Augmentation-of-Rich-People) program. This facility charges a usurious 25% annual rate of interest. Further, it can be availed only if a request is made far in advance.

Source 2*:* Alternatively, when TARP funding comes short, you can borrow from the overnight credit markets. You can use this facility anytime and it provides funding immediately. Unfortunately, the rate of interest charged is 40% per annum.

(3a) How much money would you borrow from the TARP funds?

(3b) What are your annualized capital costs if you employ the solution prescribed in (a)?

(3c) Abou Abed, one of Kanu's classmates at TCD is in exactly the same financial position with Kanu. While he runs an identical fund, most of his clients are located in the beautiful downtown Beirut. He calls Kanu up and proposes merging the two funds. He somewhat remembers the Ops class and suggests that merging would reduce the above mentioned capital costs for both funds. Do you agree? Justify your answer in no more than 100 words.

(3d) The crisis is getting worse. The overnight credit markets have now completely frozen up. Kanu no longer cares about minimizing the capital costs. All he cares about is the odds of survival, or the probability that the fund will not be able to meet redemptions. What is the minimum amount of money Kanu needs to borrow from TARP funds to ensure that he will be able to meet all redemption requests with a 95% probability?

(3e) What is the average utilization of Kanu's hedge fund in Africa?

z	0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.07	-0.08	-0.09
-2.9	0.00187	0.00181	0.00175	0.00169	0.00164	0.00159	0.00154	0.00149	0.00144	0.00139
-2.8	0.00256	0.00248	0.00240	0.00233	0.00226	0.00219	0.00212	0.00205	0.00199	0.00193
-2.7	0.00347	0.00336	0.00326	0.00317	0.00307	0.00298	0.00289	0.00280	0.00272	0.00264
-2.6	0.00466	0.00453	0.00440	0.00427	0.00415	0.00402	0.00391	0.00379	0.00368	0.00357
-2.5	0.00621	0.00604	0.00587	0.00570	0.00554	0.00539	0.00523	0.00508	0.00494	0.00480
-2.4	0.00820	0.00798	0.00776	0.00755	0.00734	0.00714	0.00695	0.00676	0.00657	0.00639
-2.3	0.01072	0.01044	0.01017	0.00990	0.00964	0.00939	0.00914	0.00889	0.00866	0.00842
-2.2	0.01390	0.01355	0.01321	0.01287	0.01255	0.01222	0.01191	0.01160	0.01130	0.01101
-2.1	0.01786	0.01743	0.01700	0.01659	0.01618	0.01578	0.01539	0.01500	0.01463	0.01426
-2.0	0.02275	0.02222	0.02169	0.02118	0.02068	0.02018	0.01970	0.01923	0.01876	0.01831
-1.9	0.02872	0.02807	0.02743	0.02680	0.02619	0.02559	0.02500	0.02442	0.02385	0.02330
-1.8	0.03593	0.03515	0.03438	0.03362	0.03288	0.03216	0.03144	0.03074	0.03005	0.02938
-1.7	0.04457	0.04363	0.04272	0.04182	0.04093	0.04006	0.03920	0.03836	0.03754	0.03673
-1.6	0.05480	0.05370	0.05262	0.05155	0.05050	0.04947	0.04846	0.04746	0.04648	0.04551
-1.5	0.06681	0.06552	0.06426	0.06301	0.06178	0.06057	0.05938	0.05821	0.05705	0.05592
-1.4	0.08076	0.07927	0.07780	0.07636	0.07493	0.07353	0.07215	0.07078	0.06944	0.06811
-1.3	0.09680	0.09510	0.09342	0.09176	0.09012	0.08851	0.08691	0.08534	0.08379	0.08226
-1.2	0.11507	0.11314	0.11123	0.10935	0.10749	0.10565	0.10383	0.10204	0.10027	0.09853
-1.1	0.13567	0.13350	0.13136	0.12924	0.12714	0.12507	0.12302	0.12100	0.11900	0.11702
-1.0	0.15866	0.15625	0.15386	0.15151	0.14917	0.14686	0.14457	0.14231	0.14007	0.13786
-0.9	0.18406	0.18141	0.17879	0.17619	0.17361	0.17106	0.16853	0.16602	0.16354	0.16109
-0.8	0.21186	0.20897	0.20611	0.20327	0.20045	0.19766	0.19489	0.19215	0.18943	0.18673
-0.7	0.24196	0.23885	0.23576	0.23270	0.22965	0.22663	0.22363	0.22065	0.21770	0.21476
-0.6	0.27425	0.27093	0.26763	0.26435	0.26109	0.25785	0.25463	0.25143	0.24825	0.24510
-0.5	0.30854	0.30503	0.30153	0.29806	0.29460	0.29116	0.28774	0.28434	0.28096	0.27760
-0.4	0.34458	0.34090	0.33724	0.33360	0.32997	0.32636	0.32276	0.31918	0.31561	0.31207
-0.3	0.38209	0.37828	0.37448	0.37070	0.36693	0.36317	0.35942	0.35569	0.35197	0.34827
-0.2	0.42074	0.41683	0.41294	0.40905	0.40517	0.40129	0.39743	0.39358	0.38974	0.38591
-0.1	0.46017	0.45620	0.45224	0.44828	0.44433	0.44038	0.43644	0.43251	0.42858	0.42465
0.0	0.50000	0.49601	0.49202	0.48803	0.48405	0.48006	0.47608	0.47210	0.46812	0.46414

