Big Data Final Project | Part 1.

Group 11

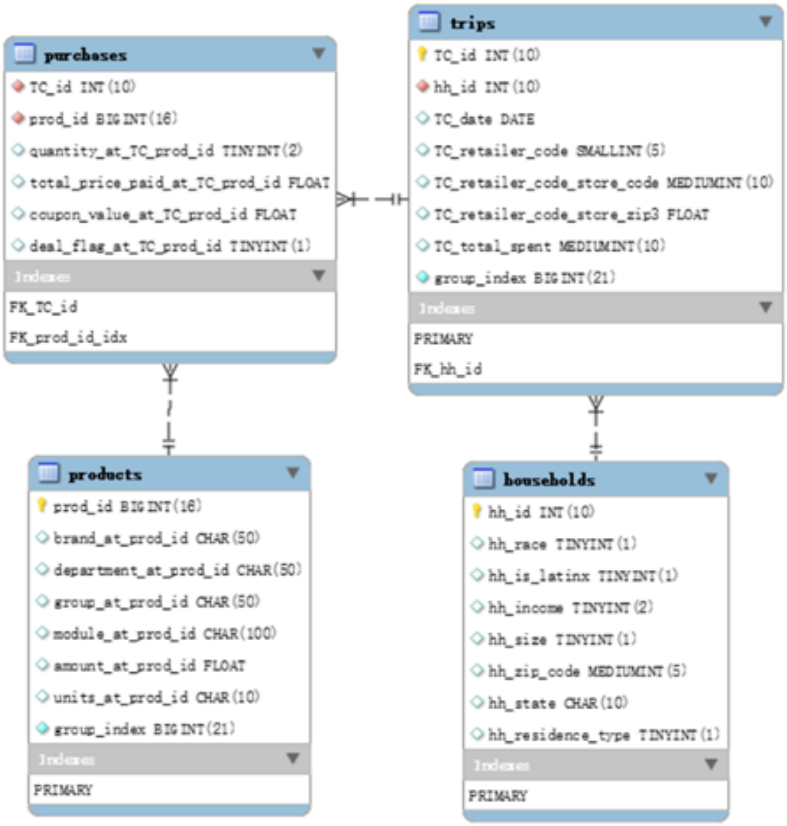
Jimmy Hu | Roger Hung | Erin Cao | Yifu Zuo | Zoey Yang

Import data from CSV files into MySQL database

The given data sets are too large to be loaded into MySQL database directly using tools provided by MySQL. Thus, we used Python to divide big data set into small parts and loaded them separately. Python's module pandas provides a tool to read big CSV files by chunks instead of loading all information into memory at one time. Another module sqlalchemy allows creating an engine that can be used to create a live MySQL connection and load data stored in pandas dataframe into MySQL database. With the combination of these modules, we can firstly read a small part of a big CSV file, then conduct some cleaning works and finally load the formatted data into database. Repeat this process until all data is cleaned and imported into database. The Python script used for this part can be seen in Jupyter Notebook "ETL.ipynb".

Create a proper database schema

A well-designed schema can largely accelerate the speed of executing queries. We tried to build tables as restrict as we can, that is, using the least data type to store data. For those columns who are not set as the primary key but are likely to be frequently used in join syntax such as hh_id in the table trips, we reset them as index. The script used to create the schema can be viewed in SQL file “CREATE_SCHEMA.sql”. The visualized schema is shown below.


purchases
TC_id INT(10)
prod_id BIGINT(16)
quantity_at_TC_prod_id TINYINT(2)
total_price_paid_at_TC_prod_id FLOAT
coupon_value_at_TC_prod_id FLOAT
deal_flag_at_TC_prod_id TINYINT(1)
Indexes
FK_TC_id
FK_prod_id_idx
trips
TC_id INT(10)
hh_id INT(10)
TC_date DATE
TC_retailer_code SMALLINT(5)
TC_retailer_code_store_code MEDIUMINT(10)
TC_retailer_code_store_zip3 FLOAT
TC_total_spent MEDIUMINT(10)
group_index BIGINT(21)
Indexes
PRIMARY
FK_hh_id
products
prod_id BIGINT(16)
brand_at_prod_id CHAR(50)
department_at_prod_id CHAR(50)
group_at_prod_id CHAR(50)
module_at_prod_id CHAR(100)
amount_at_prod_id FLOAT
units_at_prod_id CHAR(10)
group_index BIGINT(21)
Indexes
PRIMARY
households
hh_id INT(10)
hh_race TINYINT(1)
hh_is_latinx TINYINT(1)
hh_income TINYINT(2)
hh_size TINYINT(1)
hh_zip_code MEDIUMINT(5)
hh_state CHAR(10)
hh_residence_type TINYINT(1)
Indexes
PRIMARY

SQL queries can be viewed in file ’ANALYSIS.sql’.

END

Big Data Final Project | Part 2.

