

STA380-Association-Rule-Mining

Kapish Krishna

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Association rule mining

Revisit the notes on association rule mining and the R example on music playlists: `playlists.R` and `playlists.csv`. Then use the data on grocery purchases in `groceries.txt` and find some interesting association rules for these shopping baskets. The data file is a list of shopping baskets: one person's basket for each row, with multiple items per row separated by commas. Pick your own thresholds for lift and confidence; just be clear what these thresholds are and say why you picked them. Do your discovered item sets make sense? Present your discoveries in an interesting and visually appealing way.

Notes:

1. This is an exercise in visual and numerical story-telling. Do be clear in your description of what you've done, but keep the focus on the data, the figures, and the insights your analysis has drawn from the data, rather than technical details.
2. The data file is a list of baskets: one row per basket, with multiple items per row separated by commas. You'll have to cobble together your own code for processing this into the format expected by the "arules" package. This is not intrinsically all that hard, but it is the kind of data-wrangling wrinkle you'll encounter frequently on real problems, where your software package expects data in one format and the data comes in a different format. Figuring out how to bridge that gap is part of the assignment, and so we won't be giving tips on this front.

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.2      v readr      2.1.4
## v forcats    1.0.0      v stringr   1.5.0
## v ggplot2    3.4.2      v tibble    3.2.1
## v lubridate  1.9.2      v tidyr     1.3.0
## v purrr      1.0.1
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
##
## Attaching package: 'igraph'
##
##
## The following objects are masked from 'package:lubridate':
##
##   %--%, union
##
##
## The following objects are masked from 'package:dplyr':
##
##   as_data_frame, groups, union
##
```

```

##
## The following objects are masked from 'package:purrr':
##
##   compose, simplify
##
## The following object is masked from 'package:tidyr':
##
##   crossing
##
## The following object is masked from 'package:tibble':
##
##   as_data_frame
##
## The following objects are masked from 'package:stats':
##
##   decompose, spectrum
##
## The following object is masked from 'package:base':
##
##   union
##
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
##
## The following objects are masked from 'package:tidyr':
##
##   expand, pack, unpack
##
## Attaching package: 'arules'
##
## The following object is masked from 'package:dplyr':
##
##   recode
##
## The following objects are masked from 'package:base':
##
##   abbreviate, write
##
## Attaching package: 'plotly'
##

```

```
##
## The following object is masked from 'package:igraph':
##
##     groups
##
##
## The following object is masked from 'package:ggplot2':
##
##     last_plot
##
##
## The following object is masked from 'package:stats':
##
##     filter
##
##
## The following object is masked from 'package:graphics':
##
##     layout
##
#Reading the groceries.txt data
groceries_raw <- readLines('C:/Users/krish/Downloads/STA380-master/data/groceries.txt')

# Number of customers
n = length(groceries_raw)

# Split each row into list of items purchased by a single user.
total_items_list <- list()
for (line in groceries_raw){
  items <- unlist(strsplit(line, ","))
  total_items_list <- c(total_items_list, list(items))
}
#summary(total_items_list)
```

The data contains the purchase history of 9835 transactions and the list of items bought in each transaction. Now that, all the items are in a list, let's see which items are the more frequently bought and which items are rarely bought.

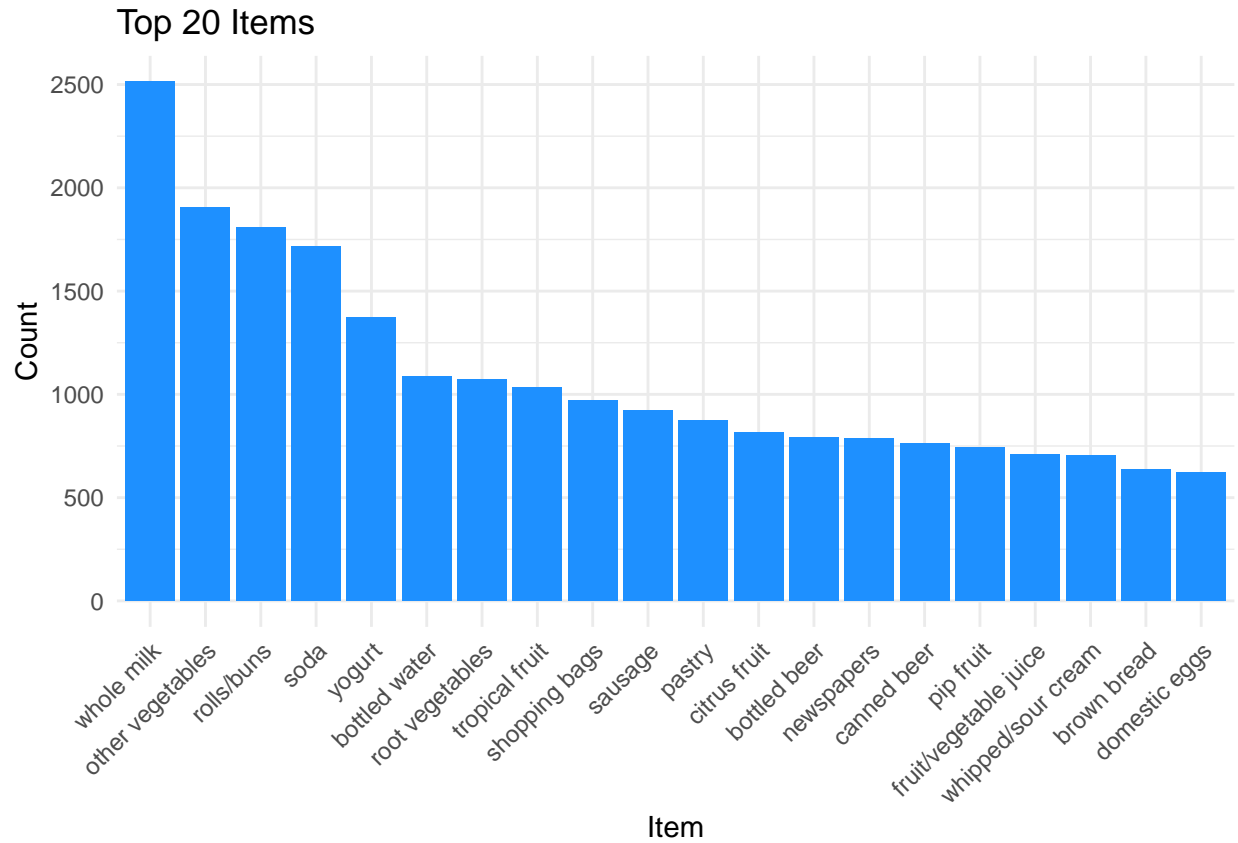
```
#combining all items in a single vector and counting the frequency of each items
all_items <- unlist(total_items_list)
item_counts <- data.frame(Item = names(table(all_items)),
                          Count = as.vector(table(all_items)))
summary(item_counts)
```

```
##      Item          Count
## Length:169      Min.    :  1.0
## Class :character 1st Qu.: 38.0
## Mode  :character Median :103.0
##                      Mean   :256.6
##                      3rd Qu.:305.0
##                      Max.   :2513.0
```

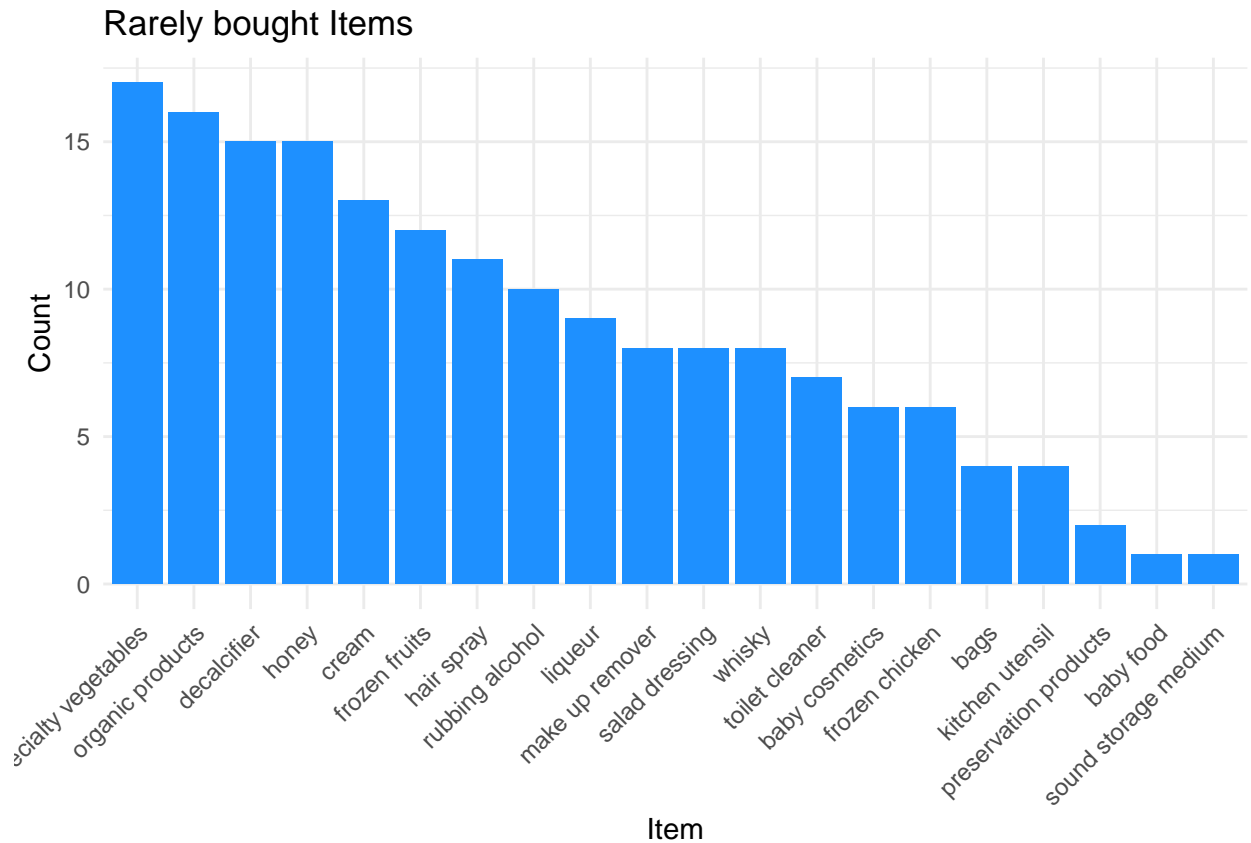
```
#plotting the top 20 items
sorted_item_counts <- item_counts[order(item_counts$Count, decreasing = TRUE), ]

ggplot(head(sorted_item_counts, 20), aes(x = reorder(Item, -Count), y = Count)) +
```

