## Part 1

A1.
Research question: What are the primary product associations among our telecommunication company's customers, and how can these associations inform cross-selling and upselling strategies?

A2.
By conducting market basket analysis, the goal is to discover patterns of product associations among customers. This analysis aims to identify which products are purchased together, allowing the telecommunications company to understand the preferences and behavior of its customer base better. Overall, it is anticipated that product associations can be identified to personalize marketing campaigns and potential product placements.

## Part 2

B1.
Market basket analysis involves examining the transactions made by customers to identify patterns of association between different products or services. The first step involves preparing the dataset, which includes transforming the data into transactional data, where each row represents a customer transaction, and columns represent the products or services produced. Market basket analysis employs techniques such as Association Rule Mining, also known as, the Apriori algorithm to identify relationships between items purchased together. This technique helps to discover frequent itemsets, which are combinations of products frequently brought together by customers. By analyzing the transaction data, the market basket analysis identifies significant association or itemsets. Market basket analysis calculates metrics such as support, confidence, and lift to quantify the strength of association between items. Support measures how frequently an itemset appears in transactions, confidence measures the likelihood that if item X is purchased, item Y will also be purchased, and lift measures how much more likely item Y is to be purchased when item X is purchased compared to when it's purchased independently.

It is anticipated that the analysis will reveal which products or services tend to be bought together most frequently, providing insights into customer preferences and behavior. Also, the analysis should produce association rules that specify relationships between items, enabling the company to understand customer purchasing patterns. By analyzing the association rules and demographic information, the company can create targeted marketing campaigns and personalized recommendations. Understanding which products are purchased together allows the company to optimize product placement in stores or online platforms and design more effective cross-selling strategies and promotions. Overall, market basket analysis enables the telecommunications companies to extract valuable insights from its customer data, leading to more informed business decision and improved marketing strategies.

B2.
Below is an example of transactions in the data set:

Apple Pencil
iPhone 12 Pro case

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Task 3: Association Rules and Lift Analysis
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B3.
One assumption of market basket analysis is the presence of association between items. This assumption suggests that the likelihood of purchasing one item is influenced by the presence or absence of other items in the transaction. Customers decisions to purchase certain items are influenced by the presence of related items. For example, if a customer buys a smartphone, the assumption of association implies that their decision to purchase a data plan or phone case may be influenced by the presence of the smartphone in their basket.

In text citations:
(“Transactional data”, n.d.)
(“What is market basket analysis?”, n.d.)

## **Part 3**

C1.
Below is the code used to transform the data set to make it suitable for market basket analysis:

```
import pandas as pd
market_basket_data = pd.read_csv
('/Users/jasminemoniquecooper/Downloads/teleco_market_basket.csv')
pd.set_option('display.max_columns', None)
market_basket_data.head(10)

pip install mlxtend

import pandas as pd
from mlxtend.preprocessing import TransactionEncoder

# Drop blank rows
market_basket_data.dropna(axis=0, how='all', inplace=True)

# Concatenate 'item' columns into a single column containing lists of items
transactions = market_basket_data.apply(lambda x: x.dropna().tolist(), axis=1)

# Convert transactions to one-hot encoded format
encoder = TransactionEncoder()
transactions_onehot = encoder.fit_transform(transactions)

# Convert one-hot encoded data to DataFrame
transactions_df = pd.DataFrame(transactions_onehot, columns=encoder.columns_)

# Remove NaN columns from the transformed data
transactions_df = transactions_df.dropna(axis=1, how='all')

# Check the shape of the transactional data
```

print("Shape of transactional data:", transactions_df.shape)

I have attached a CSV file named ‘cleaned_market_basket_data.csv’ to the submission.

C2.
To generate association rules with the Apriori algorithm, I executed the following code. I have also included the screenshots of the output to demonstrate that the code is error free.

Code:

```
# Set the random seed
import numpy as np
np.random.seed(42)

#association rules
from mlxtend.frequent_patterns import association_rules
from mlxtend.frequent_patterns import apriori

#compute frequent itemsets using the apriori algorithm
frequent_itemsets = apriori(transactions_df, min_support = 0.02, max_len = 2,
                            use_colnames= True)

#compute all association rules for frequent_itemsets
rules = association_rules(frequent_itemsets, metric="lift", min_threshold = 1.0)

pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
print(rules)
```

