

Question 1. [10 marks]

Ohio is a key swing state in the U. S. presidential election. No Republican nominee has ever won without winning Ohio's electoral votes. On October 3, a Quinnipiac poll based on 497 likely voters showed Trump with 47% and Clinton with 42% of the sample in Ohio. On October 5, a Monmouth poll based on 405 likely voters showed Trump with 42% and Clinton with 44% of the sample in Ohio.

- a) Keeping the probability of a Type I error at 0.05, perform a test to determine whether there is a statistically significant difference in Trump's support between the two polls. Use the critical value approach.

[5]

- b) Find the p-value for the test statistic in (a).

[1]

- c) Now calculate the appropriate 95% confidence interval for the difference in popular support for Trump between the two surveys.

[2]

- d) Explain whether and how the three approaches above are or are not consistent.

[2]

Question 2. [10 marks]

Appendix A shows, for a sample of Ottawa-Nepean homes, both the 2015 and the 2016 assessed values in thousands of dollars. Suppose you are interested in determining whether the typical increase in assessed values is more than \$18,000.

- a) Explain whether you should do an independent samples test or a paired samples test.

[1]

- b) Given your answer to (a), identify the most appropriate test. Explain briefly, with reference to specific boxplots.

[2]

- c) Notwithstanding your answer to (b), but being consistent to your answer to (a),

- i. Perform the appropriate parametric test to determine whether there is sufficient evidence to conclude that the mean increase is more than \$18,000. Use the 0.05 level of significance.

[4]

- ii. Now perform an appropriate non-parametric test to determine whether there is sufficient evidence to conclude that the median increase is more than \$18,000. Use the 0.05 level of significance.

[3]

Question 3. [10 marks]

Appendix B shows some graphs and summaries of median household incomes for two samples of neighbourhoods, one from Calgary (HhldInc_Cal) and the other from Edmonton (HhldInc_Edm).

- a) Test at the 0.05 level of significance to determine if there is evidence of a difference in average household income between the two cities. Use a parametric test and do not assume equal population variances.

[5]

- b) Find the p-value for the result above.

[1]

- c) Now calculate an appropriate 95% confidence interval for the difference in average household income between the two cities.

[2]

- d) What assumptions regarding the population data are *required* to justify your calculations above? Looking at the boxplots of the two samples of median incomes, explain whether these assumptions are reasonable.

Necessary assumption(s):

[2]

Question 4. [10 marks]

A CPA with a large accounting firm wants to select a random sample of transactions to determine if the population deviation rate (the proportion with material errors) is below the tolerable rate of 7%.

- a) What hypotheses should he test to be able to conclude that the population deviation rate is below 7%? (This means that the control procedures are operating effectively.)

[1]

- b) Based on his previous auditing experience, he expects to find a deviation rate of 4%. What sample size should he select if he wants to calculate the appropriate 95% confidence interval that will allow him to reject the null hypothesis? (Make whatever assumptions are necessary to provide some numerical answer.)

[3]

- c) In your calculations above, you are assuming that the

_____ has a _____ distribution.

Assuming the null hypothesis is true, this is or is not (circle one) reasonable since

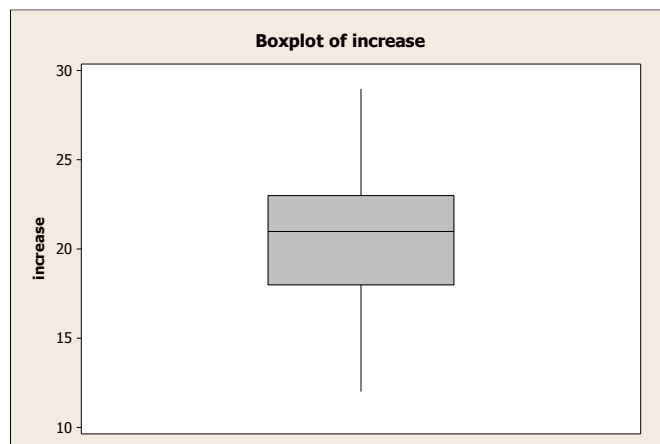
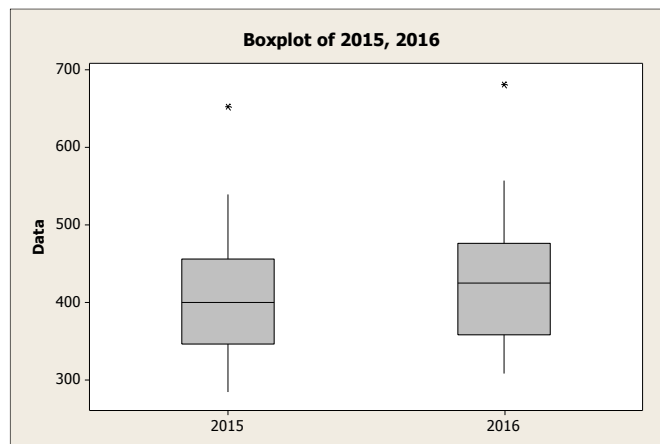
_____ . [4]