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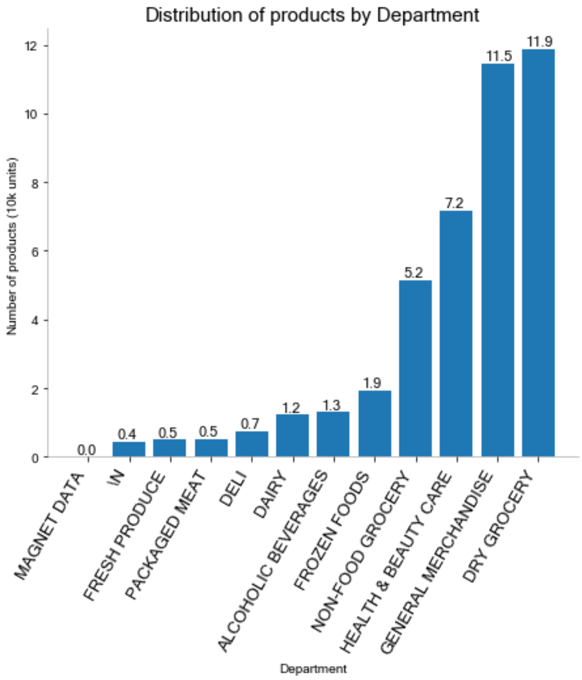
Problem A

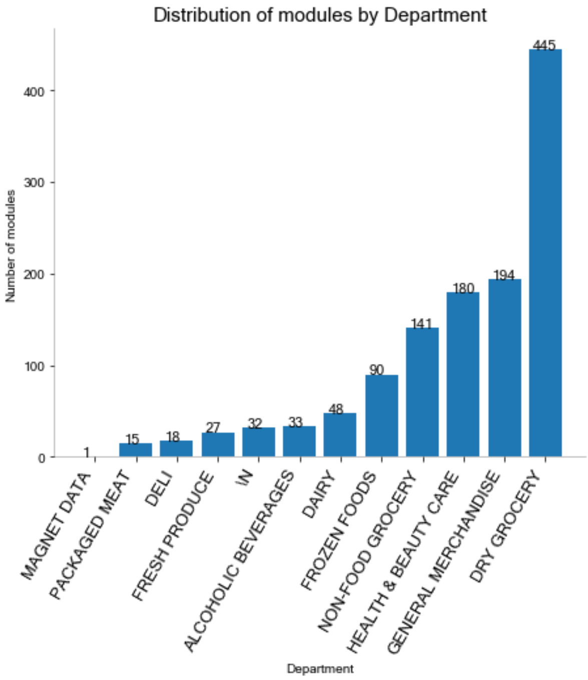
How many:

- **Store shopping trips are recorded in your database?**
- **Households appear in your database?**
- **Stores of different retailers appear in our database?**
- **Different products are recorded?**
    - **I. Products per category and products per module**
    - **Ii. Plot the distribution of products and modules per department**
- **Transactions?**
    - **I. Total transactions and transactions realized under some kind of promotion.**

In the database, there are **7,596,145** store shopping trips, **39,577** households, **863** different retailers, **26,402** different stores and **4,231,283** different products. For transactions, there are **38,587,942** records and **2,603,946** of them were realized under some kind of promotion.

The distributions of products and modules by departments can be seen as below.





According to these bar charts, we can learn that dry grocery has the most products and modules, and magnet data has the least products and modules.

Problem B.

Aggregate the data at the household-monthly level to answer the following questions:

- **How many households do not shop at least once on a 3 month periods.**
    - ○ **i. Is it reasonable?**
    - ○ **ii. Why do you think this is occurring?**

➔ No, after initial analysis, we consider this phenomenon not so reasonable.

We used two ways to calculate the number of households that do not shop at least once on a three-month period.

Firstly, we grouped all data into month level and found households that has at least a three-month gap between two continuous records. We found that **1,197** households do not shop at least once on a three-month period.

The first way is simple and fast while allows more bias in the result. To be more accurate, we also computed the answer on date level, and surprisingly found out that only **48** households meet the criteria. Thus, we concluded that using date level might be a more appropriate method than using month level.

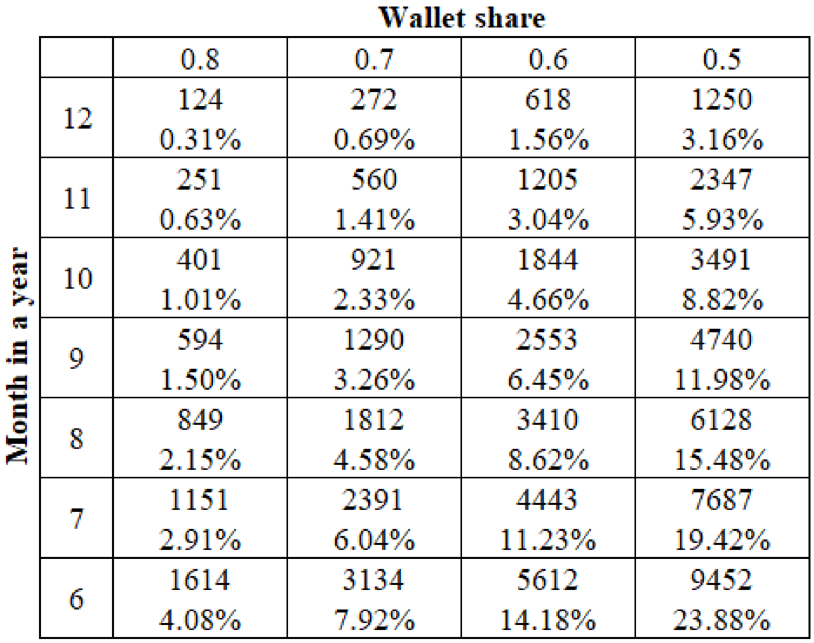
In a real case, this situation may not be reasonable since it is less likely that a household can survive without shopping in a three-month period. However, it may be some recording errors that affect the result. To be more specific, imagine how these records are documented, it highly possible that a certain group of people were asked to record every single in-store purchase. Since there is no way to examine the validity and accuracy of the data, the problem of recording errors and bias might occur.