# Screenshots:

```
# Set the random seed
import numpy as np
np.random.seed(42)

#association rules
from mlxtend.frequent_patterns import association_rules
from mlxtend.frequent_patterns import apriori

#compute frequent itemsets using the apriori algorithm
frequent_itemsets = apriori(transactions_df, min_support = 0.02, max_len = 2,
                            use_colnames= True)

#compute all association rules for frequent_itemsets
rules = association_rules(frequent_itemsets, metric="lift", min_threshold = 1.0)

pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
print(rules)
```

```
                          antecedents  \
0        (10ft iPHone Charger Cable 2 Pack)
1          (Dust-Off Compressed Gas 2 pack)
2             (Anker USB C to HDMI Adapter)
3          (Dust-Off Compressed Gas 2 pack)
4             (Anker USB C to HDMI Adapter)
5       (VIVO Dual LCD Monitor Desk mount)
6   (Apple Lightning to Digital AV Adapter)
7                          (Apple Pencil)
8   (Apple Lightning to Digital AV Adapter)
9          (Dust-Off Compressed Gas 2 pack)
10  (Apple Lightning to Digital AV Adapter)
11                 (USB 2.0 Printer cable)
12      (VIVO Dual LCD Monitor Desk mount)
13  (Apple Lightning to Digital AV Adapter)
14               (Apple USB-C Charger cable)
15                         (Apple Pencil)
```

```
                          antecedents  \
16         (Dust-Off Compressed Gas 2 pack)
17                         (Apple Pencil)
18                           (HP 61 ink)
19                         (Apple Pencil)
20  (Nylon Braided Lightning to USB cable)
21                         (Apple Pencil)
22         (Screen Mom Screen Cleaner kit)
23                         (Apple Pencil)
24                  (Stylus Pen for iPad)
25                         (Apple Pencil)
26                 (USB 2.0 Printer cable)
27                         (Apple Pencil)
28      (VIVO Dual LCD Monitor Desk mount)
29                         (Apple Pencil)
30                           (HP 61 ink)
31                (Apple USB-C Charger cable)
32                 (USB 2.0 Printer cable)
33                (Apple USB-C Charger cable)
34      (VIVO Dual LCD Monitor Desk mount)
35                (Apple USB-C Charger cable)
36   (FEIYOLD Blue light Blocking Glasses)
37         (Dust-Off Compressed Gas 2 pack)
38         (Dust-Off Compressed Gas 2 pack)
39         (Falcon Dust Off Compressed Gas)
40                           (HP 61 ink)
41         (Dust-Off Compressed Gas 2 pack)
42         (Dust-Off Compressed Gas 2 pack)
43                  (HP 62XL Tri-Color ink)
44           (Logitech M510 Wireless mouse)
45         (Dust-Off Compressed Gas 2 pack)
46  (Nylon Braided Lightning to USB cable)
47         (Dust-Off Compressed Gas 2 pack)
48         (Dust-Off Compressed Gas 2 pack)
49                (Premium Nylon USB Cable)
50         (Dust-Off Compressed Gas 2 pack)
51               (SanDisk Ultra 128GB card)
52                (SanDisk Ultra 64GB card)
53         (Dust-Off Compressed Gas 2 pack)
54         (Dust-Off Compressed Gas 2 pack)
55          (Screen Mom Screen Cleaner kit)
56                  (Stylus Pen for iPad)
57         (Dust-Off Compressed Gas 2 pack)
58           (Syntech USB C to USB Adapter)
59         (Dust-Off Compressed Gas 2 pack)
60         (Dust-Off Compressed Gas 2 pack)
```

```
                          antecedents  \
51         (Dust-Off Compressed Gas 2 pack)
52         (Dust-Off Compressed Gas 2 pack)
53                (SanDisk Ultra 64GB card)
54         (Screen Mom Screen Cleaner kit)
55         (Dust-Off Compressed Gas 2 pack)
56         (Dust-Off Compressed Gas 2 pack)
57                  (Stylus Pen for iPad)
58         (Dust-Off Compressed Gas 2 pack)
59           (Syntech USB C to USB Adapter)
60             (TopMate C5 Laptop Cooler pad)
61         (Dust-Off Compressed Gas 2 pack)
62      (VIVO Dual LCD Monitor Desk mount)
63         (Dust-Off Compressed Gas 2 pack)
64      (VIVO Dual LCD Monitor Desk mount)
65   (FEIYOLD Blue light Blocking Glasses)
66                           (HP 61 ink)
67  (Nylon Braided Lightning to USB cable)
68                           (HP 61 ink)
69                (SanDisk Ultra 64GB card)
70         (Screen Mom Screen Cleaner kit)
71                           (HP 61 ink)
72                           (HP 61 ink)
73                 (USB 2.0 Printer cable)
74      (VIVO Dual LCD Monitor Desk mount)
75                           (HP 61 ink)
76      (VIVO Dual LCD Monitor Desk mount)
77           (Logitech M510 Wireless mouse)
78         (Screen Mom Screen Cleaner kit)
79  (Nylon Braided Lightning to USB cable)
80      (VIVO Dual LCD Monitor Desk mount)
81  (Nylon Braided Lightning to USB cable)
82         (Screen Mom Screen Cleaner kit)
83                (SanDisk Ultra 64GB card)
84      (VIVO Dual LCD Monitor Desk mount)
85                (SanDisk Ultra 64GB card)
86         (Screen Mom Screen Cleaner kit)
```

```
                          antecedents  \
87                 (USB 2.0 Printer cable)
88          (Screen Mom Screen Cleaner kit)
89      (VIVO Dual LCD Monitor Desk mount)
90                   (Stylus Pen for iPad)
91                 (USB 2.0 Printer cable)
92      (VIVO Dual LCD Monitor Desk mount)
93                   (Stylus Pen for iPad)

                          consequents  antecedent support  \
0          (Dust-Off Compressed Gas 2 pack)            0.050527
1        (10ft iPHone Charger Cable 2 Pack)            0.238368
2          (Dust-Off Compressed Gas 2 pack)            0.068391
3             (Anker USB C to HDMI Adapter)            0.238368
4       (VIVO Dual LCD Monitor Desk mount)            0.068391
5             (Anker USB C to HDMI Adapter)            0.174110
6                          (Apple Pencil)            0.087188
7   (Apple Lightning to Digital AV Adapter)            0.179709
8          (Dust-Off Compressed Gas 2 pack)            0.087188
9   (Apple Lightning to Digital AV Adapter)            0.238368
10                 (USB 2.0 Printer cable)            0.087188
11  (Apple Lightning to Digital AV Adapter)            0.170911
12  (Apple Lightning to Digital AV Adapter)            0.174110
13      (VIVO Dual LCD Monitor Desk mount)            0.087188
14                         (Apple Pencil)            0.132116
15               (Apple USB-C Charger cable)            0.179709
16                         (Apple Pencil)            0.238368
17         (Dust-Off Compressed Gas 2 pack)            0.179709
18                         (Apple Pencil)            0.163845
19                           (HP 61 ink)            0.179709
20                         (Apple Pencil)            0.095321
21  (Nylon Braided Lightning to USB cable)            0.179709
22                         (Apple Pencil)            0.129583
23         (Screen Mom Screen Cleaner kit)            0.179709
24                         (Apple Pencil)            0.095054
25                   (Stylus Pen for iPad)            0.179709
26                         (Apple Pencil)            0.170911
```

```
                          antecedents  \
27                 (USB 2.0 Printer cable)
28                         (Apple Pencil)
29      (VIVO Dual LCD Monitor Desk mount)
30               (Apple USB-C Charger cable)
31                           (HP 61 ink)
32               (Apple USB-C Charger cable)
33                 (USB 2.0 Printer cable)
34               (Apple USB-C Charger cable)
35      (VIVO Dual LCD Monitor Desk mount)
36         (Dust-Off Compressed Gas 2 pack)
37   (FEIYOLD Blue light Blocking Glasses)
38         (Falcon Dust Off Compressed Gas)
39         (Dust-Off Compressed Gas 2 pack)
40         (Dust-Off Compressed Gas 2 pack)
41                           (HP 61 ink)
42                  (HP 62XL Tri-Color ink)
43         (Dust-Off Compressed Gas 2 pack)
44         (Dust-Off Compressed Gas 2 pack)
45           (Logitech M510 Wireless mouse)
46  (Nylon Braided Lightning to USB cable)
47         (Dust-Off Compressed Gas 2 pack)
48         (Dust-Off Compressed Gas 2 pack)
49                (Premium Nylon USB Cable)
50         (Dust-Off Compressed Gas 2 pack)
51               (SanDisk Ultra 128GB card)
52                (SanDisk Ultra 64GB card)
53         (Dust-Off Compressed Gas 2 pack)
54         (Dust-Off Compressed Gas 2 pack)
55          (Screen Mom Screen Cleaner kit)
56                  (Stylus Pen for iPad)
57         (Dust-Off Compressed Gas 2 pack)
58           (Syntech USB C to USB Adapter)
59         (Dust-Off Compressed Gas 2 pack)
60         (Dust-Off Compressed Gas 2 pack)

                          consequents  antecedent support  \
27                         (Apple Pencil)            0.179709
28                   (TopMate C5 Laptop Cooler pad)            0.238368
29         (Dust-Off Compressed Gas 2 pack)            0.174110
30      (VIVO Dual LCD Monitor Desk mount)            0.238368
31   (FEIYOLD Blue light Blocking Glasses)            0.174110
32      (VIVO Dual LCD Monitor Desk mount)            0.065858
33  (Nylon Braided Lightning to USB cable)            0.163845
34                           (HP 61 ink)            0.095321
35                (SanDisk Ultra 64GB card)            0.163845
36                           (HP 61 ink)            0.098254
37                           (HP 61 ink)            0.129583
38         (Screen Mom Screen Cleaner kit)            0.163845
39                 (USB 2.0 Printer cable)            0.163845
40                           (HP 61 ink)            0.170911
41                           (HP 61 ink)            0.174110
42      (VIVO Dual LCD Monitor Desk mount)            0.163845
43           (Logitech M510 Wireless mouse)            0.174110
44      (VIVO Dual LCD Monitor Desk mount)            0.071457