- d) Suppose he ends up taking a sample size of 200 and finds only 6 transactions with errors. Find the exact p-value of this result and state your final conclusion for the test in (a).

[2]

Appendix A

2015	2016	increase
456	476	20
375	396	21
394	414	20
652	681	29
346	358	12
335	352	17
290	309	19
449	472	23
477	498	21
437	460	23
399	427	28
284	308	24
539	557	18
389	404	15
404	425	21



Two-Sample T-Test and CI: 2016, 2015

Two-sample T for 2016 vs 2015

				SE
	N	Mean	StDev	Mean
2016	15	435.8	96.7	25
2015	15	415.1	94.8	24

Difference = μ (2016) - μ (2015)

Estimate for difference: 20.7333

95% lower bound for difference:

T-Test of difference (): T-Value = _____ P-Value = _____ DF = 27

Paired T-Test and CI: 2016, 2015

Paired T for 2016 - 2015

	N	Mean	StDev	SE Mean
2016	15	435.800	96.712	24.971
2015	15	415.067	94.775	24.471
Difference	15	20.7333	4.4476	1.1484

95% lower bound for mean difference: _____

T-Test of mean difference (): T-Value = _____ P-Value = _____

Mann-Whitney Test and CI: 2016, 2015 + \$18

	N	Median
2016	15	425.0
2015 + \$18	15	417.0

Point estimate for ETA1-ETA2 is 3.0

95.4 Percent CI for ETA1-ETA2 is (-60.0,64.0)

W = 238.0

Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.4179

The test is significant at 0.4178 (adjusted for ties)

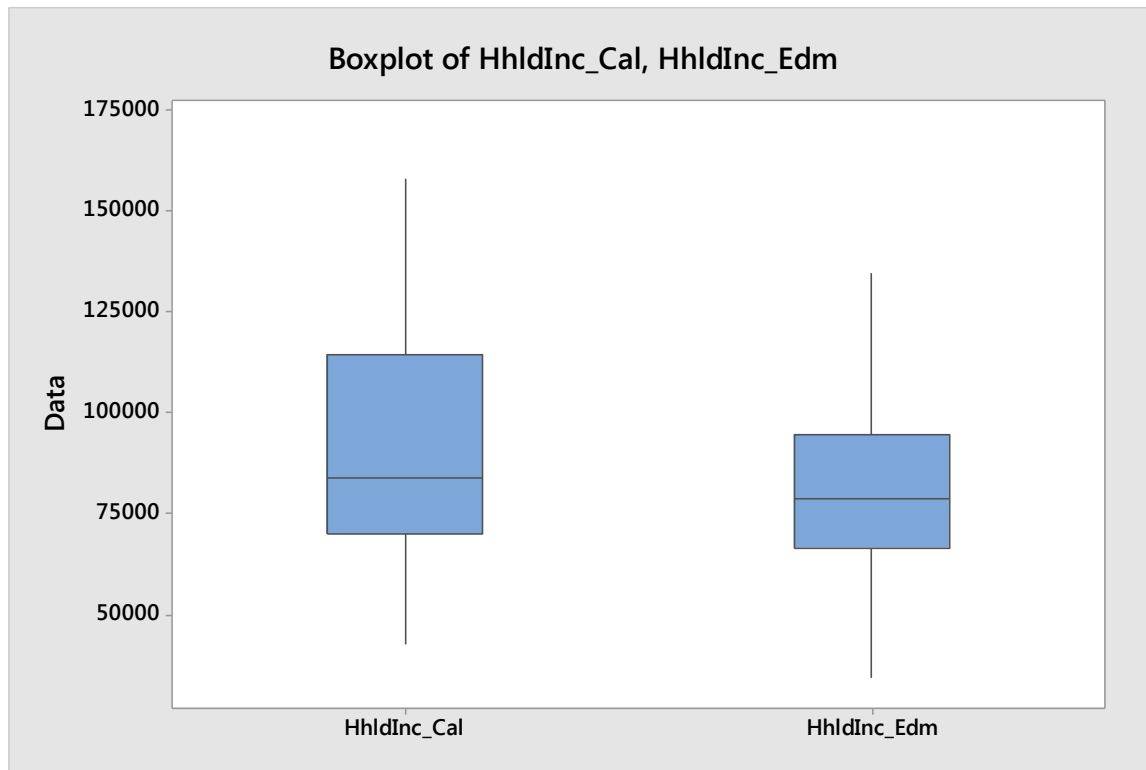
Here, "2015 + \$18" represents the 2015 data plus \$18.