```
geom_bar(stat = "identity", fill = "dodgerblue") +
labs(title = "Top 20 Items", x = "Item", y = "Count") +
theme_minimal() +
theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



```
ggplot(tail(sorted_item_counts, 20), aes(x = reorder(Item, -Count), y = Count)) +
geom_bar(stat = "identity", fill = "dodgerblue") +
labs(title = "Rarely bought Items", x = "Item", y = "Count") +
theme_minimal() +
theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



It can be seen that there are a total of 169 different items in the data. Among them, 20 most frequently bought items and 20 rarely bought items are shown in the above bar plots. Now, we will dig deep into the data and check whether there are not associations among the items. It can be seen that all the top 20 items like *milk*, *vegetables*, *yogurt*, etc., are items that are required on a daily basis. The bottom 20 items like *sound storage medium*, *baby food*, *preservation products*, *kitchen utensils* etc., are specific requirements to those customers.

```
#Assigning the items to each customer
customers <- c(1:n)
groceries <- setNames(total_items_list, customers)

## Cast this variable as a special arules "transactions" class.
groceries_trans <- as(groceries, "transactions")
summary(groceries_trans)
```

```
## transactions as itemMatrix in sparse format with
## 9835 rows (elements/itemsets/transactions) and
## 169 columns (items) and a density of 0.02609146
##
## most frequent items:
##      whole milk other vegetables      rolls/buns      soda
##           2513           1903           1809           1715
##           yogurt           (Other)
##           1372           34055
##
## element (itemset/transaction) length distribution:
## sizes
```

```

##      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16
## 2159 1643 1299 1005  855  645  545  438  350  246  182  117  78  77  55  46
##      17     18     19     20     21     22     23     24     26     27     28     29     32
##      29     14     14      9     11      4      6      1      1      1      1      3      1
##
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.
##      1.000   2.000   3.000   4.409   6.000  32.000
##
## includes extended item information - examples:
##           labels
## 1 abrasive cleaner
## 2 artif. sweetener
## 3  baby cosmetics
##
## includes extended transaction information - examples:
## transactionID
## 1             1
## 2             2
## 3             3

```

```

# Now run the 'apriori' algorithm
# Look at rules with support > .01 & confidence >.1 & length (# items) <= 4
groceries_rules <- apriori(groceries_trans,
                           parameter=list(support=.01, confidence=.1, maxlen=4))

```

```

## Apriori
##
## Parameter specification:
## confidence minval smax arem aval originalSupport maxtime support minlen
##           0.1   0.1   1 none FALSE                TRUE      5   0.01      1
## maxlen target  ext
##           4 rules TRUE
##
## Algorithmic control:
## filter tree heap memopt load sort verbose
##       0.1 TRUE TRUE  FALSE TRUE    2    TRUE
##
## Absolute minimum support count: 98
##
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[169 item(s), 9835 transaction(s)] done [0.00s].
## sorting and recoding items ... [88 item(s)] done [0.00s].
## creating transaction tree ... done [0.00s].
## checking subsets of size 1 2 3 4
##
## Warning in apriori(groceries_trans, parameter = list(support = 0.01, confidence
## = 0.1, : Mining stopped (maxlen reached). Only patterns up to a length of 4
## returned!
## done [0.00s].
## writing ... [435 rule(s)] done [0.00s].
## creating S4 object ... done [0.00s].

```