45  (Nylon Braided Lightning to USB cable)            0.129583
46         (Screen Mom Screen Cleaner kit)            0.095321
47  (Nylon Braided Lightning to USB cable)            0.174110
48      (VIVO Dual LCD Monitor Desk mount)            0.095321
49                (SanDisk Ultra 64GB card)            0.129583
50         (Screen Mom Screen Cleaner kit)            0.098254
51                (SanDisk Ultra 64GB card)            0.174110
52      (VIVO Dual LCD Monitor Desk mount)            0.098254
53                 (USB 2.0 Printer cable)            0.129583
54         (Screen Mom Screen Cleaner kit)            0.170911
55      (VIVO Dual LCD Monitor Desk mount)            0.129583
56         (Screen Mom Screen Cleaner kit)            0.174110
57                 (USB 2.0 Printer cable)            0.095054
58                   (Stylus Pen for iPad)            0.170911
59                   (Stylus Pen for iPad)            0.174110
60      (VIVO Dual LCD Monitor Desk mount)            0.095054
```

```
    consequent support   support  confidence      lift  leverage  conviction  \
0             0.238368  0.023064    0.456464  1.914955  0.011020    1.401255
1             0.050527  0.023064    0.096756  1.914955  0.011020    1.051182
2             0.238368  0.024397    0.356725  1.496530  0.008095    1.183991
3             0.068391  0.024397    0.102349  1.496530  0.008095    1.037830
4             0.174110  0.020931    0.306043  1.757755  0.009023    1.190117
5             0.068391  0.020931    0.120214  1.757755  0.009023    1.058905
6             0.179709  0.028796    0.330275  1.837830  0.013128    1.224818
7             0.087188  0.028796    0.160237  1.837830  0.013128    1.086988
8             0.238368  0.024397    0.279817  1.173883  0.003614    1.057552
9             0.087188  0.024397    0.102349  1.173883  0.003614    1.016889
10            0.170911  0.021997    0.252294  1.476173  0.007096    1.108844
11            0.087188  0.021997    0.128705  1.476173  0.007096    1.047650
12            0.087188  0.021464    0.123277  1.413918  0.006283    1.041163
13            0.174110  0.021464    0.246177  1.413918  0.006283    1.095602
14            0.179709  0.025463    0.192735  1.072479  0.001721    1.016135
15            0.132116  0.025463    0.141691  1.072479  0.001721    1.011156
16            0.179709  0.050927    0.213647  1.188845  0.008090    1.043158
17            0.238368  0.050927    0.283383  1.188845  0.008090    1.062815
18            0.179709  0.033196    0.202604  1.127397  0.003751    1.028711
19            0.163845  0.033196    0.184718  1.127397  0.003751    1.025603
20            0.179709  0.021730    0.227972  1.268559  0.004600    1.062514
21            0.095321  0.021730    0.120920  1.268559  0.004600    1.029121
22            0.179709  0.030796    0.237654  1.322437  0.007509    1.076009
23            0.129583  0.030796    0.171365  1.322437  0.007509    1.050423
24            0.179709  0.021730    0.228612  1.272118  0.004648    1.063395
25            0.095054  0.021730    0.120920  1.272118  0.004648    1.029424
26            0.179709  0.036395    0.212949  1.184961  0.005681    1.042232
27            0.170911  0.036395    0.202522  1.184961  0.005681    1.039640
28            0.179709  0.036528    0.209801  1.167446  0.005239    1.038081
29            0.174110  0.036528    0.203264  1.167446  0.005239    1.036592
30            0.132116  0.023464    0.143206  1.083943  0.001817    1.012944
31            0.163845  0.023464    0.177598  1.083943  0.001817    1.016724
32            0.132116  0.028530    0.166927  1.263488  0.005950    1.041786
33            0.170911  0.028530    0.215943  1.263488  0.005950    1.057436
34            0.132116  0.026530    0.152374  1.153335  0.003527    1.023900
```

```
    consequent support   support  confidence      lift  leverage  conviction  \
35            0.174110  0.026530    0.200807  1.153335  0.003527    1.033405
36            0.238368  0.027596    0.419028  1.757904  0.011898    1.310962
37            0.065858  0.027596    0.115772  1.757904  0.011898    1.056449
38            0.059992  0.022797    0.095638  1.594172  0.008497    1.039415
39            0.238368  0.022797    0.380000  1.594172  0.008497    1.228438
40            0.238368  0.052660    0.321400  1.348332  0.013604    1.122357
41            0.163845  0.052660    0.220917  1.348332  0.013604    1.073256
42            0.058526  0.020131    0.084452  1.442993  0.006180    1.028318
43            0.238368  0.020131    0.343964  1.442993  0.006180    1.160960
44            0.238368  0.023597    0.330224  1.385352  0.006564    1.137144
45            0.071457  0.023597    0.098993  1.385352  0.006564    1.030562
46            0.095321  0.035729    0.149888  1.572463  0.013007    1.064189
47            0.238368  0.035729    0.374825  1.572463  0.013007    1.218270
48            0.238368  0.020131    0.394256  1.653978  0.007960    1.257349
49            0.051060  0.020131    0.084452  1.653978  0.007960    1.036472
50            0.238368  0.020264    0.320000  1.342461  0.005169    1.120047
51            0.063325  0.020264    0.085011  1.342461  0.005169    1.023701
52            0.098254  0.040928    0.171700  1.747522  0.017507    1.088672
53            0.238368  0.040928    0.416554  1.747522  0.017507    1.305401
54            0.238368  0.047994    0.370370  1.553774  0.017105    1.209650
55            0.129583  0.047994    0.201342  1.553774  0.017105    1.089850
56            0.095054  0.033729    0.141499  1.488616  0.011071    1.054100
57            0.238368  0.033729    0.354839  1.488616  0.011071    1.180529
58            0.001056  0.027463    0.115213  1.421397  0.008142    1.038604
59            0.238368  0.027463    0.338816  1.421397  0.008142    1.151921
60            0.238368  0.023997    0.313589  1.315565  0.005756    1.109585
61            0.076523  0.023997    0.100671  1.315565  0.005756    1.026851
62            0.238368  0.059725    0.343032  1.439085  0.018223    1.159314
63            0.174110  0.059725    0.250559  1.439085  0.018223    1.102008
64            0.065858  0.022930    0.131700  1.999758  0.011464    1.075829
65            0.174110  0.022930    0.348178  1.999758  0.011464    1.267048
66            0.095321  0.022930    0.139951  1.468215  0.007312    1.051893
67            0.163845  0.022930    0.240559  1.468215  0.007312    1.101015
68            0.098254  0.023064    0.140765  1.432669  0.006965    1.049476
69            0.163845  0.023064    0.234735  1.432669  0.006965    1.092635
70            0.163845  0.032129    0.247942  1.513276  0.010898    1.111823
```

```
    consequent support   support  confidence      lift  leverage  conviction  \
71            0.129583  0.032129    0.196094  1.513276  0.010898    1.082736
72            0.170911  0.034395    0.209927  1.228284  0.006393    1.049383
73            0.163845  0.034395    0.201248  1.228284  0.006393    1.046827
74            0.163845  0.039195    0.225115  1.373952  0.010668    1.079070
75            0.174110  0.039195    0.239219  1.373952  0.010668    1.085581
76            0.071457  0.021197    0.121746  1.703760  0.008756    1.057260
77            0.174110  0.021197    0.296642  1.703760  0.008756    1.174209
78            0.095321  0.023597    0.182099  1.910382  0.011245    1.106099
79            0.129583  0.023597    0.247552  1.910382  0.011245    1.156781
80            0.095321  0.027863    0.160031  1.678867  0.011267    1.077039
81            0.174110  0.027863    0.292308  1.678867  0.011267    1.167018
82            0.098254  0.021997    0.169753  1.727704  0.009265    1.086118
83            0.129583  0.021997    0.223881  1.727704  0.009265    1.121499
84            0.098254  0.039195    0.225115  2.291162  0.022088    1.163716
85            0.174110  0.039195    0.398915  2.291162  0.022088    1.373997
86            0.170911  0.023730    0.183128  1.071482  0.001583    1.014956
87            0.129583  0.023730    0.138846  1.071482  0.001583    1.010756
88            0.174110  0.035462    0.273663  1.571779  0.012900    1.137061
89            0.129583  0.035462    0.203675  1.571779  0.012900    1.093043
90            0.170911  0.020131    0.211781  1.239135  0.003885    1.051852
91            0.095054  0.020131    0.117785  1.239135  0.003885    1.025766
92            0.095054  0.025197    0.144717  1.522468  0.008647    1.058066
93            0.174110  0.025197    0.265077  1.522468  0.008647    1.123778
```

```
    zhangs_metric
0        0.503221
1        0.627330
2        0.356144
3        0.435627
4        0.462740
5        0.521973
6        0.499424
7        0.555754
8        0.162275
9        0.194486
```

```
    0.353384
    0.389069
    0.354460
    0.320707
    0.077869
    0.082387
    0.208562
    0.193648
    0.135143
    0.137757
    0.234010
    0.258084
    0.280119
    0.297236
    0.236378
    0.260773
    0.188267
    0.190286
    0.173666
    0.174852
    0.092617
    0.089231
    0.251529
    0.240286
    0.160977
    0.153188
    0.461536
    0.566075
    0.489364
    0.396502
    0.308965
    0.339197
    0.403076
```

```
    0.326080
    0.299568
    0.365218
    0.477993
    0.402413
    0.416672
    0.519145
    0.272346
    0.334938
    0.561638
    0.474369
    0.409465
    0.467950
    0.430963
    0.362712
    0.389252
    0.322617
    0.259747
    0.314943
    0.369437
    0.400606
    0.605334
    0.535186
    0.381390
    0.352502
    0.361180
    0.334908
    0.389677
    0.405645
    0.222275
    0.224169
    0.329550
    0.325505
    0.500143
    0.444850
    0.547490
```

```
79  0.526755
80  0.489605
81  0.446965
82  0.483903
83  0.467090
84  0.682343
85  0.624943
86  0.076645
87  0.080466
88  0.417935
89  0.440468
90  0.213256
91  0.232768
92  0.415518
93  0.379218
```