Wilcoxon Signed Rank Test: increase

Test of median = 18.00 versus median > 18.00

	N	for	Wilcoxon	Estimated	
	N	Test	Statistic	P	Median
increase	15	14	85.5	0.021	20.50

Appendix B



Two-Sample T-Test and CI: HhldInc_Cal, HhldInc_Edm

Two-sample T for HhldInc_Cal vs HhldInc_Edm

	N	Mean	StDev	SE Mean
HhldInc_Cal	59	90716	26715	3478
HhldInc_Edm	60	80444	20688	2671

Difference = μ (HhldInc_Cal) - μ (HhldInc_Edm)

Estimate for difference: 10273

95% CI for difference:

T-Test of difference = 0 (vs _____): T-Value = _____ P-Value = _____ DF = 109

Mann-Whitney Test and CI: HhldInc_Cal, HhldInc_Edm

	N	Median
HhldInc_Cal	59	84045
HhldInc_Edm	60	78795

Point estimate for $\eta_1 - \eta_2$ is 7687

95.0 Percent CI for $\eta_1 - \eta_2$ is (-951,16996)

W = 3863.0

Test of $\eta_1 = \eta_2$ vs $\eta_1 \neq \eta_2$ is significant at 0.0865

Standard Normal Distribution

P(Z < z) (z negative)

Second decimal place in z

0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00	z
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-3.9
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-3.8
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-3.7
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	-3.6
0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	-3.5
0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	-3.4
0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	-3.3
0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	-3.2
0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	-3.1
0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013	0.0013	-3.0
0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018	0.0019	-2.9
0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025	0.0026	-2.8
0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034	0.0035	-2.7
0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045	0.0047	-2.6
0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060	0.0062	-2.5
0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0.0082	-2.4
0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0.0107	-2.3
0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0.0139	-2.2
0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0.0179	-2.1
0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0.0228	-2.0
0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0.0287	-1.9
0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0.0359	-1.8
0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0.0446	-1.7
0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537	0.0548	-1.6
0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655	0.0668	-1.5
0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0.0808	-1.4
0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0.0968	-1.3
0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0.1151	-1.2
0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0.1357	-1.1
0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0.1587	-1.0
0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0.1841	-0.9
0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0.2119	-0.8
0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0.2420	-0.7
0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0.2743	-0.6
0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0.3085	-0.5
0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0.3446	-0.4
0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0.3821	-0.3
0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0.4207	-0.2
0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562	0.4602	-0.1
0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960	0.5000	0.0

Standard Normal Distribution

P(Z < z) (z positive)

