



Market Basket Analysis



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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Transaction	Product	Row	Product	Candy Bar	Product	Deodorant	Product	Shampoo	Product	Shampoo	Product	Shampoo	Product	Shampoo	Product	Shampoo	Product
2	12359	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	12360	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	12362	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	12365	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
6	12371	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	12380	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	12383	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	12385	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	12386	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	12386	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
12	12391	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
13	12392	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	12401	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
15	12401	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
16	1401	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
17	1401	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	1401	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	1401	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	1410	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
21	1413	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	1471	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
23	1473	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
24	1563	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
25	1563	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
26	1563	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	1563	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	1563	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
29	1563	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
30	1571	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
31	1572	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
32	1572	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
33	1572	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
34	1572	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
35	1572	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
36	1572	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
37	1572	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
38	1572	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
39	1572	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
40	1575	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
41	1578	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
42	1585	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
43	1587	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
44	1620	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
45	1620	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
46	1620	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
47	1620	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
48	1620	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
49	1625	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
50	1638	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
51	1745	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
52	1752	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
53	1758	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
54	1758	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
55	1761	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
56	1761	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

2. Identifying the frequent itemset using a minimum support threshold of 1%.

There are 40 itemsets that are frequent using a minimum support threshold of 1%.

The most frequent item is magazine, which has the highest support value of 0.2413.

3. Identifying all association rules with a minimum confidence of 10%

There are 50 rules generated with a minimum confidence of 10%.

Among those rules, Rule (Pencils, Toothpaste) --> (Canday Bar) has the highest confidence value, which is 0.4638.

4. Which rules have the highest lift

Based on the rule list sorted by lift above, rule (Perfume) --> (Toothbrush), in which (Perfume) is antecedent, (Toothbrush) is consequent, has the highest lift value, which is 3.6014.

Calculation process for lift of rule (Perfume) --> (Toothbrush):

$$\begin{aligned} \text{lift}(r) &= \frac{\text{actual confidence}}{\text{benchmark confidence}} = \frac{\text{sup}(r)}{\text{sup}(a) * \text{sup}(c)} = \frac{0.021820}{0.089960 * 0.067350} \\ &= 3.601370 \end{aligned}$$

5. For the same rule, how to calculate leverage and conviction were obtained.

Calculation for leverage of rule (Perfume) --> (Toothbrush):

$$\begin{aligned} \text{leverage}(r) &= p(canda) - p(c) * p(a) = \text{sup}(r) - \text{sup}(c) * \text{sup}(a) = 0.021820 \\ &\quad - 0.067350 * 0.089960 = 0.015761 \end{aligned}$$

Calculation for conviction of rule (Perfume) --> (Toothbrush):

$$\text{leverage}(r) = \frac{1 - p(c)}{1 - p(c|a)} = \frac{1 - \text{sup}(c)}{1 - \text{conf}(r)} = \frac{1 - 0.067350}{1 - 0.242552} = 1.231306$$

6. Interpreting and discussing the 5 rules

The below table shows rules sorted by

1. highest confidence
2. highest lift
3. highest leverage
4. highest conviction

ASSOCIATION RULES						
RANKED BY	RULE NUMBER	RULE	(SUPPORT, CONFIDENCE)	LIFT	LEVERAGE	CONVICTION
CONFIDENCE	1	{Pencils, Toothpaste} --> {Candy Bar}	(1.14%, 46.38%)	2.71	0.01	1.55
	2	{Greeting Cards, Magazine} --> {Candy Bar}	(1.67%, 45.86%)	2.68	0.01	1.53
	3	{Toothpaste, Magazine} --> {Candy Bar}	(1.37%, 43.33%)	2.53	0.01	1.46
	4	{Candy Bar, Magazine} --> {Greeting Cards}	(1.67%, 41.11%)	2.80	0.01	1.45
	5	{Greeting Cards, Toothpaste} --> {Candy Bar}	(1.32%, 41.07%)	2.40	0.01	1.41
LIFT	1	{Perfume} --> {Toothbrush}	(2.18%, 24.26%)	3.60	0.02	1.23
	2	{Toothbrush} --> {Perfume}	(2.18%, 32.40%)	3.60	0.02	1.35
	3	{Toothbrush} --> {Bow}	(1.13%, 16.84%)	3.08	0.01	1.14
	4	{Bow} --> {Toothbrush}	(1.13%, 20.75%)	3.08	0.01	1.18
	5	{Greeting Cards} --> {Candy Bar, Magazine}	(1.67%, 41.11%)	2.80	0.01	1.45
LEVERAGE	1	{Candy Bar} --> {Greeting Cards}	(4.37%, 25.53%)	1.74	0.02	1.15
	2	{Greeting Cards} --> {Candy Bar}	(4.37%, 29.72%)	1.74	0.02	1.18
	3	{Perfume} --> {Toothbrush}	(2.18%, 32.40%)	3.60	0.02	1.35
	4	{Toothbrush} --> {Perfume}	(2.18%, 24.26%)	3.60	0.02	1.23
	5	{Toothpaste} --> {Candy Bar}	(3.98%, 24.80%)	1.45	0.01	1.10
CONVICTION	1	{Pencils, Toothpaste} --> {Candy Bar}	(1.14%, 46.38%)	2.71	0.01	1.55
	2	{Greeting Cards, Magazine} --> {Candy Bar}	(1.67%, 45.86%)	2.68	0.01	1.53