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C3.

Below are the values for the support, lift, and confidence of the association table:

| | antecedents \ |
|---|---|
| 0 | (10ft iPHone Charger Cable 2 Pack) |
| 1 | (Dust-Off Compressed Gas 2 pack) |
| 2 | (Anker USB C to HDMI Adapter) |
| 3 | (Dust-Off Compressed Gas 2 pack) |
| 4 | (Anker USB C to HDMI Adapter) |
| 5 | (VIVO Dual LCD Monitor Desk mount) |
| 6 | (Apple Lightning to Digital AV Adapter) |
| 7 | (Apple Pencil) |
| 8 | (Apple Lightning to Digital AV Adapter) |
| 9 | (Dust-Off Compressed Gas 2 pack) |
| 10 | (Apple Lightning to Digital AV Adapter) |
| 11 | (USB 2.0 Printer cable) |
| 12 | (VIVO Dual LCD Monitor Desk mount) |
| 13 | (Apple Lightning to Digital AV Adapter) |
| 14 | (Apple USB-C Charger cable) |
| 15 | (Apple Pencil) |
| 16 | (Dust-Off Compressed Gas 2 pack) |
| 17 | (Apple Pencil) |
| 18 | (HP 61 ink) |
| 19 | (Apple Pencil) |
| 20 | (Nylon Braided Lightning to USB cable) |
| 21 | (Apple Pencil) |
| 22 | (Screen Mom Screen Cleaner kit) |
| 23 | (Apple Pencil) |
| 24 | (Stylus Pen for iPad) |
| 25 | (Apple Pencil) |
| 26 | (USB 2.0 Printer cable) |
| 27 | (Apple Pencil) |
| 28 | (VIVO Dual LCD Monitor Desk mount) |
| 29 | (Apple Pencil) |
| 30 | (HP 61 ink) |
| 31 | (Apple USB-C Charger cable) |
| 32 | (USB 2.0 Printer cable) |
| 33 | (Apple USB-C Charger cable) |
| 34 | (VIVO Dual LCD Monitor Desk mount) |
| 35 | (Apple USB-C Charger cable) |
| 36 | (FEIYOLD Blue light Blocking Glasses) |
| 37 | (Dust-Off Compressed Gas 2 pack) |
| 38 | (Dust-Off Compressed Gas 2 pack) |
| 39 | (Falcon Dust Off Compressed Gas) |
| 40 | (HP 61 ink) |
| 41 | (Dust-Off Compressed Gas 2 pack) |
| 42 | (Dust-Off Compressed Gas 2 pack) |
| 43 | (HP 62XL Tri-Color ink) |
| 44 | (Logitech M510 Wireless mouse) |
| 45 | (Dust-Off Compressed Gas 2 pack) |
| 46 | (Dust-Off Compressed Gas 2 pack) |

| | |
|---|---|
| 47 | (Nylon Braided Lightning to USB cable) |
| 48 | (Premium Nylon USB Cable) |
| 49 | (Dust-Off Compressed Gas 2 pack) |
| 50 | (SanDisk Ultra 128GB card) |
| 51 | (Dust-Off Compressed Gas 2 pack) |
| 52 | (Dust-Off Compressed Gas 2 pack) |
| 53 | (SanDisk Ultra 64GB card) |
| 54 | (Screen Mom Screen Cleaner kit) |
| 55 | (Dust-Off Compressed Gas 2 pack) |
| 56 | (Dust-Off Compressed Gas 2 pack) |
| 57 | (Stylus Pen for iPad) |
| 58 | (Dust-Off Compressed Gas 2 pack) |
| 59 | (Syntech USB C to USB Adapter) |
| 60 | (TopMate C5 Laptop Cooler pad) |
| 61 | (Dust-Off Compressed Gas 2 pack) |
| 62 | (VIVO Dual LCD Monitor Desk mount) |
| 63 | (Dust-Off Compressed Gas 2 pack) |
| 64 | (VIVO Dual LCD Monitor Desk mount) |
| 65 | (FEIYOLD Blue light Blocking Glasses) |
| 66 | (HP 61 ink) |
| 67 | (Nylon Braided Lightning to USB cable) |
| 68 | (HP 61 ink) |
| 69 | (SanDisk Ultra 64GB card) |
| 70 | (Screen Mom Screen Cleaner kit) |
| 71 | (HP 61 ink) |
| 72 | (HP 61 ink) |
| 73 | (USB 2.0 Printer cable) |
| 74 | (VIVO Dual LCD Monitor Desk mount) |
| 75 | (HP 61 ink) |
| 76 | (VIVO Dual LCD Monitor Desk mount) |
| 77 | (Logitech M510 Wireless mouse) |
| 78 | (Screen Mom Screen Cleaner kit) |
| 79 | (Nylon Braided Lightning to USB cable) |
| 80 | (VIVO Dual LCD Monitor Desk mount) |
| 81 | (Nylon Braided Lightning to USB cable) |
| 82 | (Screen Mom Screen Cleaner kit) |
| 83 | (SanDisk Ultra 64GB card) |
| 84 | (VIVO Dual LCD Monitor Desk mount) |
| 85 | (SanDisk Ultra 64GB card) |
| 86 | (Screen Mom Screen Cleaner kit) |
| 87 | (USB 2.0 Printer cable) |
| 88 | (Screen Mom Screen Cleaner kit) |
| 89 | (VIVO Dual LCD Monitor Desk mount) |
| 90 | (Stylus Pen for iPad) |
| 91 | (USB 2.0 Printer cable) |
| 92 | (VIVO Dual LCD Monitor Desk mount) |
| 93 | (Stylus Pen for iPad) |

| | consequents | antecedent support \ |
|---|---|---|
| 0 | (Dust-Off Compressed Gas 2 pack) | 0.050527 |
| 1 | (10ft iPHone Charger Cable 2 Pack) | 0.238368 |
| 2 | (Dust-Off Compressed Gas 2 pack) | 0.068391 |
| 3 | (Anker USB C to HDMI Adapter) | 0.238368 |
| 4 | (VIVO Dual LCD Monitor Desk mount) | 0.068391 |