Second decimal place in z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.8	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Student's t distribution

t_α											
$\alpha = P(t > t_\alpha) = \text{one-tail probability}$											
ν	0.100	0.090	0.080	0.070	0.060	0.050	0.025	0.010	0.001	0.0005	0.0001
11	1.36	1.43	1.51	1.59	1.69	1.80	2.20	2.72	4.02	4.44	5.45
12	1.36	1.42	1.50	1.58	1.67	1.78	2.18	2.68	3.93	4.32	5.26
13	1.35	1.42	1.49	1.57	1.66	1.77	2.16	2.65	3.85	4.22	5.11
14	1.35	1.41	1.48	1.56	1.66	1.76	2.14	2.62	3.79	4.14	4.99
15	1.34	1.41	1.48	1.56	1.65	1.75	2.13	2.60	3.73	4.07	4.88
16	1.34	1.40	1.47	1.55	1.64	1.75	2.12	2.58	3.69	4.01	4.79
17	1.33	1.40	1.47	1.55	1.64	1.74	2.11	2.57	3.65	3.97	4.71
18	1.33	1.39	1.47	1.54	1.63	1.73	2.10	2.55	3.61	3.92	4.65
19	1.33	1.39	1.46	1.54	1.63	1.73	2.09	2.54	3.58	3.88	4.59
20	1.33	1.39	1.46	1.54	1.62	1.72	2.09	2.53	3.55	3.85	4.54
21	1.32	1.39	1.46	1.53	1.62	1.72	2.08	2.52	3.53	3.82	4.49
22	1.32	1.38	1.45	1.53	1.62	1.72	2.07	2.51	3.50	3.79	4.45
23	1.32	1.38	1.45	1.53	1.61	1.71	2.07	2.50	3.48	3.77	4.42
24	1.32	1.38	1.45	1.53	1.61	1.71	2.06	2.49	3.47	3.75	4.38
25	1.32	1.38	1.45	1.52	1.61	1.71	2.06	2.49	3.45	3.73	4.35
26	1.31	1.38	1.45	1.52	1.61	1.71	2.06	2.48	3.43	3.71	4.32
27	1.31	1.38	1.44	1.52	1.61	1.70	2.05	2.47	3.42	3.69	4.30
28	1.31	1.38	1.44	1.52	1.60	1.70	2.05	2.47	3.41	3.67	4.28
29	1.31	1.37	1.44	1.52	1.60	1.70	2.05	2.46	3.40	3.66	4.25
30	1.31	1.37	1.44	1.52	1.60	1.70	2.04	2.46	3.39	3.65	4.23
40	1.30	1.36	1.43	1.51	1.59	1.68	2.02	2.42	3.31	3.55	4.09
50	1.30	1.36	1.43	1.50	1.58	1.68	2.01	2.40	3.26	3.50	4.01
60	1.30	1.36	1.42	1.50	1.58	1.67	2.00	2.39	3.23	3.46	3.96
70	1.29	1.35	1.42	1.49	1.57	1.67	1.99	2.38	3.21	3.44	3.93
80	1.29	1.35	1.42	1.49	1.57	1.66	1.99	2.37	3.20	3.42	3.90
90	1.29	1.35	1.42	1.49	1.57	1.66	1.99	2.37	3.18	3.40	3.88
100	1.29	1.35	1.42	1.49	1.57	1.66	1.98	2.36	3.17	3.39	3.86
1000	1.28	1.34	1.41	1.48	1.56	1.65	1.96	2.33	3.10	3.30	3.73

Binomial distribution

$n = 200$							
$p = 0.01$							
x	$P(X = x)$	$P(X = x)$	$P(X = x)$	$P(X = x)$	$P(X = x)$	$P(X = x)$	$P(X = x)$
0	0.1340	0.0176	0.0023	0.0003	0.0000		
1	0.2707	0.0718	0.0140	0.0024	0.0004	0.0001	
2	0.2720	0.1458	0.0430	0.0098	0.0019	0.0003	0.0001
3	0.1814	0.1963	0.0879	0.0270	0.0067	0.0014	0.0003
4	0.0902	0.1973	0.1338	0.0555	0.0174	0.0045	0.0010
5	0.0357	0.1579	0.1622	0.0906	0.0359	0.0113	0.0030
6	0.0117	0.1047	0.1631	0.1227	0.0614	0.0235	0.0075
7	0.0033	0.0592	0.1398	0.1417	0.0896	0.0416	0.0155
8	0.0008	0.0292	0.1043	0.1425	0.1137	0.0641	0.0282
9	0.0002	0.0127	0.0688	0.1266	0.1277	0.0873	0.0453
10	0.0000	0.0049	0.0407	0.1008	0.1284	0.1064	0.0652