```

# Look at the output... so many rules!
inspect(groceries_rules)

```

##	lhs	rhs	support	confidence	coverage	li
## [1]	{}	=> {bottled water}	0.11052364	0.1105236	1.00000000	1.000000
## [2]	{}	=> {tropical fruit}	0.10493137	0.1049314	1.00000000	1.000000
## [3]	{}	=> {root vegetables}	0.10899847	0.1089985	1.00000000	1.000000
## [4]	{}	=> {soda}	0.17437722	0.1743772	1.00000000	1.000000
## [5]	{}	=> {yogurt}	0.13950178	0.1395018	1.00000000	1.000000
## [6]	{}	=> {rolls/buns}	0.18393493	0.1839349	1.00000000	1.000000
## [7]	{}	=> {other vegetables}	0.19349263	0.1934926	1.00000000	1.000000
## [8]	{}	=> {whole milk}	0.25551601	0.2555160	1.00000000	1.000000
## [9]	{hard cheese}	=> {whole milk}	0.01006609	0.4107884	0.02450432	1.60768
## [10]	{butter milk}	=> {other vegetables}	0.01037112	0.3709091	0.02796136	1.91691
## [11]	{butter milk}	=> {whole milk}	0.01159126	0.4145455	0.02796136	1.62238
## [12]	{ham}	=> {whole milk}	0.01148958	0.4414062	0.02602949	1.72750
## [13]	{sliced cheese}	=> {whole milk}	0.01077783	0.4398340	0.02450432	1.72135
## [14]	{oil}	=> {whole milk}	0.01128622	0.4021739	0.02806304	1.57396
## [15]	{onions}	=> {other vegetables}	0.01423488	0.4590164	0.03101169	2.37226
## [16]	{onions}	=> {whole milk}	0.01209964	0.3901639	0.03101169	1.52696
## [17]	{berries}	=> {yogurt}	0.01057448	0.3180428	0.03324860	2.27984
## [18]	{berries}	=> {other vegetables}	0.01026945	0.3088685	0.03324860	1.59628
## [19]	{berries}	=> {whole milk}	0.01179461	0.3547401	0.03324860	1.38832
## [20]	{hamburger meat}	=> {other vegetables}	0.01382816	0.4159021	0.03324860	2.14944
## [21]	{hamburger meat}	=> {whole milk}	0.01474326	0.4434251	0.03324860	1.73541
## [22]	{hygiene articles}	=> {whole milk}	0.01281139	0.3888889	0.03294357	1.52197
## [23]	{salty snack}	=> {other vegetables}	0.01077783	0.2849462	0.03782410	1.47264
## [24]	{salty snack}	=> {whole milk}	0.01118454	0.2956989	0.03782410	1.15726
## [25]	{sugar}	=> {other vegetables}	0.01077783	0.3183183	0.03385867	1.64511
## [26]	{sugar}	=> {whole milk}	0.01504830	0.4444444	0.03385867	1.73939
## [27]	{waffles}	=> {other vegetables}	0.01006609	0.2619048	0.03843416	1.35356
## [28]	{waffles}	=> {whole milk}	0.01270971	0.3306878	0.03843416	1.29419
## [29]	{long life bakery product}	=> {other vegetables}	0.01067616	0.2853261	0.03741739	1.47460
## [30]	{long life bakery product}	=> {whole milk}	0.01352313	0.3614130	0.03741739	1.41444
## [31]	{dessert}	=> {other vegetables}	0.01159126	0.3123288	0.03711235	1.61416
## [32]	{dessert}	=> {whole milk}	0.01372649	0.3698630	0.03711235	1.44751
## [33]	{canned beer}	=> {shopping bags}	0.01138790	0.1465969	0.07768175	1.48790
## [34]	{shopping bags}	=> {canned beer}	0.01138790	0.1155831	0.09852567	1.48790
## [35]	{canned beer}	=> {soda}	0.01382816	0.1780105	0.07768175	1.02083
## [36]	{canned beer}	=> {rolls/buns}	0.01128622	0.1452880	0.07768175	0.78988
## [37]	{cream cheese }	=> {yogurt}	0.01240468	0.3128205	0.03965430	2.24241
## [38]	{cream cheese }	=> {other vegetables}	0.01372649	0.3461538	0.03965430	1.78897
## [39]	{cream cheese }	=> {whole milk}	0.01647178	0.4153846	0.03965430	1.62566
## [40]	{chicken}	=> {root vegetables}	0.01087951	0.2535545	0.04290798	2.32622
## [41]	{chicken}	=> {other vegetables}	0.01789527	0.4170616	0.04290798	2.15543
## [42]	{chicken}	=> {whole milk}	0.01759024	0.4099526	0.04290798	1.60441
## [43]	{white bread}	=> {soda}	0.01026945	0.2439614	0.04209456	1.39904
## [44]	{white bread}	=> {other vegetables}	0.01372649	0.3260870	0.04209456	1.68526
## [45]	{white bread}	=> {whole milk}	0.01708185	0.4057971	0.04209456	1.58814
## [46]	{chocolate}	=> {soda}	0.01352313	0.2725410	0.04961871	1.56293
## [47]	{chocolate}	=> {rolls/buns}	0.01179461	0.2377049	0.04961871	1.29233
## [48]	{chocolate}	=> {other vegetables}	0.01270971	0.2561475	0.04961871	1.32381
## [49]	{chocolate}	=> {whole milk}	0.01667514	0.3360656	0.04961871	1.31524
## [50]	{coffee}	=> {rolls/buns}	0.01098119	0.1891419	0.05805796	1.02830
## [51]	{coffee}	=> {other vegetables}	0.01342145	0.2311734	0.05805796	1.19474
## [52]	{coffee}	=> {whole milk}	0.01870869	0.3222417	0.05805796	1.26114
## [53]	{frozen vegetables}	=> {root vegetables}	0.01159126	0.2410148	0.04809354	2.21117

## [54]	{root vegetables}	=> {frozen vegetables}	0.01159126	0.1063433	0.10899847	2.211171
## [55]	{frozen vegetables}	=> {yogurt}	0.01240468	0.2579281	0.04809354	1.848923
## [56]	{frozen vegetables}	=> {rolls/buns}	0.01016777	0.2114165	0.04809354	1.149409
## [57]	{frozen vegetables}	=> {other vegetables}	0.01779359	0.3699789	0.04809354	1.912108
## [58]	{frozen vegetables}	=> {whole milk}	0.02043721	0.4249471	0.04809354	1.663094
## [59]	{beef}	=> {root vegetables}	0.01738688	0.3313953	0.05246568	3.040368
## [60]	{root vegetables}	=> {beef}	0.01738688	0.1595149	0.10899847	3.040368
## [61]	{beef}	=> {yogurt}	0.01169293	0.2228682	0.05246568	1.597601
## [62]	{beef}	=> {rolls/buns}	0.01362481	0.2596899	0.05246568	1.411851
## [63]	{beef}	=> {other vegetables}	0.01972547	0.3759690	0.05246568	1.943066
## [64]	{other vegetables}	=> {beef}	0.01972547	0.1019443	0.19349263	1.943066
## [65]	{beef}	=> {whole milk}	0.02125064	0.4050388	0.05246568	1.585179
## [66]	{curd}	=> {whipped/sour cream}	0.01047280	0.1965649	0.05327911	2.742144
## [67]	{whipped/sour cream}	=> {curd}	0.01047280	0.1460993	0.07168277	2.742144
## [68]	{curd}	=> {tropical fruit}	0.01026945	0.1927481	0.05327911	1.836899
## [69]	{curd}	=> {root vegetables}	0.01087951	0.2041985	0.05327911	1.873406
## [70]	{curd}	=> {yogurt}	0.01728521	0.3244275	0.05327911	2.325611
## [71]	{yogurt}	=> {curd}	0.01728521	0.1239067	0.13950178	2.325611
## [72]	{curd}	=> {rolls/buns}	0.01006609	0.1889313	0.05327911	1.027163
## [73]	{curd}	=> {other vegetables}	0.01718353	0.3225191	0.05327911	1.666823
## [74]	{curd}	=> {whole milk}	0.02613116	0.4904580	0.05327911	1.919488
## [75]	{whole milk}	=> {curd}	0.02613116	0.1022682	0.25551601	1.919488
## [76]	{napkins}	=> {tropical fruit}	0.01006609	0.1922330	0.05236401	1.831988
## [77]	{napkins}	=> {soda}	0.01199797	0.2291262	0.05236401	1.313963
## [78]	{napkins}	=> {yogurt}	0.01230300	0.2349515	0.05236401	1.684211
## [79]	{napkins}	=> {rolls/buns}	0.01169293	0.2233010	0.05236401	1.214021
## [80]	{napkins}	=> {other vegetables}	0.01443823	0.2757282	0.05236401	1.425006
## [81]	{napkins}	=> {whole milk}	0.01972547	0.3766990	0.05236401	1.474261
## [82]	{pork}	=> {root vegetables}	0.01362481	0.2363316	0.05765125	2.168209
## [83]	{root vegetables}	=> {pork}	0.01362481	0.1250000	0.10899847	2.168209
## [84]	{pork}	=> {soda}	0.01189629	0.2063492	0.05765125	1.183344
## [85]	{pork}	=> {rolls/buns}	0.01128622	0.1957672	0.05765125	1.064328
## [86]	{pork}	=> {other vegetables}	0.02165735	0.3756614	0.05765125	1.941476
## [87]	{other vegetables}	=> {pork}	0.02165735	0.1119285	0.19349263	1.941476
## [88]	{pork}	=> {whole milk}	0.02216573	0.3844797	0.05765125	1.504711
## [89]	{frankfurter}	=> {sausage}	0.01006609	0.1706897	0.05897306	1.816810
## [90]	{sausage}	=> {frankfurter}	0.01006609	0.1071429	0.09395018	1.816810
## [91]	{frankfurter}	=> {root vegetables}	0.01016777	0.1724138	0.05897306	1.581806
## [92]	{frankfurter}	=> {soda}	0.01128622	0.1913793	0.05897306	1.097501
## [93]	{frankfurter}	=> {yogurt}	0.01118454	0.1896552	0.05897306	1.359511
## [94]	{frankfurter}	=> {rolls/buns}	0.01921708	0.3258621	0.05897306	1.771611
## [95]	{rolls/buns}	=> {frankfurter}	0.01921708	0.1044776	0.18393493	1.771611
## [96]	{frankfurter}	=> {other vegetables}	0.01647178	0.2793103	0.05897306	1.443511
## [97]	{frankfurter}	=> {whole milk}	0.02053889	0.3482759	0.05897306	1.363023
## [98]	{bottled beer}	=> {bottled water}	0.01576004	0.1957071	0.08052872	1.770723
## [99]	{bottled water}	=> {bottled beer}	0.01576004	0.1425943	0.11052364	1.770723
## [100]	{bottled beer}	=> {soda}	0.01698017	0.2108586	0.08052872	1.209209
## [101]	{bottled beer}	=> {rolls/buns}	0.01362481	0.1691919	0.08052872	0.919844
## [102]	{bottled beer}	=> {other vegetables}	0.01616675	0.2007576	0.08052872	1.037544
## [103]	{bottled beer}	=> {whole milk}	0.02043721	0.2537879	0.08052872	0.993236
## [104]	{brown bread}	=> {sausage}	0.01067616	0.1645768	0.06487036	1.751743
## [105]	{sausage}	=> {brown bread}	0.01067616	0.1136364	0.09395018	1.751743
## [106]	{brown bread}	=> {tropical fruit}	0.01067616	0.1645768	0.06487036	1.568423
## [107]	{tropical fruit}	=> {brown bread}	0.01067616	0.1017442	0.10493137	1.568423

## [108] {brown bread}	=> {root vegetables}	0.01016777	0.1567398	0.06487036	1.438000
## [109] {brown bread}	=> {soda}	0.01260803	0.1943574	0.06487036	1.114580
## [110] {brown bread}	=> {yogurt}	0.01453991	0.2241379	0.06487036	1.606700
## [111] {yogurt}	=> {brown bread}	0.01453991	0.1042274	0.13950178	1.606700
## [112] {brown bread}	=> {rolls/buns}	0.01260803	0.1943574	0.06487036	1.056660
## [113] {brown bread}	=> {other vegetables}	0.01870869	0.2884013	0.06487036	1.490500
## [114] {brown bread}	=> {whole milk}	0.02521607	0.3887147	0.06487036	1.521290
## [115] {margarine}	=> {bottled water}	0.01026945	0.1753472	0.05856634	1.586510
## [116] {margarine}	=> {root vegetables}	0.01108287	0.1892361	0.05856634	1.736130
## [117] {root vegetables}	=> {margarine}	0.01108287	0.1016791	0.10899847	1.736130
## [118] {margarine}	=> {soda}	0.01016777	0.1736111	0.05856634	0.995600
## [119] {margarine}	=> {yogurt}	0.01423488	0.2430556	0.05856634	1.742310
## [120] {yogurt}	=> {margarine}	0.01423488	