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| | | |
|---|---|---|
| 5 | (Anker USB C to HDMI Adapter) | 0.174110 |
| 6 | (Apple Pencil) | 0.087188 |
| 7 | (Apple Lightning to Digital AV Adapter) | 0.179709 |
| 8 | (Dust-Off Compressed Gas 2 pack) | 0.087188 |
| 9 | (Apple Lightning to Digital AV Adapter) | 0.238368 |
| 10 | (USB 2.0 Printer cable) | 0.087188 |
| 11 | (Apple Lightning to Digital AV Adapter) | 0.170911 |
| 12 | (Apple Lightning to Digital AV Adapter) | 0.174110 |
| 13 | (VIVO Dual LCD Monitor Desk mount) | 0.087188 |
| 14 | (Apple Pencil) | 0.132116 |
| 15 | (Apple USB-C Charger cable) | 0.179709 |
| 16 | (Apple Pencil) | 0.238368 |
| 17 | (Dust-Off Compressed Gas 2 pack) | 0.179709 |
| 18 | (Apple Pencil) | 0.163845 |
| 19 | (HP 61 ink) | 0.179709 |
| 20 | (Apple Pencil) | 0.095321 |
| 21 | (Nylon Braided Lightning to USB cable) | 0.179709 |
| 22 | (Apple Pencil) | 0.129583 |
| 23 | (Screen Mom Screen Cleaner kit) | 0.179709 |
| 24 | (Apple Pencil) | 0.095054 |
| 25 | (Stylus Pen for iPad) | 0.179709 |
| 26 | (Apple Pencil) | 0.170911 |
| 27 | (USB 2.0 Printer cable) | 0.179709 |
| 28 | (Apple Pencil) | 0.174110 |
| 29 | (VIVO Dual LCD Monitor Desk mount) | 0.179709 |
| 30 | (Apple USB-C Charger cable) | 0.163845 |
| 31 | (HP 61 ink) | 0.132116 |
| 32 | (Apple USB-C Charger cable) | 0.170911 |
| 33 | (USB 2.0 Printer cable) | 0.132116 |
| 34 | (Apple USB-C Charger cable) | 0.174110 |
| 35 | (VIVO Dual LCD Monitor Desk mount) | 0.132116 |
| 36 | (Dust-Off Compressed Gas 2 pack) | 0.065858 |
| 37 | (FEIYOLD Blue light Blocking Glasses) | 0.238368 |
| 38 | (Falcon Dust Off Compressed Gas) | 0.238368 |
| 39 | (Dust-Off Compressed Gas 2 pack) | 0.059992 |
| 40 | (Dust-Off Compressed Gas 2 pack) | 0.163845 |
| 41 | (HP 61 ink) | 0.238368 |
| 42 | (HP 62XL Tri-Color ink) | 0.238368 |
| 43 | (Dust-Off Compressed Gas 2 pack) | 0.058526 |
| 44 | (Dust-Off Compressed Gas 2 pack) | 0.071457 |
| 45 | (Logitech M510 Wireless mouse) | 0.238368 |
| 46 | (Nylon Braided Lightning to USB cable) | 0.238368 |
| 47 | (Dust-Off Compressed Gas 2 pack) | 0.095321 |
| 48 | (Dust-Off Compressed Gas 2 pack) | 0.051060 |
| 49 | (Premium Nylon USB Cable) | 0.238368 |
| 50 | (Dust-Off Compressed Gas 2 pack) | 0.063325 |
| 51 | (SanDisk Ultra 128GB card) | 0.238368 |
| 52 | (SanDisk Ultra 64GB card) | 0.238368 |
| 53 | (Dust-Off Compressed Gas 2 pack) | 0.098254 |
| 54 | (Dust-Off Compressed Gas 2 pack) | 0.129583 |
| 55 | (Screen Mom Screen Cleaner kit) | 0.238368 |
| 56 | (Stylus Pen for iPad) | 0.238368 |
| 57 | (Dust-Off Compressed Gas 2 pack) | 0.095054 |
| 58 | (Syntech USB C to USB Adapter) | 0.238368 |

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| | | |
|---|---|---|
| 59 | (Dust-Off Compressed Gas 2 pack) | 0.081056 |
| 60 | (Dust-Off Compressed Gas 2 pack) | 0.076523 |
| 61 | (TopMate C5 Laptop Cooler pad) | 0.238368 |
| 62 | (Dust-Off Compressed Gas 2 pack) | 0.174110 |
| 63 | (VIVO Dual LCD Monitor Desk mount) | 0.238368 |
| 64 | (FEIYOLD Blue light Blocking Glasses) | 0.174110 |
| 65 | (VIVO Dual LCD Monitor Desk mount) | 0.065858 |
| 66 | (Nylon Braided Lightning to USB cable) | 0.163845 |
| 67 | (HP 61 ink) | 0.095321 |
| 68 | (SanDisk Ultra 64GB card) | 0.163845 |
| 69 | (HP 61 ink) | 0.098254 |
| 70 | (HP 61 ink) | 0.129583 |
| 71 | (Screen Mom Screen Cleaner kit) | 0.163845 |
| 72 | (USB 2.0 Printer cable) | 0.163845 |
| 73 | (HP 61 ink) | 0.170911 |
| 74 | (HP 61 ink) | 0.174110 |
| 75 | (VIVO Dual LCD Monitor Desk mount) | 0.163845 |
| 76 | (Logitech M510 Wireless mouse) | 0.174110 |
| 77 | (VIVO Dual LCD Monitor Desk mount) | 0.071457 |
| 78 | (Nylon Braided Lightning to USB cable) | 0.129583 |
| 79 | (Screen Mom Screen Cleaner kit) | 0.095321 |
| 80 | (Nylon Braided Lightning to USB cable) | 0.174110 |
| 81 | (VIVO Dual LCD Monitor Desk mount) | 0.095321 |
| 82 | (SanDisk Ultra 64GB card) | 0.129583 |
| 83 | (Screen Mom Screen Cleaner kit) | 0.098254 |
| 84 | (SanDisk Ultra 64GB card) | 0.174110 |
| 85 | (VIVO Dual LCD Monitor Desk mount) | 0.098254 |
| 86 | (USB 2.0 Printer cable) | 0.129583 |
| 87 | (Screen Mom Screen Cleaner kit) | 0.170911 |
| 88 | (VIVO Dual LCD Monitor Desk mount) | 0.129583 |
| 89 | (Screen Mom Screen Cleaner kit) | 0.174110 |
| 90 | (USB 2.0 Printer cable) | 0.095054 |
| 91 | (Stylus Pen for iPad) | 0.170911 |
| 92 | (Stylus Pen for iPad) | 0.174110 |
| 93 | (VIVO Dual LCD Monitor Desk mount) | 0.095054 |

