

Case Report

MotoTech Manufacturing Company

ISOM3900 - Decision Analytics

Introduction

There are many factors that we may consider to be influential to the final result. In some situations, we may consider that there is only one single factor affecting the result. In this case, we will use **one-way ANOVA** to check if there are significant differences among the groups. If the differences are significant, then it means the factor is actually affecting the actual result. Additionally, when there are instead two factors that are affecting the actual result, **two-way ANOVA** will be used to test whether both factors are independently or dependently affecting the actual results. ANOVA is particularly useful when we are trying to make decisions such as which factors we should focus on if we are trying to improve the overall result.

In MotoTech Case, supplier and temperature are considered as the two factors affecting the thickness of integrated chips. To further improve the consistency of thickness, both single-factor and two-factor ANOVA are utilized to test the significance of those factors and how they affect the average thickness of integrated chips.

Assignment

1) Do you agree with VR4U's recommendation that neither supplier nor temperature affects the thickness? If yes, why? If no, why not?

First, we run a one way ANOVA in the Excel file tab "*Exhibit 1*" which shows the dataset between supplier and thickness.

$H_0: \mu_1 = \mu_2 = \mu_3$ (all suppliers group means are equal)

H_A : Not all μ_j are equal, $j = 1, 2, 3$ (at least one supplier group mean is different from the rest)

View ANOVA: Single Factor Figure 1

Since the between groups' p-value is lower than alpha (0.05), the null hypothesis is not rejected. The result is that the mean thickness from the suppliers groups are equal, which means there are no significant differences.

Then, we run a one way ANOVA in the excel file tab "*Exhibit 2*" which shows the dataset between temperature and thickness.

$H_0: \mu_1 = \mu_2 = \mu_3$ (all temperatures group means are equal)

H_A : Not all μ_j are equal, $j = 1, 2, 3$ (at least one temperatures group mean is different from the rest)

View ANOVA: Single Factor Figure 2

Since the between groups' p-value is lower than alpha (0.05), the null hypothesis is not rejected. The result is that the mean thickness from the temperatures groups are equal, which means there are no significant differences.

To conclude, we agree with VR4U's recommendation that neither supplier nor temperature affects the thickness.

2) What would you recommend the MotoTech company to do? Which supplier and which temperature should they choose?

Rather than running two single-factor independent ANOVA tests, we can consolidate the data and run a two-factor with replication ANOVA test. The following is the result:

View ANOVA: Two-Factor with Replication Figure 1

We have seen that the interaction's p-value is smaller than alpha (0.05), which implies there is an interaction effect, hence we ignore the p-value from the Sample and Columns due to it being misleading. The graph in the following shows the interactions:

View Interaction Effect Figure 1

Since there is an interaction effect, we need to conduct a single factor one way ANOVA with replication to show the details of the interaction. Before that, we have rearranged the dataset, as shown as follows:

View Rearranged Dataset

The result of one way ANOVA:

View ANOVA Single Factor Figure 3

Since the p-value is lower than alpha (0.05), the next step is to conduct tukey-kramer test, details are shown as follows:

View Tukey-Kramer Figure 1

Noted that the Q statistics is 4.47, which is generated from the “Q_table.pdf” with $\alpha = 0.05$, numerator degree of freedom = 9, denominator degree of freedom = 120 (our dataset’s degree of freedom is 126).

By gathering the result given that the comparison result is “Means are different”, we have come up with a conclusion to choose between (High + Pinnacle) and (Low + Premier).

Appendix

Anova: Single Factor						
SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
Pinnacle	45	135456.219	3010.1382	22.88095603		
Allied	45	135449.985	3009.999667	3.2938325		
Premier	45	135464.323	3010.318289	22.67741107		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	2.297154193	2	1.148577096	0.0705338	0.931931339	3.064760677
Within Groups	2149.496782	132	16.28406653			
Total	2151.793937	134				