	3	{Toothpaste, Magazine} - -> {Candy Bar}	(1.37%, 43.33%)	2.53	0.01	1.46
	4	{Candy Bar, Magazine} - -> {Greeting Cards}	(1.67%, 41.11%)	2.80	0.01	1.45
	5	{Greeting Cards, Toothpaste} --> {Candy Bar}	(1.32%, 41.07%)	2.40	0.01	1.41

Observations 6a:

For the top five rules based on highest confidence:

RULE 1 is {Pencils, Toothpaste} --> {Candy Bar}, which means if pencils and toothpaste are purchased, then with confidence 46.38% candy bar is also purchased. This rule has a lift ratio of 2.71. This combination appears in 1.14% of the baskets and the lift tells us that combination is 2.7x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 2 is {Greeting Cards, Magazine} --> {Candy Bar}, which means if greeting cards and magazines are purchased, then with confidence 45.86% candy bar is also purchased. This rule has a lift ratio of 2.68. This combination appears in 1.67% of the baskets and the lift tells us that combination is 2.6x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 3 is {Toothpaste, Magazine} --> {Candy Bar}, which means if toothpaste and magazine are purchased, then with confidence 43.33% candy bar is also purchased. This rule has a lift ratio of 2.53. This combination appears in 1.37% of the baskets and the lift tells us that combination is 2.5x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 4 is {Candy Bar, Magazine} --> {Greeting Cards}, which means if candy bar and magazine are purchased, then with confidence 41.11% greeting cards is also purchased. This rule has a lift ratio of 2.80. This combination appears in 1.67% of the baskets and the lift tells us that combination is 2.8x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 5 is {Greeting Cards, Toothpaste} --> {Candy Bar}, which means if greeting cards and toothpaste are purchased, the with confidence 41.07% candy bar is also purchased. This rule has a lift ratio of 2.80. This combination appears in 1.67% of the baskets and the lift tells us that combination is 1.67x more likely to occur together than one would expect from the individual rates of incidence alone.

Observations 6b:

For the top five rules based on highest lift:

RULE 1 is {Perfume} --> {Toothbrush}, which means if perfume is purchased, toothbrush is purchased with 24.26% confidence. This rule has a lift ratio of 3.60. This combination appears in 2.18% of the baskets and the lift tells us that combination is 3.6x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 2 is {Toothbrush} --> {Perfume}, which means if toothbrush is purchased, perfume is purchased with 32.40% based on confidence. This rule has a lift ratio of 3.60. This combination appears in 2.18% of the baskets and the lift tells us that combination is 3.6x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 3 is {Toothbrush} --> {Bow}, which means if toothbrush is purchased, bow is purchased with 16.84% based on confidence. This rule has a lift ratio of 3.08. This combination appears in 1.13% of the baskets and the lift tells us that combination is 3.08x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 4 is {Bow} --> {Toothbrush}, which means if bow is purchased, toothbrush is purchased with 20.75% based on confidence. This rule has a lift ratio of 3.08. This combination appears in 1.13% of the baskets and the lift tells us that combination is 3.08x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 5 is {Greeting Cards} --> {Candy Bar, Magazine}, which means if greeting cards is purchased, candy bar and magazine are purchased with 41.11% based on confidence.

This rule has a lift ratio of 2.80. This combination appears in 1.67% of the baskets and the lift tells us that combination is 2.8x more likely to occur together than one would expect from the individual rates of incidence alone.