| | consequent support | support | confidence | lift | leverage | conviction \ |
|---|---|---|---|---|---|---|
| 0 | 0.238368 | 0.023064 | 0.456464 | 1.914955 | 0.011020 | 1.401255 |
| 1 | 0.050527 | 0.023064 | 0.096756 | 1.914955 | 0.011020 | 1.051182 |
| 2 | 0.238368 | 0.024397 | 0.356725 | 1.496530 | 0.008095 | 1.183991 |
| 3 | 0.068391 | 0.024397 | 0.102349 | 1.496530 | 0.008095 | 1.037830 |
| 4 | 0.174110 | 0.020931 | 0.306043 | 1.757755 | 0.009023 | 1.190117 |
| 5 | 0.068391 | 0.020931 | 0.120214 | 1.757755 | 0.009023 | 1.058905 |
| 6 | 0.179709 | 0.028796 | 0.330275 | 1.837830 | 0.013128 | 1.224818 |
| 7 | 0.087188 | 0.028796 | 0.160237 | 1.837830 | 0.013128 | 1.086988 |
| 8 | 0.238368 | 0.024397 | 0.279817 | 1.173883 | 0.003614 | 1.057552 |
| 9 | 0.087188 | 0.024397 | 0.102349 | 1.173883 | 0.003614 | 1.016889 |
| 10 | 0.170911 | 0.021997 | 0.252294 | 1.476173 | 0.007096 | 1.108844 |
| 11 | 0.087188 | 0.021997 | 0.128705 | 1.476173 | 0.007096 | 1.047650 |
| 12 | 0.087188 | 0.021464 | 0.123277 | 1.413918 | 0.006283 | 1.041163 |
| 13 | 0.174110 | 0.021464 | 0.246177 | 1.413918 | 0.006283 | 1.095602 |
| 14 | 0.179709 | 0.025463 | 0.192735 | 1.072479 | 0.001721 | 1.016135 |
| 15 | 0.132116 | 0.025463 | 0.141691 | 1.072479 | 0.001721 | 1.011156 |
| 16 | 0.179709 | 0.050927 | 0.213647 | 1.188845 | 0.008090 | 1.043158 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | 0.238368 | 0.050927 | 0.283383 | 1.188845 | 0.008090 | 1.062815 |
| 18 | 0.179709 | 0.033196 | 0.202604 | 1.127397 | 0.003751 | 1.028711 |
| 19 | 0.163845 | 0.033196 | 0.184718 | 1.127397 | 0.003751 | 1.025603 |
| 20 | 0.179709 | 0.021730 | 0.227972 | 1.268559 | 0.004600 | 1.062514 |
| 21 | 0.095321 | 0.021730 | 0.120920 | 1.268559 | 0.004600 | 1.029121 |
| 22 | 0.179709 | 0.030796 | 0.237654 | 1.322437 | 0.007509 | 1.076009 |
| 23 | 0.129583 | 0.030796 | 0.171365 | 1.322437 | 0.007509 | 1.050423 |
| 24 | 0.179709 | 0.021730 | 0.228612 | 1.272118 | 0.004648 | 1.063395 |
| 25 | 0.095054 | 0.021730 | 0.120920 | 1.272118 | 0.004648 | 1.029424 |
| 26 | 0.179709 | 0.036395 | 0.212949 | 1.184961 | 0.005681 | 1.042232 |
| 27 | 0.170911 | 0.036395 | 0.202522 | 1.184961 | 0.005681 | 1.039640 |
| 28 | 0.179709 | 0.036528 | 0.209801 | 1.167446 | 0.005239 | 1.038081 |
| 29 | 0.174110 | 0.036528 | 0.203264 | 1.167446 | 0.005239 | 1.036592 |
| 30 | 0.132116 | 0.023464 | 0.143206 | 1.083943 | 0.001817 | 1.012944 |
| 31 | 0.163845 | 0.023464 | 0.177598 | 1.083943 | 0.001817 | 1.016724 |
| 32 | 0.132116 | 0.028530 | 0.166927 | 1.263488 | 0.005950 | 1.041786 |
| 33 | 0.170911 | 0.028530 | 0.215943 | 1.263488 | 0.005950 | 1.057436 |
| 34 | 0.132116 | 0.026530 | 0.152374 | 1.153335 | 0.003527 | 1.023900 |
| 35 | 0.174110 | 0.026530 | 0.200807 | 1.153335 | 0.003527 | 1.033405 |
| 36 | 0.238368 | 0.027596 | 0.419028 | 1.757904 | 0.011898 | 1.310962 |
| 37 | 0.065858 | 0.027596 | 0.115772 | 1.757904 | 0.011898 | 1.056449 |
| 38 | 0.059992 | 0.022797 | 0.095638 | 1.594172 | 0.008497 | 1.039415 |
| 39 | 0.238368 | 0.022797 | 0.380000 | 1.594172 | 0.008497 | 1.228438 |
| 40 | 0.238368 | 0.052660 | 0.321400 | 1.348332 | 0.013604 | 1.122357 |
| 41 | 0.163845 | 0.052660 | 0.220917 | 1.348332 | 0.013604 | 1.073256 |
| 42 | 0.058526 | 0.020131 | 0.084452 | 1.442993 | 0.006180 | 1.028318 |
| 43 | 0.238368 | 0.020131 | 0.343964 | 1.442993 | 0.006180 | 1.160960 |
| 44 | 0.238368 | 0.023597 | 0.330224 | 1.385352 | 0.006564 | 1.137144 |
| 45 | 0.071457 | 0.023597 | 0.098993 | 1.385352 | 0.006564 | 1.030562 |
| 46 | 0.095321 | 0.035729 | 0.149888 | 1.572463 | 0.013007 | 1.064189 |
| 47 | 0.238368 | 0.035729 | 0.374825 | 1.572463 | 0.013007 | 1.218270 |
| 48 | 0.238368 | 0.020131 | 0.394256 | 1.653978 | 0.007960 | 1.257349 |
| 49 | 0.051060 | 0.020131 | 0.084452 | 1.653978 | 0.007960 | 1.036472 |
| 50 | 0.238368 | 0.020264 | 0.320000 | 1.342461 | 0.005169 | 1.120047 |
| 51 | 0.063325 | 0.020264 | 0.085011 | 1.342461 | 0.005169 | 1.023701 |
| 52 | 0.098254 | 0.040928 | 0.171700 | 1.747522 | 0.017507 | 1.088672 |
| 53 | 0.238368 | 0.040928 | 0.416554 | 1.747522 | 0.017507 | 1.305401 |
| 54 | 0.238368 | 0.047994 | 0.370370 | 1.553774 | 0.017105 | 1.209650 |
| 55 | 0.129583 | 0.047994 | 0.201342 | 1.553774 | 0.017105 | 1.089850 |
| 56 | 0.095054 | 0.033729 | 0.141499 | 1.488616 | 0.011071 | 1.054100 |
| 57 | 0.238368 | 0.033729 | 0.354839 | 1.488616 | 0.011071 | 1.180529 |
| 58 | 0.081056 | 0.027463 | 0.115213 | 1.421397 | 0.008142 | 1.038604 |
| 59 | 0.238368 | 0.027463 | 0.338816 | 1.421397 | 0.008142 | 1.151921 |
| 60 | 0.238368 | 0.023997 | 0.313589 | 1.315565 | 0.005756 | 1.109585 |
| 61 | 0.076523 | 0.023997 | 0.100671 | 1.315565 | 0.005756 | 1.026851 |
| 62 | 0.238368 | 0.059725 | 0.343032 | 1.439085 | 0.018223 | 1.159314 |
| 63 | 0.174110 | 0.059725 | 0.250559 | 1.439085 | 0.018223 | 1.102008 |
| 64 | 0.065858 | 0.022930 | 0.131700 | 1.999758 | 0.011464 | 1.075829 |
| 65 | 0.174110 | 0.022930 | 0.348178 | 1.999758 | 0.011464 | 1.267048 |
| 66 | 0.095321 | 0.022930 | 0.139951 | 1.468215 | 0.007312 | 1.051893 |
| 67 | 0.163845 | 0.022930 | 0.240559 | 1.468215 | 0.007312 | 1.101015 |
| 68 | 0.098254 | 0.023064 | 0.140765 | 1.432669 | 0.006965 | 1.049476 |
| 69 | 0.163845 | 0.023064 | 0.234735 | 1.432669 | 0.006965 | 1.092635 |
| 70 | 0.163845 | 0.032129 | 0.247942 | 1.513276 | 0.010898 | 1.111823 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 71 | 0.129583 | 0.032129 | 0.196094 | 1.513276 | 0.010898 | 1.082736 |
| 72 | 0.170911 | 0.034395 | 0.209927 | 1.228284 | 0.006393 | 1.049383 |
| 73 | 0.163845 | 0.034395 | 0.201248 | 1.228284 | 0.006393 | 1.046827 |
| 74 | 0.163845 | 0.039195 | 0.225115 | 1.373952 | 0.010668 | 1.079070 |
| 75 | 0.174110 | 0.039195 | 0.239219 | 1.373952 | 0.010668 | 1.085581 |
| 76 | 0.071457 | 0.021197 | 0.121746 | 1.703760 | 0.008756 | 1.057260 |
| 77 | 0.174110 | 0.021197 | 0.296642 | 1.703760 | 0.008756 | 1.174209 |
| 78 | 0.095321 | 0.023597 | 0.182099 | 1.910382 | 0.011245 | 1.106099 |
| 79 | 0.129583 | 0.023597 | 0.247552 | 1.910382 | 0.011245 | 1.156781 |
| 80 | 0.095321 | 0.027863 | 0.160031 | 1.678867 | 0.011267 | 1.077039 |
| 81 | 0.174110 | 0.027863 | 0.292308 | 1.678867 | 0.011267 | 1.167018 |
| 82 | 0.098254 | 0.021997 | 0.169753 | 1.727704 | 0.009265 | 1.086118 |
| 83 | 0.129583 | 0.021997 | 0.223881 | 1.727704 | 0.009265 | 1.121499 |
| 84 | 0.098254 | 0.039195 | 0.225115 | 2.291162 | 0.022088 | 1.163716 |
| 85 | 0.174110 | 0.039195 | 0.398915 | 2.291162 | 0.022088 | 1.373997 |
| 86 | 0.170911 | 0.023730 | 0.183128 | 1.071482 | 0.001583 | 1.014956 |
| 87 | 0.129583 | 0.023730 | 0.138846 | 1.071482 | 0.001583 | 1.010756 |
| 88 | 0.174110 | 0.035462 | 0.273663 | 1.571779 | 0.012900 | 1.137061 |
| 89 | 0.129583 | 0.035462 | 0.203675 | 1.571779 | 0.012900 | 1.093043 |
| 90 | 0.170911 | 0.020131 | 0.211781 | 1.239135 | 0.003885 | 1.051852 |
| 91 | 0.095054 | 0.020131 | 0.117785 | 1.239135 | 0.003885 | 1.025766 |
| 92 | 0.095054 | 0.025197 | 0.144717 | 1.522468 | 0.008647 | 1.058066 |
| 93 | 0.174110 | 0.025197 | 0.265077 | 1.522468 | 0.008647 | 1.123778 |