0.1020408	0.13950178	1.742310
## [121] {margarine}	=> {rolls/buns}	0.01474326	0.2517361	0.05856634	1.368610
## [122] {margarine}	=> {other vegetables}	0.01972547	0.3368056	0.05856634	1.740660
## [123] {other vegetables}	=> {margarine}	0.01972547	0.1019443	0.19349263	1.740660
## [124] {margarine}	=> {whole milk}	0.02419929	0.4131944	0.05856634	1.617090
## [125] {butter}	=> {whipped/sour cream}	0.01016777	0.1834862	0.05541434	2.559690
## [126] {whipped/sour cream}	=> {butter}	0.01016777	0.1418440	0.07168277	2.559690
## [127] {butter}	=> {root vegetables}	0.01291307	0.2330275	0.05541434	2.137890
## [128] {root vegetables}	=> {butter}	0.01291307	0.1184701	0.10899847	2.137890
## [129] {butter}	=> {yogurt}	0.01464159	0.2642202	0.05541434	1.894020
## [130] {yogurt}	=> {butter}	0.01464159	0.1049563	0.13950178	1.894020
## [131] {butter}	=> {rolls/buns}	0.01342145	0.2422018	0.05541434	1.316780
## [132] {butter}	=> {other vegetables}	0.02003050	0.3614679	0.05541434	1.868120
## [133] {other vegetables}	=> {butter}	0.02003050	0.1035208	0.19349263	1.868120
## [134] {butter}	=> {whole milk}	0.02755465	0.4972477	0.05541434	1.946050
## [135] {whole milk}	=> {butter}	0.02755465	0.1078392	0.25551601	1.946050
## [136] {newspapers}	=> {bottled water}	0.01128622	0.1414013	0.07981698	1.279370
## [137] {bottled water}	=> {newspapers}	0.01128622	0.1021159	0.11052364	1.279370
## [138] {newspapers}	=> {tropical fruit}	0.01179461	0.1477707	0.07981698	1.408260
## [139] {tropical fruit}	=> {newspapers}	0.01179461	0.1124031	0.10493137	1.408260
## [140] {newspapers}	=> {root vegetables}	0.01148958	0.1439490	0.07981698	1.320650
## [141] {root vegetables}	=> {newspapers}	0.01148958	0.1054104	0.10899847	1.320650
## [142] {newspapers}	=> {soda}	0.01464159	0.1834395	0.07981698	1.051960
## [143] {newspapers}	=> {yogurt}	0.01535333	0.1923567	0.07981698	1.378880
## [144] {yogurt}	=> {newspapers}	0.01535333	0.1100583	0.13950178	1.378880
## [145] {newspapers}	=> {rolls/buns}	0.01972547	0.2471338	0.07981698	1.343590
## [146] {rolls/buns}	=> {newspapers}	0.01972547	0.1072416	0.18393493	1.343590
## [147] {newspapers}	=> {other vegetables}	0.01931876	0.2420382	0.07981698	1.250890
## [148] {newspapers}	=> {whole milk}	0.02735130	0.3426752	0.07981698	1.341110
## [149] {whole milk}	=> {newspapers}	0.02735130	0.1070434	0.25551601	1.341110
## [150] {domestic eggs}	=> {citrus fruit}	0.01037112	0.1634615	0.06344687	1.974990
## [151] {citrus fruit}	=> {domestic eggs}	0.01037112	0.1253071	0.08276563	1.974990
## [152] {domestic eggs}	=> {tropical fruit}	0.01138790	0.1794872	0.06344687	1.710510
## [153] {tropical fruit}	=> {domestic eggs}	0.01138790	0.1085271	0.10493137	1.710510
## [154] {domestic eggs}	=> {root vegetables}	0.01433655	0.2259615	0.06344687	2.073070
## [155] {root vegetables}	=> {domestic eggs}	0.01433655	0.1315299	0.10899847	2.073070
## [156] {domestic eggs}	=> {soda}	0.01240468	0.1955128	0.06344687	1.121200
## [157] {domestic eggs}	=> {yogurt}	0.01433655	0.2259615	0.06344687	1.619770
## [158] {yogurt}	=> {domestic eggs}	0.01433655	0.1027697	0.13950178	1.619770
## [159] {domestic eggs}	=> {rolls/buns}	0.01565836	0.2467949	0.06344687	1.341750
## [160] {domestic eggs}	=> {other vegetables}	0.02226741	0.3509615	0.06344687	1.813820
## [161] {other vegetables}	=> {domestic eggs}	0.02226741	0.1150815	0.19349263	1.813820

## [162] {domestic eggs}	=> {whole milk}	0.02999492	0.4727564	0.06344687	1.850201
## [163] {whole milk}	=> {domestic eggs}	0.02999492	0.1173896	0.25551601	1.850201
## [164] {fruit/vegetable juice}	=> {citrus fruit}	0.01037112	0.1434599	0.07229283	1.733321
## [165] {citrus fruit}	=> {fruit/vegetable juice}	0.01037112	0.1253071	0.08276563	1.733321
## [166] {fruit/vegetable juice}	=> {shopping bags}	0.01067616	0.1476793	0.07229283	1.498891
## [167] {shopping bags}	=> {fruit/vegetable juice}	0.01067616	0.1083591	0.09852567	1.498891
## [168] {fruit/vegetable juice}	=> {sausage}	0.01006609	0.1392405	0.07229283	1.482061
## [169] {sausage}	=> {fruit/vegetable juice}	0.01006609	0.1071429	0.09395018	1.482061
## [170] {fruit/vegetable juice}	=> {bottled water}	0.01423488	0.1969058	0.07229283	1.781571
## [171] {bottled water}	=> {fruit/vegetable juice}	0.01423488	0.1287948	0.11052364	1.781571
## [172] {fruit/vegetable juice}	=> {tropical fruit}	0.01372649	0.1898734	0.07229283	1.809501
## [173] {tropical fruit}	=> {fruit/vegetable juice}	0.01372649	0.1308140	0.10493137	1.809501
## [174] {fruit/vegetable juice}	=> {root vegetables}	0.01199797	0.1659634	0.07229283	1.522621
## [175] {root vegetables}	=> {fruit/vegetable juice}	0.01199797	0.1100746	0.10899847	1.522621
## [176] {fruit/vegetable juice}	=> {soda}	0.01840366	0.2545710	0.07229283	1.459881
## [177] {soda}	=> {fruit/vegetable juice}	0.01840366	0.1055394	0.17437722	1.459881
## [178] {fruit/vegetable juice}	=> {yogurt}	0.01870869	0.2587904	0.07229283	1.855101
## [179] {yogurt}	=> {fruit/vegetable juice}	0.01870869	0.1341108	0.13950178	1.855101
## [180] {fruit/vegetable juice}	=> {rolls/buns}	0.01453991	0.2011252	0.07229283	1.093451
## [181] {fruit/vegetable juice}	=> {other vegetables}	0.02104728	0.2911392	0.07229283	1.504651
## [182] {other vegetables}	=> {fruit/vegetable juice}	0.02104728	0.1087756	0.19349263	1.504651
## [183] {fruit/vegetable juice}	=> {whole milk}	0.02663955	0.3684951	0.07229283	1.442161
## [184] {whole milk}	=> {fruit/vegetable juice}	0.02663955	0.1042579	0.25551601	1.442161
## [185] {whipped/sour cream}	=> {citrus fruit}	0.01087951	0.1517730	0.07168277	1.833761
## [186] {citrus fruit}	=> {whipped/sour cream}	0.01087951	0.1314496	0.08276563	1.833761
## [187] {whipped/sour cream}	=> {tropical fruit}	0.01382816	0.1929078	0.07168277	1.838411
## [188] {tropical fruit}	=> {whipped/sour cream}	0.01382816	0.1317829	0.10493137	1.838411
## [189] {whipped/sour cream}	=> {root vegetables}	0.01708185	0.2382979	0.07168277	2.186241
## [190] {root vegetables}	=> {whipped/sour cream}	0.01708185	0.1567164	0.10899847	2.186241
## [191] {whipped/sour cream}	=> {soda}	0.01159126	0.1617021	0.07168277	0.927311
## [192] {whipped/sour cream}	=> {yogurt}	0.02074225	0.2893617	0.07168277	2.074251
## [193] {yogurt}	=> {whipped/sour cream}	0.02074225	0.1486880	0.13950178	2.074251
## [194] {whipped/sour cream}	=> {rolls/buns}	0.01464159	0.2042553	0.07168277	1.110471
## [195] {whipped/sour cream}	=> {other vegetables}	0.02887646	0.4028369	0.07168277	2.081921
## [196] {other vegetables}	=> {whipped/sour cream}	0.02887646	0.1492380	0.19349263	2.081921
## [197] {whipped/sour cream}	=> {whole milk}	0.03223183	0.4496454	0.07168277	1.759751
## [198] {whole milk}	=> {whipped/sour cream}	0.03223183	0.1261441	0.25551601	1.759751
## [199] {pip fruit}	=> {pastry}	0.01067616	0.1411290	0.07564820	1.586291
## [200] {pastry}	=> {pip fruit}	0.01067616	0.1200000	0.08896797	1.586291
## [201] {pip fruit}	=> {citrus fruit}	0.01382816	0.1827957	0.07564820	2.208591
## [202] {citrus fruit}	=> {pip fruit}	0.01382816	0.1670762	0.08276563	2.208591
## [203] {pip fruit}	=> {sausage}	0.01077783	0.1424731	0.07564820	1.516471
## [204] {sausage}	=> {pip fruit}	0.01077783	0.1147186	0.09395018	1.516471
## [205] {pip fruit}	=> {bottled water}	0.01057448	0.1397849	0.07564820	1.264751
## [206] {pip fruit}	=> {tropical fruit}	0.02043721	0.2701613	0.07564820	2.574641
## [207] {tropical fruit}	=> {pip fruit}	0.02043721	0.1947674	0.10493137	2.574641
## [208] {pip fruit}	=> {root vegetables}	0.01555669	0.2056452	0.07564820	1.886671
## [209] {root vegetables}	=> {pip fruit}	0.01555669	0.1427239	0.10899847	1.886671
## [210] {pip fruit}	=> {soda}	0.01331978	0.1760753	0.07564820	1.009731
## [211] {pip fruit}	=> {yogurt}	0.01799695	0.2379032	0.07564820	1.705371
## [212] {yogurt}	=> {pip fruit}	0.01799695	0.1290087	0.13950178	1.705371
## [213] {pip fruit}	=> {rolls/buns}	0.01392984	0.1841398	0.07564820	1.001111
## [214] {pip fruit}	=> {other vegetables}	0.02613116	0.3454301	0.07564820	1.785231
## [215] {other vegetables}	=> {pip fruit}	0.02613116	0.1350499	0.19349263	1.785231

## [216] {pip fruit}	=> {whole milk}	0.03009659	0.3978495	0.07564820	1.557043
## [217] {whole milk}	=> {pip fruit}	0.03009659	0.1177875	0.25551601	1.557043
## [218] {pastry}	=> {shopping bags}	0.01189629	0.1337143	0.08896797	1.357151
## [219] {shopping bags}	=> {pastry}	0.01189629	0.1207430	0.09852567	1.357151
## [220] {pastry}	=> {sausage}	0.01250635	0.1405714	0.08896797	1.496233
## [221] {sausage}	=> {pastry}	0.01250635	0.1331169	0.09395018	1.496233
## [222] {pastry}	=> {tropical fruit}	0.01321810	0.1485714	0.08896797	1.415891
## [223] {tropical fruit}	=> {pastry}	0.01321810	0.1259690	0.10493137	1.415891
## [224] {pastry}	=> {root vegetables}	0.01098119	0.1234286	0.08896797	1.132388
## [225] {root vegetables}	=> {pastry}	0.01098119	0.1007463	0.10899847	1.132388
## [226] {pastry}	=> {soda}	0.02104728	0.2365714	0.08896797	1.356664
## [227] {soda}	=> {pastry}	0.02104728	0.1206997	0.17437722	1.356664
## [228] {pastry}	=> {yogurt}	0.01769192	0.1988571	0.08896797	1.425481
## [229] {yogurt}	=> {pastry}	0.01769192	0.1268222	0.13950178	1.425481
## [230] {pastry}	=> {rolls/buns}	0.02094560	0.2354286	0.08896797	1.279953
## [231] {rolls/buns}	=> {pastry}	0.02094560	0.1138751	0.18393493	1.279953
## [232] {pastry}	=> {other vegetables}	0.02257245	0.2537143	0.08896797	1.311234
## [233] {other vegetables}	=> {pastry}	0.02257245	0.1166579	0.19349263	1.311234
## [234] {pastry}	