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.50000	0.50399	0.50798	0.51197	0.51595	0.51994	0.52392	0.52790	0.53188	0.53586
0.1	0.53983	0.54380	0.54776	0.55172	0.55567	0.55962	0.56356	0.56749	0.57142	0.57535
0.2	0.57926	0.58317	0.58706	0.59095	0.59483	0.59871	0.60257	0.60642	0.61026	0.61409
0.3	0.61791	0.62172	0.62552	0.62930	0.63307	0.63683	0.64058	0.64431	0.64803	0.65173
0.4	0.65542	0.65910	0.66276	0.66640	0.67003	0.67364	0.67724	0.68082	0.68439	0.68793
0.5	0.69146	0.69497	0.69847	0.70194	0.70540	0.70884	0.71226	0.71566	0.71904	0.72240
0.6	0.72575	0.72907	0.73237	0.73565	0.73891	0.74215	0.74537	0.74857	0.75175	0.75490
0.7	0.75804	0.76115	0.76424	0.76730	0.77035	0.77337	0.77637	0.77935	0.78230	0.78524
0.8	0.78814	0.79103	0.79389	0.79673	0.79955	0.80234	0.80511	0.80785	0.81057	0.81327
0.9	0.81594	0.81859	0.82121	0.82381	0.82639	0.82894	0.83147	0.83398	0.83646	0.83891
1.0	0.84134	0.84375	0.84614	0.84849	0.85083	0.85314	0.85543	0.85769	0.85993	0.86214
1.1	0.86433	0.86650	0.86864	0.87076	0.87286	0.87493	0.87698	0.87900	0.88100	0.88298
1.2	0.88493	0.88686	0.88877	0.89065	0.89251	0.89435	0.89617	0.89796	0.89973	0.90147
1.3	0.90320	0.90490	0.90658	0.90824	0.90988	0.91149	0.91309	0.91466	0.91621	0.91774
1.4	0.91924	0.92073	0.92220	0.92364	0.92507	0.92647	0.92785	0.92922	0.93056	0.93189
1.5	0.93319	0.93448	0.93574	0.93699	0.93822	0.93943	0.94062	0.94179	0.94295	0.94408
1.6	0.94520	0.94630	0.94738	0.94845	0.94950	0.95053	0.95154	0.95254	0.95352	0.95449
1.7	0.95543	0.95637	0.95728	0.95818	0.95907	0.95994	0.96080	0.96164	0.96246	0.96327
1.8	0.96407	0.96485	0.96562	0.96638	0.96712	0.96784	0.96856	0.96926	0.96995	0.97062
1.9	0.97128	0.97193	0.97257	0.97320	0.97381	0.97441	0.97500	0.97558	0.97615	0.97670
2.0	0.97725	0.97778	0.97831	0.97882	0.97932	0.97982	0.98030	0.98077	0.98124	0.98169
2.1	0.98214	0.98257	0.98300	0.98341	0.98382	0.98422	0.98461	0.98500	0.98537	0.98574
2.2	0.98610	0.98645	0.98679	0.98713	0.98745	0.98778	0.98809	0.98840	0.98870	0.98899
2.3	0.98928	0.98956	0.98983	0.99010	0.99036	0.99061	0.99086	0.99111	0.99134	0.99158
2.4	0.99180	0.99202	0.99224	0.99245	0.99266	0.99286	0.99305	0.99324	0.99343	0.99361
2.5	0.99379	0.99396	0.99413	0.99430	0.99446	0.99461	0.99477	0.99492	0.99506	0.99520
2.6	0.99534	0.99547	0.99560	0.99573	0.99585	0.99598	0.99609	0.99621	0.99632	0.99643
2.7	0.99653	0.99664	0.99674	0.99683	0.99693	0.99702	0.99711	0.99720	0.99728	0.99736
2.8	0.99744	0.99752	0.99760	0.99767	0.99774	0.99781	0.99788	0.99795	0.99801	0.99807
2.9	0.99813	0.99819	0.99825	0.99831	0.99836	0.99841	0.99846	0.99851	0.99856	0.99861