| | zhangs_metric |
|---|---|
| 0 | 0.503221 |
| 1 | 0.627330 |
| 2 | 0.356144 |
| 3 | 0.435627 |
| 4 | 0.462740 |
| 5 | 0.521973 |
| 6 | 0.499424 |
| 7 | 0.555754 |
| 8 | 0.162275 |
| 9 | 0.194486 |
| 10 | 0.353384 |
| 11 | 0.389069 |
| 12 | 0.354460 |
| 13 | 0.320707 |
| 14 | 0.077869 |
| 15 | 0.082387 |
| 16 | 0.208562 |
| 17 | 0.193648 |
| 18 | 0.135143 |
| 19 | 0.137757 |
| 20 | 0.234010 |
| 21 | 0.258084 |
| 22 | 0.280119 |
| 23 | 0.297236 |
| 24 | 0.236378 |
| 25 | 0.260773 |
| 26 | 0.188267 |
| 27 | 0.190286 |
| 28 | 0.173666 |

| | |
|---|---|
| 29 | 0.174852 |
| 30 | 0.092617 |
| 31 | 0.089231 |
| 32 | 0.251529 |
| 33 | 0.240286 |
| 34 | 0.160977 |
| 35 | 0.153188 |
| 36 | 0.461536 |
| 37 | 0.566075 |
| 38 | 0.489364 |
| 39 | 0.396502 |
| 40 | 0.308965 |
| 41 | 0.339197 |
| 42 | 0.403076 |
| 43 | 0.326080 |
| 44 | 0.299568 |
| 45 | 0.365218 |
| 46 | 0.477993 |
| 47 | 0.402413 |
| 48 | 0.416672 |
| 49 | 0.519145 |
| 50 | 0.272346 |
| 51 | 0.334938 |
| 52 | 0.561638 |
| 53 | 0.474369 |
| 54 | 0.409465 |
| 55 | 0.467950 |
| 56 | 0.430963 |
| 57 | 0.362712 |
| 58 | 0.389252 |
| 59 | 0.322617 |
| 60 | 0.259747 |
| 61 | 0.314943 |
| 62 | 0.369437 |
| 63 | 0.400606 |
| 64 | 0.605334 |
| 65 | 0.535186 |
| 66 | 0.381390 |
| 67 | 0.352502 |
| 68 | 0.361180 |
| 69 | 0.334908 |
| 70 | 0.389677 |
| 71 | 0.405645 |
| 72 | 0.222275 |
| 73 | 0.224169 |
| 74 | 0.329550 |
| 75 | 0.325505 |
| 76 | 0.500143 |
| 77 | 0.444850 |
| 78 | 0.547490 |
| 79 | 0.526755 |
| 80 | 0.489605 |
| 81 | 0.446965 |
| 82 | 0.483903 |

83 0.467090
84 0.682343
85 0.624943
86 0.076645
87 0.080466
88 0.417935
89 0.440468
90 0.213256
91 0.232768
92 0.415518
93 0.379218

C4.
Below are the top three relevant rules generated by the Apriori algorithm, ranked by the confidence metric.

Rule 1:
Antecedents: 10 ft iPhone Charger Cable 2 Pack
Consequents: Dust-Off Compressed Gas 2 Pack
Support: 0.023064
Confidence: 0.456464
Lift: 1.914955

This rule suggests that there is a 46% likelihood that if a customer purchases a 10 ft iPhone Charger Cable 2 Pack, they will also purchase a Dust-Off Compressed Gas 2 Pack. The support metric, which indicates the frequency of occurrence of this itemset in the dataset, shows that this association occurs approximately 2%. Additionally, the lift value, which measures the strength of association between the items, which is greater than one, indicates a strong positive association. This suggests the relationship between the items is unlikely to be due to random chance.