=> {whole milk}	0.03324860	0.3737143	0.08896797	1.462581
## [235] {whole milk}	=> {pastry}	0.03324860	0.1301234	0.25551601	1.462581
## [236] {citrus fruit}	=> {sausage}	0.01128622	0.1363636	0.08276563	1.451441
## [237] {sausage}	=> {citrus fruit}	0.01128622	0.1201299	0.09395018	1.451441
## [238] {citrus fruit}	=> {bottled water}	0.01352313	0.1633907	0.08276563	1.478333
## [239] {bottled water}	=> {citrus fruit}	0.01352313	0.1223551	0.11052364	1.478333
## [240] {citrus fruit}	=> {tropical fruit}	0.01992883	0.2407862	0.08276563	2.294701
## [241] {tropical fruit}	=> {citrus fruit}	0.01992883	0.1899225	0.10493137	2.294701
## [242] {citrus fruit}	=> {root vegetables}	0.01769192	0.2137592	0.08276563	1.961121
## [243] {root vegetables}	=> {citrus fruit}	0.01769192	0.1623134	0.10899847	1.961121
## [244] {citrus fruit}	=> {soda}	0.01281139	0.1547912	0.08276563	0.887671
## [245] {citrus fruit}	=> {yogurt}	0.02165735	0.2616708	0.08276563	1.875753
## [246] {yogurt}	=> {citrus fruit}	0.02165735	0.1552478	0.13950178	1.875753
## [247] {citrus fruit}	=> {rolls/buns}	0.01677682	0.2027027	0.08276563	1.102034
## [248] {citrus fruit}	=> {other vegetables}	0.02887646	0.3488943	0.08276563	1.803141
## [249] {other vegetables}	=> {citrus fruit}	0.02887646	0.1492380	0.19349263	1.803141
## [250] {citrus fruit}	=> {whole milk}	0.03050330	0.3685504	0.08276563	1.442371
## [251] {whole milk}	=> {citrus fruit}	0.03050330	0.1193792	0.25551601	1.442371
## [252] {shopping bags}	=> {sausage}	0.01565836	0.1589267	0.09852567	1.691601
## [253] {sausage}	=> {shopping bags}	0.01565836	0.1666667	0.09395018	1.691601
## [254] {shopping bags}	=> {bottled water}	0.01098119	0.1114551	0.09852567	1.008421
## [255] {shopping bags}	=> {tropical fruit}	0.01352313	0.1372549	0.09852567	1.308041
## [256] {tropical fruit}	=> {shopping bags}	0.01352313	0.1288760	0.10493137	1.308041
## [257] {shopping bags}	=> {root vegetables}	0.01281139	0.1300310	0.09852567	1.192961
## [258] {root vegetables}	=> {shopping bags}	0.01281139	0.1175373	0.10899847	1.192961
## [259] {shopping bags}	=> {soda}	0.02460600	0.2497420	0.09852567	1.432191
## [260] {soda}	=> {shopping bags}	0.02460600	0.1411079	0.17437722	1.432191
## [261] {shopping bags}	=> {yogurt}	0.01525165	0.1547988	0.09852567	1.109651
## [262] {yogurt}	=> {shopping bags}	0.01525165	0.1093294	0.13950178	1.109651
## [263] {shopping bags}	=> {rolls/buns}	0.01952211	0.1981424	0.09852567	1.077241
## [264] {rolls/buns}	=> {shopping bags}	0.01952211	0.1061360	0.18393493	1.077241
## [265] {shopping bags}	=> {other vegetables}	0.02318251	0.2352941	0.09852567	1.216031
## [266] {other vegetables}	=> {shopping bags}	0.02318251	0.1198108	0.19349263	1.216031
## [267] {shopping bags}	=> {whole milk}	0.02450432	0.2487100	0.09852567	0.973361
## [268] {sausage}	=> {bottled water}	0.01199797	0.1277056	0.09395018	1.155451
## [269] {bottled water}	=> {sausage}	0.01199797	0.1085557	0.11052364	1.155451

## [270] {sausage}	=> {tropical fruit}	0.01392984	0.1482684	0.09395018	1.413003
## [271] {tropical fruit}	=> {sausage}	0.01392984	0.1327519	0.10493137	1.413003
## [272] {sausage}	=> {root vegetables}	0.01494662	0.1590909	0.09395018	1.459570
## [273] {root vegetables}	=> {sausage}	0.01494662	0.1371269	0.10899847	1.459570
## [274] {sausage}	=> {soda}	0.02430097	0.2586580	0.09395018	1.483322
## [275] {soda}	=> {sausage}	0.02430097	0.1393586	0.17437722	1.483322
## [276] {sausage}	=> {yogurt}	0.01962379	0.2088745	0.09395018	1.497283
## [277] {yogurt}	=> {sausage}	0.01962379	0.1406706	0.13950178	1.497283
## [278] {sausage}	=> {rolls/buns}	0.03060498	0.3257576	0.09395018	1.771048
## [279] {rolls/buns}	=> {sausage}	0.03060498	0.1663903	0.18393493	1.771048
## [280] {sausage}	=> {other vegetables}	0.02694459	0.2867965	0.09395018	1.482209
## [281] {other vegetables}	=> {sausage}	0.02694459	0.1392538	0.19349263	1.482209
## [282] {sausage}	=> {whole milk}	0.02989324	0.3181818	0.09395018	1.245253
## [283] {whole milk}	=> {sausage}	0.02989324	0.1169916	0.25551601	1.245253
## [284] {bottled water}	=> {tropical fruit}	0.01850534	0.1674333	0.11052364	1.595648
## [285] {tropical fruit}	=> {bottled water}	0.01850534	0.1763566	0.10493137	1.595648
## [286] {bottled water}	=> {root vegetables}	0.01565836	0.1416743	0.11052364	1.299783
## [287] {root vegetables}	=> {bottled water}	0.01565836	0.1436567	0.10899847	1.299783
## [288] {bottled water}	=> {soda}	0.02897814	0.2621895	0.11052364	1.503570
## [289] {soda}	=> {bottled water}	0.02897814	0.1661808	0.17437722	1.503570
## [290] {bottled water}	=> {yogurt}	0.02297916	0.2079117	0.11052364	1.490387
## [291] {yogurt}	=> {bottled water}	0.02297916	0.1647230	0.13950178	1.490387
## [292] {bottled water}	=> {rolls/buns}	0.02419929	0.2189512	0.11052364	1.190373
## [293] {rolls/buns}	=> {bottled water}	0.02419929	0.1315644	0.18393493	1.190373
## [294] {bottled water}	=> {other vegetables}	0.02480935	0.2244710	0.11052364	1.160101
## [295] {other vegetables}	=> {bottled water}	0.02480935	0.1282186	0.19349263	1.160101
## [296] {bottled water}	=> {whole milk}	0.03436706	0.3109476	0.11052364	1.216933
## [297] {whole milk}	=> {bottled water}	0.03436706	0.1345006	0.25551601	1.216933
## [298] {tropical fruit}	=> {root vegetables}	0.02104728	0.2005814	0.10493137	1.840223
## [299] {root vegetables}	=> {tropical fruit}	0.02104728	0.1930970	0.10899847	1.840223
## [300] {tropical fruit}	=> {soda}	0.02084392	0.1986434	0.10493137	1.139153
## [301] {soda}	=> {tropical fruit}	0.02084392	0.1195335	0.17437722	1.139153
## [302] {tropical fruit}	=> {yogurt}	0.02928317	0.2790698	0.10493137	2.000474
## [303] {yogurt}	=> {tropical fruit}	0.02928317	0.2099125	0.13950178	2.000474
## [304] {tropical fruit}	=> {rolls/buns}	0.02460600	0.2344961	0.10493137	1.274880
## [305] {rolls/buns}	=> {tropical fruit}	0.02460600	0.1337756	0.18393493	1.274880
## [306] {tropical fruit}	=> {other vegetables}	0.03589222	0.3420543	0.10493137	1.767783
## [307] {other vegetables}	=> {tropical fruit}	0.03589222	0.1854966	0.19349263	1.767783
## [308] {tropical fruit}	=> {whole milk}	0.04229792	0.4031008	0.10493137	1.577593
## [309] {whole milk}	=> {tropical fruit}	0.04229792	0.1655392	0.25551601	1.577593
## [310] {root vegetables}	=> {soda}	0.01860702	0.1707090	0.10899847	0.978963
## [311] {soda}	=> {root vegetables}	0.01860702	0.1067055	0.17437722	0.978963
## [312] {root vegetables}	=> {yogurt}	0.02582613	0.2369403	0.10899847	1.698479
## [313] {yogurt}	=> {root vegetables}	0.02582613	0.1851312	0.13950178	1.698479
## [314] {root vegetables}	=> {rolls/buns}	0.02430097	0.2229478	0.10899847	1.212101
## [315] {rolls/buns}	=> {root vegetables}	0.02430097	0.1321172	0.18393493	1.212101
## [316] {root vegetables}	=> {other vegetables}	0.04738180	0.4347015	0.10899847	2.246604
## [317] {other vegetables}	=> {root vegetables}	0.04738180	0.2448765	0.19349263	2.246604
## [318] {root vegetables}	=> {whole milk}	0.04890696	0.4486940	0.10899847	1.756033
## [319] {whole milk}	=> {root vegetables}	0.04890696	0.1914047	0.25551601	1.756033
## [320] {soda}	=> {yogurt}	0.02735130	0.1568513	0.17437722	1.124367
## [321] {yogurt}	=> {soda}	0.02735130	0.1960641	0.13950178	1.124367
## [322] {soda}	=> {rolls/buns}	0.03833249	0.2198251	0.17437722	1.195124
## [323] {rolls/buns}	=> {soda}	0.03833249	0.2084024	0.18393493	1.195124

## [324] {soda}	=> {other vegetables}	0.03274021	0.1877551	0.17437722	0.97034
## [325] {other vegetables}	=> {soda}	0.03274021	0.1692065	0.19349263	0.97034
## [326] {soda}	=> {whole milk}	0.04006101	0.2297376	0.17437722	0.89911
## [327] {whole milk}	=> {soda}	0.04006101	0.1567847	0.25551601	0.89911
## [328] {yogurt}	=> {rolls/buns}	0.03436706	0.2463557	0.13950178	1.33936
## [329] {rolls/buns}	=> {yogurt}	0.03436706	0.1868436	0.18393493	1.33936
## [330] {yogurt}	=> {other vegetables}	0.04341637	0.3112245	0.13950178	1.60845
## [331] {other vegetables}	=> {yogurt}	0.04341637	0.2243826	0.19349263	1.60845
## [332] {yogurt}	=> {whole milk}	0.05602440	0.4016035	0.13950178	1.57173
## [333] {whole milk}	=> {yogurt}	0.05602440	0.2192598	0.25551601	1.57173
## [334] {rolls/buns}	=> {other vegetables}	0.04260295	0.2316197	0.18393493	1.19704
## [335] {other vegetables}	=> {rolls/buns}	0.04260295	0.2201787	0.19349263	1.19704
## [336] {rolls/buns}	=> {whole milk}	0.05663447	0.3079049	0.18393493	1.20503
## [337] {whole milk}	=> {rolls/buns}	0.05663447	0.2216474	0.25551601	1.20503
## [338] {other vegetables}	=> {whole milk}	0.07483477	0.3867578	0.19349263	1.51363
## [339] {whole milk}	=> {other vegetables}	0.07483477	0.2928770	0.25551601	1.51363
## [340] {curd, yogurt}	=> {whole milk}	0.01006609	0.5823529	0.01728521	2.27912
## [341] {curd, whole milk}	=> {yogurt}	0.01006609	0.3852140	0.02613116	2.76135
## [342] {whole milk, yogurt}	=> {curd}	0.01006609	0.1796733	0.05602440	3.37230
## [343] {other vegetables, pork}	=> {whole milk}	0.01016777	0.4694836	0.02165735	1.83739
## [344] {pork, whole milk}	=> {other vegetables}	0.01016777	0.4587156	0.02216573	2.37071
## [345] {other vegetables, whole milk}	=> {pork}	0.01016777	0.1358696	0.07483477	2.35674
## [346] {butter, other vegetables}	=> {whole milk}	0.01148958	0.5736041	0.02003050	2.24488
## [347] {butter, whole milk}	=> {other vegetables}	0.01148958	0.4169742	0.02755465	2.15498
## [348] {other vegetables, whole milk}	=> {butter}	0.01148958	0.1535326	0.07483477	2.77062
## [349] {domestic eggs, other vegetables}	=> {whole milk}	0.01230300	