Table 1.1 Standard Normal Distribution, $\Phi(z)$.

z	0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.07	-0.08	-0.09
-2.9	2.90054	2.91052	2.92051	2.93049	2.94047	2.95046	2.96044	2.97042	2.98041	2.99040
-2.8	2.80076	2.81074	2.82071	2.83069	2.84066	2.85064	2.86062	2.87060	2.88058	2.89056
-2.7	2.70106	2.71103	2.72099	2.73096	2.74093	2.75090	2.76087	2.77084	2.78081	2.79079
-2.6	2.60146	2.61142	2.62137	2.63133	2.64129	2.65125	2.66121	2.67117	2.68113	2.69110
-2.5	2.50200	2.51194	2.52188	2.53183	2.54177	2.55171	2.56166	2.57161	2.58156	2.59151
-2.4	2.40272	2.41264	2.42256	2.43248	2.44241	2.45234	2.46227	2.47220	2.48213	2.49207
-2.3	2.30366	2.31356	2.32345	2.33335	2.34325	2.35316	2.36307	2.37298	2.38289	2.39280
-2.2	2.20489	2.21475	2.22462	2.23449	2.24436	2.25423	2.26411	2.27400	2.28388	2.29377
-2.1	2.10647	2.11629	2.12612	2.13595	2.14579	2.15563	2.16547	2.17532	2.18517	2.19503
-2.0	2.00849	2.01827	2.02805	2.03783	2.04762	2.05742	2.06722	2.07702	2.08683	2.09665
-1.9	1.91105	1.92077	1.93049	1.94022	1.94996	1.95970	1.96945	1.97920	1.98896	1.99872
-1.8	1.81428	1.82392	1.83357	1.84323	1.85290	1.86257	1.87226	1.88195	1.89164	1.90134
-1.7	1.71829	1.72785	1.73742	1.74699	1.75658	1.76617	1.77578	1.78539	1.79501	1.80464
-1.6	1.62324	1.63270	1.64217	1.65165	1.66114	1.67064	1.68015	1.68967	1.69920	1.70874
-1.5	1.52931	1.53865	1.54800	1.55736	1.56674	1.57612	1.58552	1.59494	1.60436	1.61380
-1.4	1.43667	1.44587	1.45508	1.46431	1.47356	1.48281	1.49208	1.50137	1.51067	1.51998
-1.3	1.34553	1.35457	1.36363	1.37270	1.38179	1.39090	1.40002	1.40916	1.41831	1.42748
-1.2	1.25610	1.26496	1.27384	1.28274	1.29165	1.30059	1.30954	1.31851	1.32750	1.33650
-1.1	1.16862	1.17727	1.18595	1.19465	1.20336	1.21210	1.22086	1.22964	1.23844	1.24726
-1.0	1.08332	1.09174	1.10019	1.10866	1.11716	1.12568	1.13422	1.14279	1.15138	1.15999
-0.9	1.00043	1.00860	1.01680	1.02503	1.03328	1.04156	1.04986	1.05819	1.06654	1.07491
-0.8	0.92021	0.92810	0.93603	0.94398	0.95196	0.95997	0.96801	0.97607	0.98417	0.99229
-0.7	0.84288	0.85048	0.85810	0.86576	0.87345	0.88117	0.88892	0.89669	0.90450	0.91234
-0.6	0.76867	0.77595	0.78325	0.79059	0.79797	0.80537	0.81281	0.82028	0.82778	0.83531
-0.5	0.69780	0.70473	0.71170	0.71870	0.72573	0.73281	0.73991	0.74705	0.75422	0.76143
-0.4	0.63044	0.63701	0.64362	0.65027	0.65695	0.66367	0.67042	0.67721	0.68404	0.69090
-0.3	0.56676	0.57296	0.57920	0.58547	0.59178	0.59813	0.60452	0.61094	0.61740	0.62390
-0.2	0.50689	0.51271	0.51856	0.52445	0.53038	0.53634	0.54235	0.54840	0.55448	0.56060
-0.1	0.45094	0.45635	0.46181	0.46731	0.47285	0.47842	0.48404	0.48969	0.49539	0.50112
0.0	0.39894	0.40396	0.40902	0.41412	0.41926	0.42444	0.42966	0.43492	0.44022	0.44556