Observations 6c:

For the top five rules based on highest leverage:

RULE 1 is {Candy Bar} --> {Greeting Cards}, which means if candy bar is purchased, greeting cards are purchased with confidence 25.53%. This rule has a lift ratio of 1.73. This combination appears in 4.37% of the baskets and

the lift tells us that combination is 1.7x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 2 is {Greeting Cards} --> {Candy Bar}, which means if greeting cards are purchased, candy bar is also purchased with confidence 29.72%. This rule has a lift ratio of 1.73. This combination appears in 4.37% of the baskets and the lift tells us that combination is 1.7x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 3 is {Toothbrush} --> {Perfume}, which means if toothbrush is purchased, perfume is purchased with confidence 32.40%. This rule has a lift ratio of 3.60. This combination appears in 2.18% of the baskets and the lift tells us that combination is 3.6x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 4 is {Perfume} --> {Toothbrush}, which means if perfume is purchased, toothbrush is purchased with confidence 24.255%. This rule has a lift ratio of 3.60. This combination appears in 2.18% of the baskets and the lift tells us that combination is 3.6x more likely to occur together than one would expect from the individual rates of incidence alone.

RULE 5 is {Toothpaste} --> {Candy Bar}, which means if Toothpaste is purchased, candy bar is also purchased with 41.11% confidence. This rule has a lift ratio of 1.45. This combination appears in 3.97% of the baskets and the lift tells us that combination is 1.45x more likely to occur together than one would expect from the individual rates of incidence alone.

Observations 6d:

As for the top five rules based on highest conviction, we got totally same rule list as we got when we sorted the rules using confidence.

Based on the 5 rules based on different criteria, we could detect the following phenomena which are interesting:

LIFT	1	{Perfume} --> {Toothbrush}	(2.18%, 24.26%)	3.60	0.02	1.23
	2	{Toothbrush} --> {Perfume}	(2.18%, 32.40%)	3.60	0.02	1.35
	3	{Toothbrush} --> {Bow}	(1.13%, 16.84%)	3.08	0.01	1.14
	4	{Bow} --> {Toothbrush}	(1.13%, 20.75%)	3.08	0.01	1.18
	5	{Greeting Cards} --> {Candy Bar, Magazine}	(1.67%, 41.11%)	2.80	0.01	1.45

- 1) Let's look at the rules generated and sorted by lift. It's clear that {Toothbrush} --> {Perfume} has better confidence than {Perfume} --> {Toothbrush} and support, lift and leverage remain the same but the conviction increases, the rule would be incorrect 35% more often as compared to rule 1 that would be incorrect 23% more often if the association between a and b was purely random chance. Although rule 2 has chance of being correct more often but based on the cost and margin associated, we will choose rule 2 and consider rule 1 redundant.
- 2) Utilizing the different criteria, we got different lists of top 5 rules, but cross comparing these lists could provide better reference for us to pick best rules, such as:
 - a. Rules including {Greeting Cards} and {Candy Bar} either as antecedent or consequent appear multiple times, meaning that these two items are highly correlated.
 - b. Rules containing {Magazine} and {Candy Bar}, also rules with {Magazine} and {Greeting Cards} appear many times in the top lists; Sometimes, they combine as a set appearing as an antecedent or consequent set, showing that these three items are highest associated.
 - c. Rule with (Toothpaste) as antecedent and (Candy Bar) as consequent appear multiple times, indicating a higher correlation.
 - d. Rules with Perfume and Toothbrush as either antecedent or consequent appear twice in the list with top conviction, showing their correlation.

7. Conclusion

Comparing the rule lists using different criteria, the metrics referring to lift seem preferable to the others. But since the lift measures co-occurrences only, and conviction gives us the measure of the information of the absence as well, we will first sort by lift and then conviction.

As in charge of these departments, I would you use the results as below:

As in-charge of these departments we can use such rules strategically in various ways.

For example:

- 1) We can pair the transactions with customer data, to improve our marketing efforts to do targeted mailings/email suggestions.
- 2) We can also adjust the price and profit margins together. We can put one item on the sale while increasing the price of the other.
- 3) We can put highly correlated items closer while displaying them on shelves, such as toothpaste and candy bar, greeting card, candy bar, and magazines, perfume and toothbrush, etc.
- 4) We can bind the highly associated products in the sales process by providing some percentage of discounts to customers who buy the associated items in a set.
- 5) We can partner with banks to give customers cashbacks on their purchase of highly associated products.
- 6) We can start a membership and rewards program based on these associations.