0.5525114	0.02226741	2.16233
## [350] {domestic eggs, whole milk}	=> {other vegetables}	0.01230300	0.4101695	0.02999492	2.11981
## [351] {other vegetables, whole milk}	=> {domestic eggs}	0.01230300	0.1644022	0.07483477	2.59117
## [352] {fruit/vegetable juice, other vegetables}	=> {whole milk}	0.01047280	0.4975845	0.02104728	1.94737
## [353] {fruit/vegetable juice, whole milk}	=> {other vegetables}	0.01047280	0.3931298	0.02663955	2.03175
## [354] {other vegetables, whole milk}	=> {fruit/vegetable juice}	0.01047280	0.1399457	0.07483477	1.93581
## [355] {whipped/sour cream, yogurt}	=> {other vegetables}	0.01016777	0.4901961	0.02074225	2.53340
## [356] {other vegetables, whipped/sour cream}	=> {yogurt}	0.01016777	0.3521127	0.02887646	2.52407
## [357] {other vegetables, yogurt}	=> {whipped/sour cream}	0.01016777	0.2341920	0.04341637	3.26706
## [358] {whipped/sour cream, yogurt}	=> {whole milk}	0.01087951	0.5245098	0.02074225	2.05274

## [359] {whipped/sour cream, ## whole milk}	=> {yogurt}	0.01087951	0.3375394	0.03223183	2.419600
## [360] {whole milk, ## yogurt}	=> {whipped/sour cream}	0.01087951	0.1941924	0.05602440	2.709051
## [361] {other vegetables, ## whipped/sour cream}	=> {whole milk}	0.01464159	0.5070423	0.02887646	1.984381
## [362] {whipped/sour cream, ## whole milk}	=> {other vegetables}	0.01464159	0.4542587	0.03223183	2.347671
## [363] {other vegetables, ## whole milk}	=> {whipped/sour cream}	0.01464159	0.1956522	0.07483477	2.729411
## [364] {other vegetables, ## pip fruit}	=> {whole milk}	0.01352313	0.5175097	0.02613116	2.025351
## [365] {pip fruit, ## whole milk}	=> {other vegetables}	0.01352313	0.4493243	0.03009659	2.322171
## [366] {other vegetables, ## whole milk}	=> {pip fruit}	0.01352313	0.1807065	0.07483477	2.388771
## [367] {other vegetables, ## pastry}	=> {whole milk}	0.01057448	0.4684685	0.02257245	1.833421
## [368] {pastry, ## whole milk}	=> {other vegetables}	0.01057448	0.3180428	0.03324860	1.643691
## [369] {other vegetables, ## whole milk}	=> {pastry}	0.01057448	0.1413043	0.07483477	1.588261
## [370] {citrus fruit, ## root vegetables}	=> {other vegetables}	0.01037112	0.5862069	0.01769192	3.029601
## [371] {citrus fruit, ## other vegetables}	=> {root vegetables}	0.01037112	0.3591549	0.02887646	3.295041
## [372] {other vegetables, ## root vegetables}	=> {citrus fruit}	0.01037112	0.2188841	0.04738180	2.644621
## [373] {citrus fruit, ## yogurt}	=> {whole milk}	0.01026945	0.4741784	0.02165735	1.855761
## [374] {citrus fruit, ## whole milk}	=> {yogurt}	0.01026945	0.3366667	0.03050330	2.413351
## [375] {whole milk, ## yogurt}	=> {citrus fruit}	0.01026945	0.1833031	0.05602440	2.214721
## [376] {citrus fruit, ## other vegetables}	=> {whole milk}	0.01301474	0.4507042	0.02887646	1.763891
## [377] {citrus fruit, ## whole milk}	=> {other vegetables}	0.01301474	0.4266667	0.03050330	2.205071
## [378] {other vegetables, ## whole milk}	=> {citrus fruit}	0.01301474	0.1739130	0.07483477	2.101271
## [379] {other vegetables, ## sausage}	=> {whole milk}	0.01016777	0.3773585	0.02694459	1.476841
## [380] {sausage, ## whole milk}	=> {other vegetables}	0.01016777	0.3401361	0.02989324	1.757871
## [381] {other vegetables, ## whole milk}	=> {sausage}	0.01016777	0.1358696	0.07483477	1.446181
## [382] {bottled water, ## other vegetables}	=> {whole milk}	0.01077783	0.4344262	0.02480935	1.700191
## [383] {bottled water, ## whole milk}	=> {other vegetables}	0.01077783	0.3136095	0.03436706	1.620781
## [384] {other vegetables, ## whole milk}	=> {bottled water}	0.01077783	0.1440217	0.07483477	1.303081
## [385] {root vegetables, ## tropical fruit}	=> {other vegetables}	0.01230300	0.5845411	0.02104728	3.020991

## [386] {other vegetables, ## tropical fruit}	=> {root vegetables}	0.01230300	0.3427762	0.03589222	3.144779
## [387] {other vegetables, ## root vegetables}	=> {tropical fruit}	0.01230300	0.2596567	0.04738180	2.474538
## [388] {root vegetables, ## tropical fruit}	=> {whole milk}	0.01199797	0.5700483	0.02104728	2.230969
## [389] {tropical fruit, ## whole milk}	=> {root vegetables}	0.01199797	0.2836538	0.04229792	2.602368
## [390] {root vegetables, ## whole milk}	=> {tropical fruit}	0.01199797	0.2453222	0.04890696	2.337938
## [391] {tropical fruit, ## yogurt}	=> {other vegetables}	0.01230300	0.4201389	0.02928317	2.171348
## [392] {other vegetables, ## tropical fruit}	=> {yogurt}	0.01230300	0.3427762	0.03589222	2.457148
## [393] {other vegetables, ## yogurt}	=> {tropical fruit}	0.01230300	0.2833724	0.04341637	2.700548
## [394] {tropical fruit, ## yogurt}	=> {whole milk}	0.01514997	0.5173611	0.02928317	2.024768
## [395] {tropical fruit, ## whole milk}	=> {yogurt}	0.01514997	0.3581731	0.04229792	2.567518
## [396] {whole milk, ## yogurt}	=> {tropical fruit}	0.01514997	0.2704174	0.05602440	2.577088
## [397] {rolls/buns, ## tropical fruit}	=> {whole milk}	0.01098119	0.4462810	0.02460600	1.746588
## [398] {tropical fruit, ## whole milk}	=> {rolls/buns}	0.01098119	0.2596154	0.04229792	1.411458
## [399] {rolls/buns, ## whole milk}	=> {tropical fruit}	0.01098119	0.1938959	0.05663447	1.847838
## [400] {other vegetables, ## tropical fruit}	=> {whole milk}	0.01708185	0.4759207	0.03589222	1.862588
## [401] {tropical fruit, ## whole milk}	=> {other vegetables}	0.01708185	0.4038462	0.04229792	2.087138
## [402] {other vegetables, ## whole milk}	=> {tropical fruit}	0.01708185	0.2282609	0.07483477	2.175338
## [403] {root vegetables, ## yogurt}	=> {other vegetables}	0.01291307	0.5000000	0.02582613	2.584078
## [404] {other vegetables, ## root vegetables}	=> {yogurt}	0.01291307	0.2725322	0.04738180	1.953618
## [405] {other vegetables, ## yogurt}	=> {root vegetables}	0.01291307	0.2974239	0.04341637	2.728698
## [406] {root vegetables, ## yogurt}	=> {whole milk}	0.01453991	0.5629921	0.02582613	2.203358
## [407] {root vegetables, ## whole milk}	=> {yogurt}	0.01453991	0.2972973	0.04890696	2.131138
## [408] {whole milk, ## yogurt}	=> {root vegetables}	0.01453991	0.2595281	0.05602440	2.381028
## [409] {rolls/buns, ## root vegetables}	=> {other vegetables}	0.01220132	0.5020921	0.02430097	2.594888
## [410] {other vegetables, ## root vegetables}	=> {rolls/buns}	0.01220132	0.2575107	0.04738180	1.400018
## [411] {other vegetables, ## rolls/buns}	=> {root vegetables}	0.01220132	0.2863962	0.04260295	2.627528
## [412] {rolls/buns, ## root vegetables}	=> {whole milk}	0.01270971	0.5230126	0.02430097	2.046888

## [413]	{root vegetables, whole milk}	=> {rolls/buns}	0.01270971	0.2598753	0.04890696	1.412861
## [414]	{rolls/buns, whole milk}	=> {root vegetables}	0.01270971	0.2244165	0.05663447	2.058891
## [415]	{other vegetables, root vegetables}	=> {whole milk}	0.02318251	0.4892704	0.04738180	1.914831
## [416]	{root vegetables, whole milk}	=> {other vegetables}	0.02318251	0.4740125	0.04890696	2.449771
## [417]	{other vegetables, whole milk}	=> {root vegetables}	0.02318251	0.3097826	0.07483477	2.842081
## [418]	{soda, yogurt}	=> {whole milk}	0.01047280	0.3828996	0.02735130	1.498531
## [419]	{soda, whole milk}	=> {yogurt}	0.01047280	0.2614213	0.04006101	1.873961
## [420]	{whole milk, yogurt}	=> {soda}	0.01047280	0.1869328	0.05602440	1.072001
## [421]	{other vegetables, soda}	=> {whole milk}	0.01392984	0.4254658	0.03274021	1.665121
## [422]	{soda, whole milk}	=> {other vegetables}	0.01392984	0.3477157	0.04006101	1.797041
## [423]	{other vegetables, whole milk}	=> {soda}	0.01392984	0.1861413	0.07483477	1.067461
## [424]	{rolls/buns, yogurt}	=> {other vegetables}	0.01148958	0.3343195	0.03436706	1.727811
## [425]	{other vegetables, yogurt}	=> {rolls/buns}	0.01148958	0.2646370	0.04341637	1.438751
## [426]	{other vegetables, rolls/buns}	=> {yogurt}	0.01148958	0.2696897	0.04260295	1.933231
## [427]	{rolls/buns, yogurt}	=> {whole milk}	0.01555669	0.4526627	0.03436706	1.771561
## [428]	{whole milk, yogurt}	=> {rolls/buns}	0.01555669	0.2776770	0.05602440	1.509641
## [429]	{rolls/buns, whole milk}	=> {yogurt}	0.01555669	0.2746858	0.05663447	1.969041
## [430]	{other vegetables, yogurt}	=> {whole milk}	0.02226741	0.5128806	0.04341637	2.007231
## [431]	{whole milk, yogurt}	=> {other vegetables}	0.02226741	0.3974592	0.05602440	2.054131
## [432]	{other vegetables, whole milk}	=> {yogurt}	0.02226741	0.2975543	0.07483477	2.132971
## [433]	{other vegetables, rolls/buns}	=> {whole milk}	0.01789527	0.4200477	0.04260295	1.643911
## [434]	{rolls/buns, whole milk}	=> {other vegetables}	0.01789527	0.3159785	0.05663447	1.633021
## [435]	{other vegetables, whole milk}	=> {rolls/buns}	0.01789527	0.2391304	0.07483477	1.300081

There are 435 rules generated by this `apriori` function with support = 0.01, confidence = 0.1 and maximum number of items to be considered is 4. The thresholds for support and confidence are taken such that the rules associate items which are bought by at least 1% of customers. In general, items which are bought rarely (less than 1% of customers) are considered as specific requirements for those customers. We want to look at the rules for which the confidence is at least 10% just to find interesting associations.

As expected, the most bought items like *whole milk*, *other vegetables*, *rolls/buns* etc., don't need any associations. However, there are certain items which are bought with other items. Let's dive deep into these

rules for better understanding.

It can be seen that maximum lift is just above 3. Let us observe the subset of rules with lift > 3.