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.39894	0.39396	0.38902	0.38412	0.37926	0.37444	0.36966	0.36492	0.36022	0.35556
0.1	0.35094	0.34635	0.34181	0.33731	0.33285	0.32842	0.32404	0.31969	0.31539	0.31112
0.2	0.30689	0.30271	0.29856	0.29445	0.29038	0.28634	0.28235	0.27840	0.27448	0.27060
0.3	0.26676	0.26296	0.25920	0.25547	0.25178	0.24813	0.24452	0.24094	0.23740	0.23390
0.4	0.23044	0.22701	0.22362	0.22027	0.21695	0.21367	0.21042	0.20721	0.20404	0.20090
0.5	0.19780	0.19473	0.19170	0.18870	0.18573	0.18281	0.17991	0.17705	0.17422	0.17143
0.6	0.16867	0.16595	0.16325	0.16059	0.15797	0.15537	0.15281	0.15028	0.14778	0.14531
0.7	0.14288	0.14048	0.13810	0.13576	0.13345	0.13117	0.12892	0.12669	0.12450	0.12234
0.8	0.12021	0.11810	0.11603	0.11398	0.11196	0.10997	0.10801	0.10607	0.10417	0.10229
0.9	0.10043	0.09860	0.09680	0.09503	0.09328	0.09156	0.08986	0.08819	0.08654	0.08491
1.0	0.08332	0.08174	0.08019	0.07866	0.07716	0.07568	0.07422	0.07279	0.07138	0.06999
1.1	0.06862	0.06727	0.06595	0.06465	0.06336	0.06210	0.06086	0.05964	0.05844	0.05726
1.2	0.05610	0.05496	0.05384	0.05274	0.05165	0.05059	0.04954	0.04851	0.04750	0.04650
1.3	0.04553	0.04457	0.04363	0.04270	0.04179	0.04090	0.04002	0.03916	0.03831	0.03748
1.4	0.03667	0.03587	0.03508	0.03431	0.03356	0.03281	0.03208	0.03137	0.03067	0.02998
1.5	0.02931	0.02865	0.02800	0.02736	0.02674	0.02612	0.02552	0.02494	0.02436	0.02380
1.6	0.02324	0.02270	0.02217	0.02165	0.02114	0.02064	0.02015	0.01967	0.01920	0.01874
1.7	0.01829	0.01785	0.01742	0.01699	0.01658	0.01617	0.01578	0.01539	0.01501	0.01464
1.8	0.01428	0.01392	0.01357	0.01323	0.01290	0.01257	0.01226	0.01195	0.01164	0.01134
1.9	0.01105	0.01077	0.01049	0.01022	0.00996	0.00970	0.00945	0.00920	0.00896	0.00872
2.0	0.00849	0.00827	0.00805	0.00783	0.00762	0.00742	0.00722	0.00702	0.00683	0.00665
2.1	0.00647	0.00629	0.00612	0.00595	0.00579	0.00563	0.00547	0.00532	0.00517	0.00503
2.2	0.00489	0.00475	0.00462	0.00449	0.00436	0.00423	0.00411	0.00400	0.00388	0.00377
2.3	0.00366	0.00356	0.00345	0.00335	0.00325	0.00316	0.00307	0.00298	0.00289	0.00280
2.4	0.00272	0.00264	0.00256	0.00248	0.00241	0.00234	0.00227	0.00220	0.00213	0.00207
2.5	0.00200	0.00194	0.00188	0.00183	0.00177	0.00171	0.00166	0.00161	0.00156	0.00151
2.6	0.00146	0.00142	0.00137	0.00133	0.00129	0.00125	0.00121	0.00117	0.00113	0.00110
2.7	0.00106	0.00103	0.00099	0.00096	0.00093	0.00090	0.00087	0.00084	0.00081	0.00079
2.8	0.00076	0.00074	0.00071	0.00069	0.00066	0.00064	0.00062	0.00060	0.00058	0.00056
2.9	0.00054	0.00052	0.00051	0.00049	0.00047	0.00046	0.00044	0.00042	0.00041	0.00040

Table 1.2 Standard Normal Loss Function, $L(z)$.