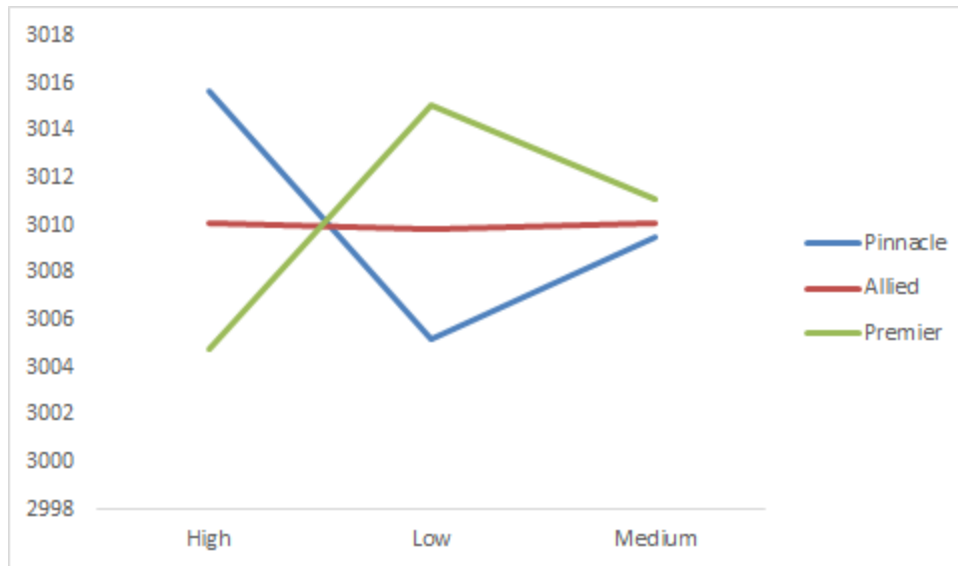
ANOVA: Single Factor Figure 1

Anova: Single Factor						
SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
High	45	135459.005	3010.200111	23.6143606		
Low	45	135452.206	3010.049022	21.86211625		
Medium	45	135459.316	3010.207022	3.41162184		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.717594237	2	0.358797119	0.022017452	0.978226755	3.064760677
Within Groups	2151.076342	132	16.2960329			
Total	2151.793937	134				

ANOVA: Single Factor Figure 2

Anova: Two-Factor With Replication						
SUMMARY	High	Low	Medium	Total		
<i>Pinnacle</i>						
Count	15	15	15	45		
Sum	45235.339	45078.34	45142.54	135456.219		
Average	3015.689267	3005.222667	3009.502667	3010.1382		
Variance	4.787305495	6.163006667	1.624787095	22.88095603		
<i>Allied</i>						
Count	15	15	15	45		
Sum	45151.793	45147.44	45150.752	135449.985		
Average	3010.119533	3009.829333	3010.050133	3009.999667		
Variance	2.676931981	3.333900524	4.292003552	3.2938325		
<i>Premier</i>						
Count	15	15	15	45		
Sum	45071.873	45226.426	45166.024	135464.323		
Average	3004.791533	3015.095067	3011.068267	3010.318289		
Variance	3.120143981	6.922027067	3.452799924	22.67741107		
<i>Total</i>						
Count	45	45	45			
Sum	135459.005	135452.206	135459.316			
Average	3010.200111	3010.049022	3010.207022			
Variance	23.6143606	21.86211625	3.41162184			
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Sample	2.297154193	2	1.148577096	0.284200382	0.753096976	3.068100269
Columns	0.717594237	2	0.358797119	0.088779655	0.915104366	3.068100269
Interaction	1639.5585	4	409.8896251	101.4218275	1.98525E-38	2.443590781
Within	509.220688	126	4.041434032			
Total	2151.793937	134				

ANOVA: Two-Factor with Replication Figure 1



Interaction Effect Figure 1

High-Pinnacle	High-Allied	High-Premier	Low-Pinnacle	Low-Allied	Low-Premier	Medium-Pinnacle	Medium-Allied	Medium-Premier
3015.789	3009.544	3005.264	3007.520	3013.402	3012.517	3008.081	3007.439	3008.222
3016.481	3014.054	3004.111	3007.160	3010.555	3015.323	3009.986	3008.796	3010.907
3018.824	3011.743	3006.489	3002.183	3008.844	3016.848	3011.145	3012.171	3009.463
3017.623	3008.409	3007.552	3002.551	3009.630	3012.960	3010.034	3010.829	3010.777
3012.477	3009.881	3004.892	3003.725	3010.390	3017.433	3009.890	3014.053	3012.816
3013.338	3007.599	3002.288	3004.398	3008.531	3012.313	3008.905	3009.849	3007.791
3017.935	3008.567	3007.603	3006.289	3007.465	3015.492	3007.885	3011.363	3014.196
3014.894	3009.942	3004.680	3008.280	3010.053	3011.332	3009.401	3006.747	3012.559
3014.638	3010.279	3003.934	3009.330	3009.254	3015.716	3007.391	3008.608	3012.208
3016.027	3012.004	3004.331	3007.781	3011.104	3017.213	3010.331	3010.109	3011.225
3012.691	3011.253	3006.333	3004.381	3007.019	3018.044	3009.551	3013.550	3011.715
3019.760	3008.682	3002.328	3001.721	3008.666	3015.407	3012.442	3009.468	3009.355
3013.608	3009.636	3005.172	3006.357	3010.044	3015.973	3009.251	3010.044	3010.450
3015.329	3009.888	3005.053	3002.182	3009.063	3019.431	3008.777	3008.413	3013.630
3015.925	3010.312	3001.843	3004.482	3013.420	3010.424	3009.470	3009.313	3010.710