```
## Choose a subset
```

```
inspect(subset(groceries_rules, subset=lift > 3))
```

##	lhs	rhs	support
## [1]	{beef}	=> {root vegetables}	0.01738688
## [2]	{root vegetables}	=> {beef}	0.01738688
## [3]	{whole milk, yogurt}	=> {curd}	0.01006609
## [4]	{other vegetables, yogurt}	=> {whipped/sour cream}	0.01016777
## [5]	{citrus fruit, root vegetables}	=> {other vegetables}	0.01037112
## [6]	{citrus fruit, other vegetables}	=> {root vegetables}	0.01037112
## [7]	{root vegetables, tropical fruit}	=> {other vegetables}	0.01230300
## [8]	{other vegetables, tropical fruit}	=> {root vegetables}	0.01230300

##	confidence	coverage	lift	count
## [1]	0.3313953	0.05246568	3.040367	171
## [2]	0.1595149	0.10899847	3.040367	171
## [3]	0.1796733	0.05602440	3.372304	99
## [4]	0.2341920	0.04341637	3.267062	100
## [5]	0.5862069	0.01769192	3.029608	102
## [6]	0.3591549	0.02887646	3.295045	102
## [7]	0.5845411	0.02104728	3.020999	121
## [8]	0.3427762	0.03589222	3.144780	121

There are only 8 rules which gives a lift more than 3 and almost all are related to vegetables and fruits. *Curd* has the highest lift. *Curd*, which is bought by just 1% of total customers, is bought by 18% of customers who bought *whole milk* and *yogurt*. Similarly, *other vegetables*, which are bought by only 1% total customers, are bought by 58% of customers who bought *root vegetables* and *citrus fruit*.

Let's look at rules with more than 50% confidence.

```
inspect(subset(groceries_rules, subset=confidence > 0.5))
```

##	lhs	rhs	support
## [1]	{curd, yogurt}	=> {whole milk}	0.01006609
## [2]	{butter, other vegetables}	=> {whole milk}	0.01148958
## [3]	{domestic eggs, other vegetables}	=> {whole milk}	0.01230300
## [4]	{whipped/sour cream, yogurt}	=> {whole milk}	0.01087951
## [5]	{other vegetables, whipped/sour cream}	=> {whole milk}	0.01464159
## [6]	{other vegetables, pip fruit}	=> {whole milk}	0.01352313
## [7]	{citrus fruit, root vegetables}	=> {other vegetables}	0.01037112
## [8]	{root vegetables, tropical fruit}	=> {other vegetables}	0.01230300
## [9]	{root vegetables, tropical fruit}	=> {whole milk}	0.01199797
## [10]	{tropical fruit, yogurt}	=> {whole milk}	0.01514997
## [11]	{root vegetables, yogurt}	=> {whole milk}	0.01453991
## [12]	{rolls/buns, root vegetables}	=> {other vegetables}	0.01220132
## [13]	{rolls/buns, root vegetables}	=> {whole milk}	0.01270971
## [14]	{other vegetables, yogurt}	=> {whole milk}	0.02226741

##	confidence	coverage	lift	count
## [1]	0.5823529	0.01728521	2.279125	99
## [2]	0.5736041	0.02003050	2.244885	113
## [3]	0.5525114	0.02226741	2.162336	121
## [4]	0.5245098	0.02074225	2.052747	107
## [5]	0.5070423	0.02887646	1.984385	144
## [6]	0.5175097	0.02613116	2.025351	133

```
## [7] 0.5862069 0.01769192 3.029608 102
## [8] 0.5845411 0.02104728 3.020999 121
## [9] 0.5700483 0.02104728 2.230969 118
## [10] 0.5173611 0.02928317 2.024770 149
## [11] 0.5629921 0.02582613 2.203354 143
## [12] 0.5020921 0.02430097 2.594890 120
## [13] 0.5230126 0.02430097 2.046888 125
## [14] 0.5128806 0.04341637 2.007235 219
```

There are only 14 items with confidence more than 0.5 and all these are for buying *whole milk* or *other vegetables*. This shows that though these are the most bought items, the probability of buying them increases when combined with other items.

Now, we will go through the rules with lift more than 2 and confidence more than 40%.