Rule 2:
Antecedents: FEIYOLD Blue light Blocking Glasses
Consequents: Dust-Off Compressed Gas 2 Pack
Support: 0.027596
Confidence: 0.419028
Lift: 1.757904

This rule suggests that there is a 42% likelihood that if a customer purchases a FEIYOLD Blue light Blocking Glasses, they will also purchase a Dust-Off Compressed Gas 2 Pack. The support metric, which indicates the frequency of occurrence of this itemset in the dataset, shows that this association occurs approximately 3% of the time, which is slightly higher than the support of rule one. Furthermore, the lift value, which measures the strength of association between the items, is greater than one, indicates a strong positive association. This suggests the relationship between the items is unlikely due to random chance.

Rule 3:
Antecedents: SanDisk Ultra 64GB card

Consequents: Dust-Off Compressed Gas 2 Pack
Support: 0.040928
Confidence: 0.416554
Lift: 1.747522

This rule suggests that there is a 42% likelihood that if a customer purchases a SanDisk Ultra 64GB card, they will also purchase a Dust-Off Compressed Gas 2 Pack. The support metric, which indicates the frequency of occurrence, is low and indicates this association occurs 4% of the time. Although the support value is low, the lift value, which measures the strength of association between items, is greater than one. This suggests the relationship has a strong positive association and the relationship between items is unlikely due to random chance.

These top three relevant rules ranked by the confidence metric provide insights into the associations between different items purchased by customers, allowing for targeted marketing strategies and product placement optimizations to enhance sales and customer satisfaction.

Screenshot of the top three relevant rules ranked by confidence:

```
: #top 3 rules ranked by the confidence metric

top_three_rules = rules.sort_values('confidence', ascending = False).head(3)
print(top_three_rules)
```

```
                          antecedents                       consequents  \
0      (10ft iPHone Charger Cable 2 Pack)  (Dust-Off Compressed Gas 2 pack)
36  (FEIYOLD Blue light Blocking Glasses)  (Dust-Off Compressed Gas 2 pack)
53              (SanDisk Ultra 64GB card)  (Dust-Off Compressed Gas 2 pack)

    antecedent support  consequent support   support  confidence      lift  \
0             0.050527            0.238368  0.023064    0.456464  1.914955
36            0.065858            0.238368  0.027596    0.419028  1.757904
53            0.098254            0.238368  0.040928    0.416554  1.747522

    leverage  conviction  zhangs_metric
0   0.011020    1.401255       0.503221
36  0.011898    1.310962       0.461536
53  0.017507    1.305401       0.474369
```

In text citations:
(“What is market basket analysis?”, n.d.)
(“Identifying association rules”, n.d.)
(“Confidence and lift”, n.d.)
(“The simplest metric”, n.d.)

## **Part 4**

D1.
Support, lift, and confidence are pivotal metrics in association rule mining, each offering distinct insights into the relationships between items in transactional data. The top three relevant rules, ranked by confidence, serve as a lens through which businesses can gain deep insights into customer purchasing behavior and preferences. These rules not only highlight specific item associations but also provide a nuanced understanding of the strength and reliability of those associations.

By examining these rules, companies can discern meaningful patterns and trends in customer transactions. For instance, they may discover that certain products are frequently purchased together, indicating popular item combinations among customers. This is known as support, which measures the frequency of occurrence of a specific combination of items in the transactional data, highlighting which item sets are prevalent within the dataset. Higher support values indicate more frequent occurrences.

Selecting rules with high confidence and lift values ensures the identification of robust associations that are more likely to drive sales and customer satisfaction. Lift evaluates the relationship between items by quantifying the strength of association between two items. If the lift value is greater than 1, than there is a positive association. This means that the items occur in transactions together more often than expected, indicating the relationship is unlikely to be explained by random chance. On the other hand, a lift value less than 1, means that there is a negative association, indicating the relationship might be explained by random chance. The lift value helps to discern meaningful association from random occurrences. Confidence can add a more complete picture, by measuring the likelihood of the consequent item being purchased given that the antecedent item is bought. Higher confidence values signify more reliable rules, offering stronger probability for guiding marketing strategies and product recommendations. For instance, consider rule one, featuring the antecedent of a 10 ft iPhone Charger Cable 2 Pack and the consequent of a Dust-Off Compressed Gas 2 Pack. Despite having a lower support value compared to rule two, this rule has the highest lift and confidence values. This indicates a stronger association between the items, lending greater reliability to the observed correlations.

The comparison and analysis of these metrics across different rules enable businesses to prioritize and strategize effectively. By analyzing these metrics together, businesses can uncover valuable insights into customer behavior and make informed decisions to enhance marketing effectiveness, optimize product recommendations, and improve overall business performance.

D2.

The analysis findings carry significant practical implications for telecommunication companies. By revealing meaningful associations among various customer purchases, this analysis equips companies with insights to make informed decisions that can positively influence sales, enhance customer satisfaction, and boost overall business performance. Moreover, delving into metrics like support, lift, and confidence allows companies to pinpoint the most popular item combinations and strongest associations. For example, when certain item pairs exhibit high lift and confidence values, indicating a robust association and high likelihood of purchase, companies can prioritize these items in their inventory and marketing efforts. Additionally, the analysis helps in refining recommendation systems. By leveraging insights from association rule mining, companies can offer more tailored recommendations to customers based on their purchase history and preferences. For example, among the top three rules ranked by confidence, rule two highlights that customers are likely to purchase FEIYOLD Blue light Blocking Glasses and Dust-Off Compressed Gas 2 Pack in a transaction. This assertion can be made confidently, supported by the higher values of both confidence and lift. By harnessing these insights, telecommunication companies can gain a competitive edge and adapt more effectively to the evolving needs of their customer base.

D3.

A recommended course of action for the telecommunication companies is to prioritize the identification of item combinations with moderate support, high confidence, and high lift values for targeted cross-selling strategies. Moderate support is chosen to accommodate the varying frequencies of item

combinations, ensuring that the selected associations are both prevalent and meaningful. High lift provides assurance in identifying robust product associations, while high confidence values indicate a strong likelihood of the item combinations being purchased together by customers. By focusing on these criteria, the company can pinpoint product associations that are most likely to resonate with customers.

Specifically, I would prioritize rule one from the association rule mining results. Rule one includes the antecedent of a 10 ft iPhone Charger Cable 2 Pack and the consequent of Dust-Off Compressed Gas 2 Pack. This choice is informed by its highest confidence and lift levels. While the support level is marginally lower than that of rule two, this combination is deemed more suitable. The rationale behind this preference lies in its 4% higher confidence value, indicating a higher likelihood of being purchased together. Additionally, among all three rules, it boasts the highest lift value, signifying the strongest association between the items. In essence, selecting this combination for targeted marketing or product placement strategies holds promise for maximizing sales potential and enhancing customer satisfaction, given its robust association metrics and potential appeal to customers.

Implementing targeted cross-selling strategies based on item combination meeting these criteria holds the potential for increased customer engagement, higher average order values, and improved business performance. By continuously monitoring the effectiveness of these strategies and refining the approach over time, the company can sustain revenue growth through strategic product recommendations.

In text citations:
(“Confidence and lift”, n.d.)
(“The simplest metric”, n.d.)

**Part 5**

Citations for code:

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