Rearranged Dataset

Anova: Single Factor						
SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
High-Pinnacle	15	45235.34	3015.689	4.787305		
High-Allied	15	45151.79	3010.12	2.676932		
High-Premier	15	45071.87	3004.792	3.120144		
Low-Pinnacle	15	45078.34	3005.223	6.163007		
Low-Allied	15	45147.44	3009.829	3.333901		
Low-Premier	15	45226.43	3015.095	6.922027		
Medium-Pinnacle	15	45142.54	3009.503	1.624787		
Medium-Allied	15	45150.75	3010.05	4.292004		
Medium-Premier	15	45166.02	3011.068	3.4528		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1642.573	8	205.3217	50.80416	7.65E-36	2.012654
Within Groups	509.2207	126	4.041434			
Total	2151.794	134				

ANOVA: Single Factor Figure 3

Tukey Kramer Multiple Comparisons										
				Comparison	Abs. Diff.	St. Error of Diff	CR	Result	Comparison	
Group	Index	Sample Mean	Sample Size	1	2	5.57	0.519065444	2.320223	Means are different	1
High-Pinnacle	1	3015.689267	15	1	3	10.90	0.519065444	2.320223	Means are different	1
High-Allied	2	3010.119533	15	1	4	10.47	0.519065444	2.320223	Means are different	1
High-Premier	3	3004.791533	15	1	5	5.86	0.519065444	2.320223	Means are different	1
Low-Pinnacle	4	3005.222667	15	1	6	0.59	0.519065444	2.320223	Means are not different	
Low-Allied	5	3009.829333	15	1	7	6.19	0.519065444	2.320223	Means are different	1
Low-Premier	6	3015.095067	15	1	8	5.64	0.519065444	2.320223	Means are different	1
Medium-Pinnacle	7	3009.502667	15	1	9	4.62	0.519065444	2.320223	Means are different	1
Medium-Allied	8	3010.050133	15	2	3	5.33	0.519065444	2.320223	Means are different	2
Medium-Premier	9	3011.068267	15	2	4	4.90	0.519065444	2.320223	Means are different	2
				2	5	0.29	0.519065444	2.320223	Means are not different	
				2	6	4.98	0.519065444	2.320223	Means are different	6
				2	7	0.62	0.519065444	2.320223	Means are not different	
Other Data				2	8	0.07	0.519065444	2.320223	Means are not different	
Level of significance		0.05		2	9	0.95	0.519065444	2.320223	Means are not different	
Numerator d.f.		9		3	4	0.43	0.519065444	2.320223	Means are not different	
Denominator d.f.		126		3	5	5.04	0.519065444	2.320223	Means are different	5
MSW		4.041434032		3	6	10.30	0.519065444	2.320223	Means are different	6
Q Statistic		4.47		3	7	4.71	0.519065444	2.320223	Means are different	7
				3	8	5.26	0.519065444	2.320223	Means are different	8
				3	9	6.28	0.519065444	2.320223	Means are different	9
				4	5	4.61	0.519065444	2.320223	Means are different	5
				4	6	9.87	0.519065444	2.320223	Means are different	6
				4	7	4.28	0.519065444	2.320223	Means are different	7
				4	8	4.83	0.519065444	2.320223	Means are different	8
				4	9	5.85	0.519065444	2.320223	Means are different	9
				5	6	5.27	0.519065444	2.320223	Means are different	6
				5	7	0.33	0.519065444	2.320223	Means are not different	
				5	8	0.22	0.519065444	2.320223	Means are not different	
				5	9	1.24	0.519065444	2.320223	Means are not different	
				6	7	5.59	0.519065444	2.320223	Means are different	6
				6	8	5.04	0.519065444	2.320223	Means are different	6
				6	9	4.03	0.519065444	2.320223	Means are different	6
				7	8	0.55	0.519065444	2.320223	Means are not different	
				7	9	1.57	0.519065444	2.320223	Means are not different	
				8	9	1.02	0.519065444	2.320223	Means are not different	

Tukey-Kramer Figure 1