```
inspect(subset(groceries_rules, subset=lift > 2 & confidence > 0.4))
```

##	lhs	rhs	support	
## [1]	{onions}	=> {other vegetables}	0.01423488	
## [2]	{hamburger meat}	=> {other vegetables}	0.01382816	
## [3]	{chicken}	=> {other vegetables}	0.01789527	
## [4]	{whipped/sour cream}	=> {other vegetables}	0.02887646	
## [5]	{root vegetables}	=> {other vegetables}	0.04738180	
## [6]	{curd, yogurt}	=> {whole milk}	0.01006609	
## [7]	{pork, whole milk}	=> {other vegetables}	0.01016777	
## [8]	{butter, other vegetables}	=> {whole milk}	0.01148958	
## [9]	{butter, whole milk}	=> {other vegetables}	0.01148958	
## [10]	{domestic eggs, other vegetables}	=> {whole milk}	0.01230300	
## [11]	{domestic eggs, whole milk}	=> {other vegetables}	0.01230300	
## [12]	{whipped/sour cream, yogurt}	=> {other vegetables}	0.01016777	
## [13]	{whipped/sour cream, yogurt}	=> {whole milk}	0.01087951	
## [14]	{whipped/sour cream, whole milk}	=> {other vegetables}	0.01464159	
## [15]	{other vegetables, pip fruit}	=> {whole milk}	0.01352313	
## [16]	{pip fruit, whole milk}	=> {other vegetables}	0.01352313	
## [17]	{citrus fruit, root vegetables}	=> {other vegetables}	0.01037112	
## [18]	{citrus fruit, whole milk}	=> {other vegetables}	0.01301474	
## [19]	{root vegetables, tropical fruit}	=> {other vegetables}	0.01230300	
## [20]	{root vegetables, tropical fruit}	=> {whole milk}	0.01199797	
## [21]	{tropical fruit, yogurt}	=> {other vegetables}	0.01230300	
## [22]	{tropical fruit, yogurt}	=> {whole milk}	0.01514997	
## [23]	{tropical fruit, whole milk}	=> {other vegetables}	0.01708185	
## [24]	{root vegetables, yogurt}	=> {other vegetables}	0.01291307	
## [25]	{root vegetables, yogurt}	=> {whole milk}	0.01453991	
## [26]	{rolls/buns, root vegetables}	=> {other vegetables}	0.01220132	
## [27]	{rolls/buns, root vegetables}	=> {whole milk}	0.01270971	
## [28]	{root vegetables, whole milk}	=> {other vegetables}	0.02318251	
## [29]	{other vegetables, yogurt}	=> {whole milk}	0.02226741	
##	confidence	coverage	lift	count
## [1]	0.4590164	0.03101169	2.372268	140
## [2]	0.4159021	0.03324860	2.149447	136
## [3]	0.4170616	0.04290798	2.155439	176
## [4]	0.4028369	0.07168277	2.081924	284
## [5]	0.4347015	0.10899847	2.246605	466
## [6]	0.5823529	0.01728521	2.279125	99
## [7]	0.4587156	0.02216573	2.370714	100
## [8]	0.5736041	0.02003050	2.244885	113

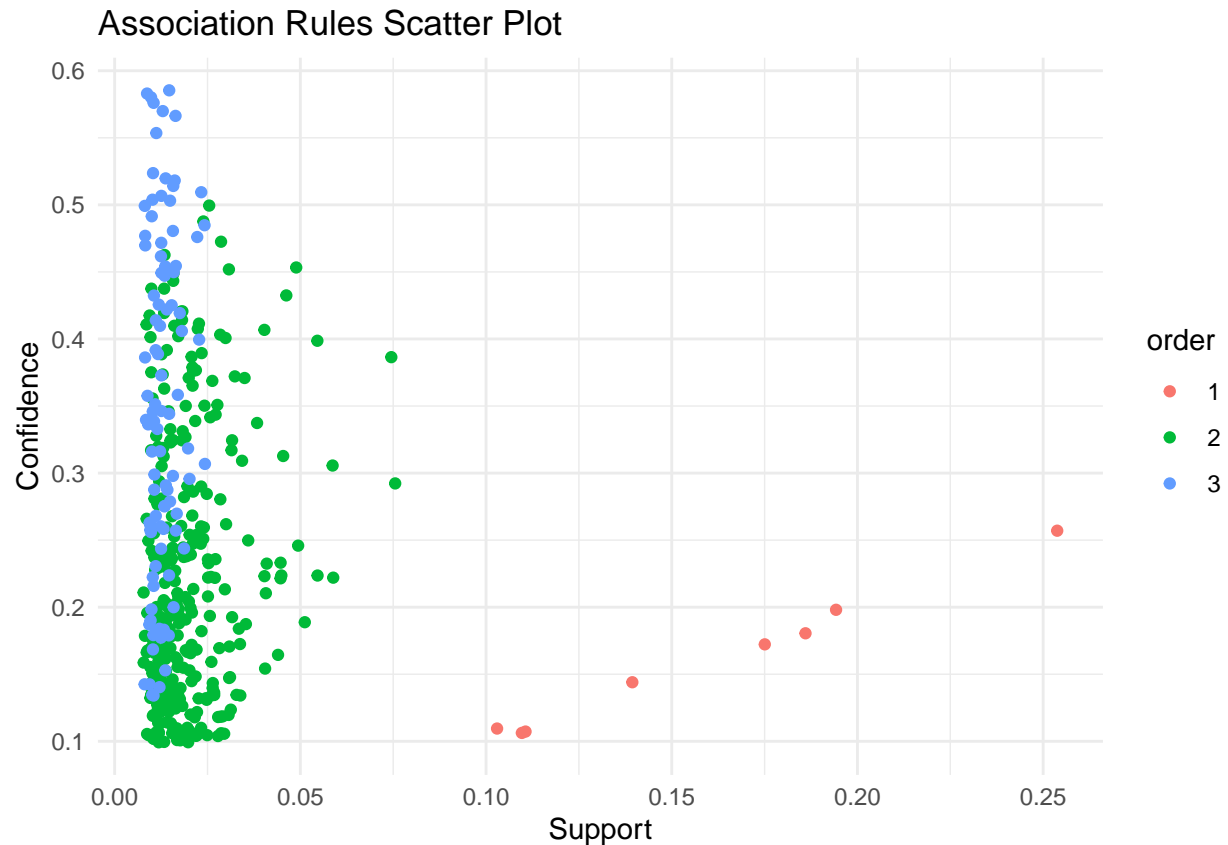
```
## [9] 0.4169742 0.02755465 2.154987 113
## [10] 0.5525114 0.02226741 2.162336 121
## [11] 0.4101695 0.02999492 2.119820 121
## [12] 0.4901961 0.02074225 2.533410 100
## [13] 0.5245098 0.02074225 2.052747 107
## [14] 0.4542587 0.03223183 2.347679 144
## [15] 0.5175097 0.02613116 2.025351 133
## [16] 0.4493243 0.03009659 2.322178 133
## [17] 0.5862069 0.01769192 3.029608 102
## [18] 0.4266667 0.03050330 2.205080 128
## [19] 0.5845411 0.02104728 3.020999 121
## [20] 0.5700483 0.02104728 2.230969 118
## [21] 0.4201389 0.02928317 2.171343 121
## [22] 0.5173611 0.02928317 2.024770 149
## [23] 0.4038462 0.04229792 2.087140 168
## [24] 0.5000000 0.02582613 2.584078 127
## [25] 0.5629921 0.02582613 2.203354 143
## [26] 0.5020921 0.02430097 2.594890 120
## [27] 0.5230126 0.02430097 2.046888 125
## [28] 0.4740125 0.04890696 2.449770 228
## [29] 0.5128806 0.04341637 2.007235 219
```

All these rules indicate that the most bought items individually, i.e, *whole milk* and *other vegetables*, are the items with more lift and confidence when associated with other items.

Now, let us see these rules in plots.

```
# "two key" plot: coloring is by size (order) of item set
plot(groceries_rules, method='two-key plot') +
  labs(title = "Association Rules Scatter Plot", x = "Support", y = "Confidence") +
  theme_minimal()
```

To reduce overplotting, jitter is added! Use jitter = 0 to prevent jitter.



```
# graph-based visualization
# export
# associations are represented as edges
# For rules, each item in the LHS is connected
# with a directed edge to the item in the RHS.
groceries_graph = associations2igraph(subset(groceries_rules, lift>1.5), associationsAsNodes = FALSE)
igraph::write_graph(groceries_graph, file='groceries.graphml', format = "graphml")
```

This plot shows the relation between support and confidence of each rule. It can be inferred that the support is low for most of the items. Only a few items have more support and confidence is low for those items. The below picture from graphml file shows the list of items and their associations.

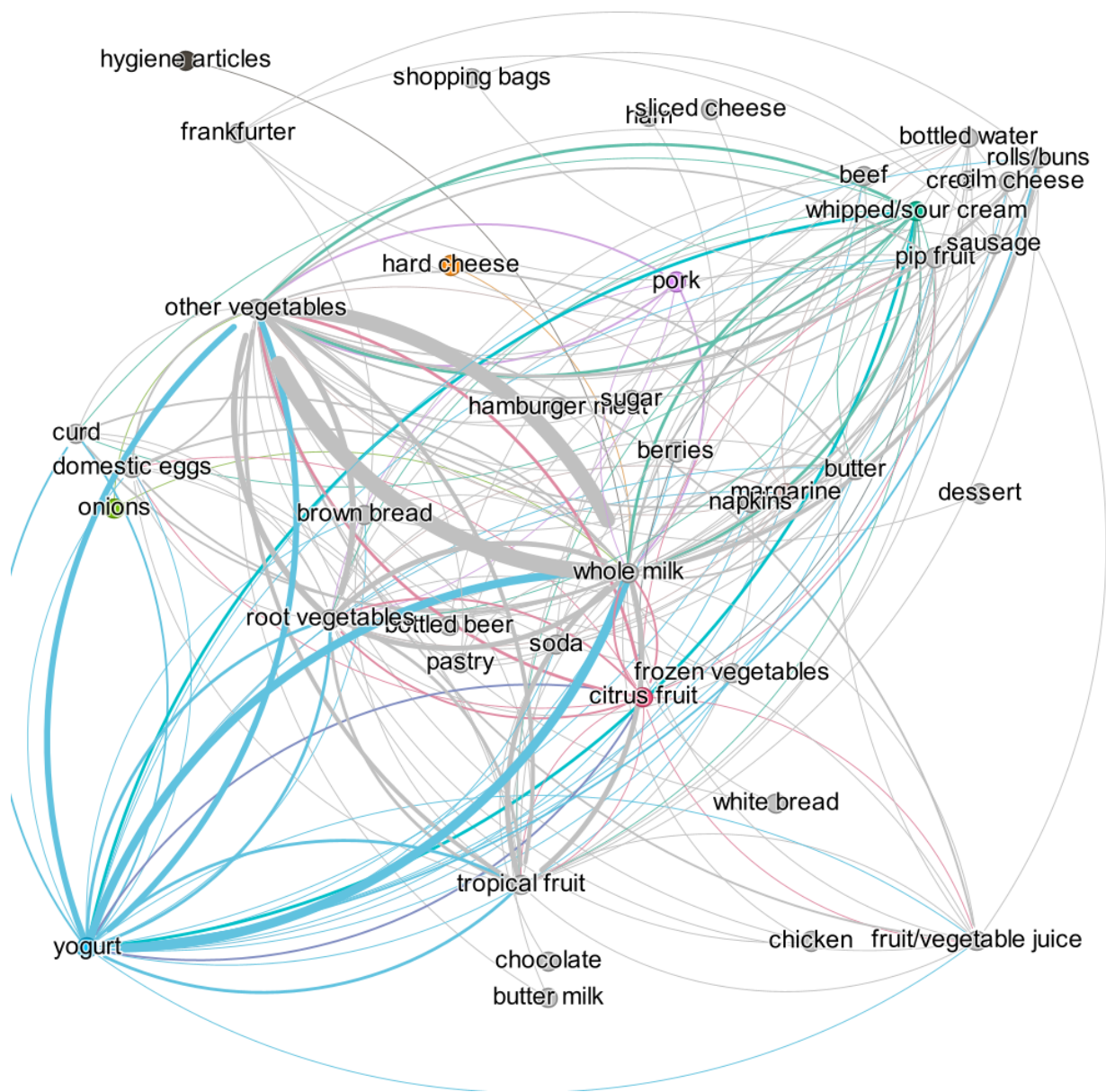


Figure 1: Graphml file of groceries_rules