- **Loyalism: Among the households who shop at least once a month, which % of them concentrate at least 80% of their grocery expenditure (on average) on single retailer? And among 2 retailers?**

➔ 0.031% of the households concentrate at least 80% of their grocery expenditure on a single retailer.

If defining the loyalism as those households whose expenditure on a certain retailer is larger than 80% of their monthly average expenditure, **the results can be biased since a household's expenditures may fluctuate through months.** Thus, we computed the exact wallet share of all the retailers only to find out which household's wallet share is usually occupied by one retailer.

The table below shows the total number of households in terms of loyalism. The x-axis denotes the wallet share from 50% to 80%. The y-axis denotes the time period from 6 months to 12 months in the same year.



Wallet share

Month in a year

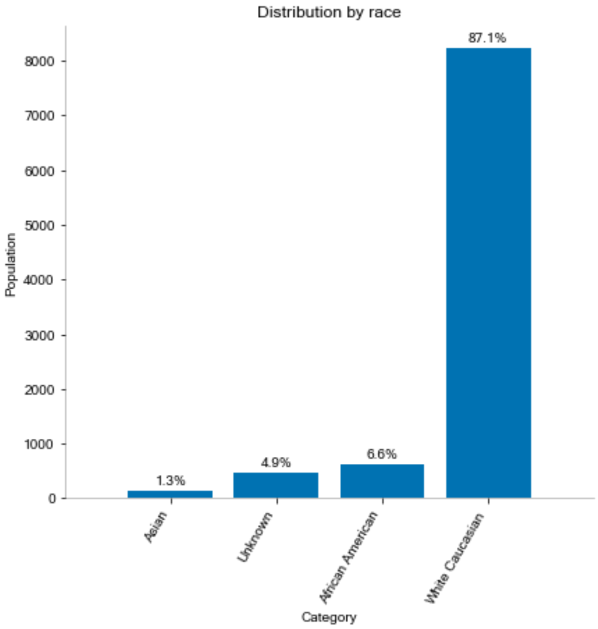
	0.8	0.7	0.6	0.5
12	124 0.31%	272 0.69%	618 1.56%	1250 3.16%
11	251 0.63%	560 1.41%	1205 3.04%	2347 5.93%
10	401 1.01%	921 2.33%	1844 4.66%	3491 8.82%
9	594 1.50%	1290 3.26%	2553 6.45%	4740 11.98%
8	849 2.15%	1812 4.58%	3410 8.62%	6128 15.48%
7	1151 2.91%	2391 6.04%	4443 11.23%	7687 19.42%
6	1614 4.08%	3134 7.92%	5612 14.18%	9452 23.88%

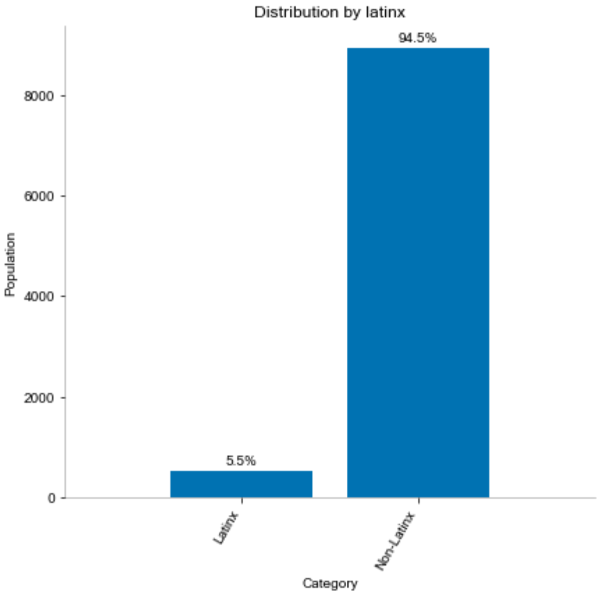
If following the definition of loyalism that keeps 80% wallet for 12 months, we will only find **124** households are loyalists, accounting for **0.31%** of the population. The result is indeed hard for further analysis. Thus, we experimented with different matrices and found if we would loosen the standard of loyalism to 50% wallet share and 6 months in terms of time period, we can have **9,452** households that account for **23.88%** of the population, which, in this case, makes more sense. **We will take this new standard in the following analysis.**

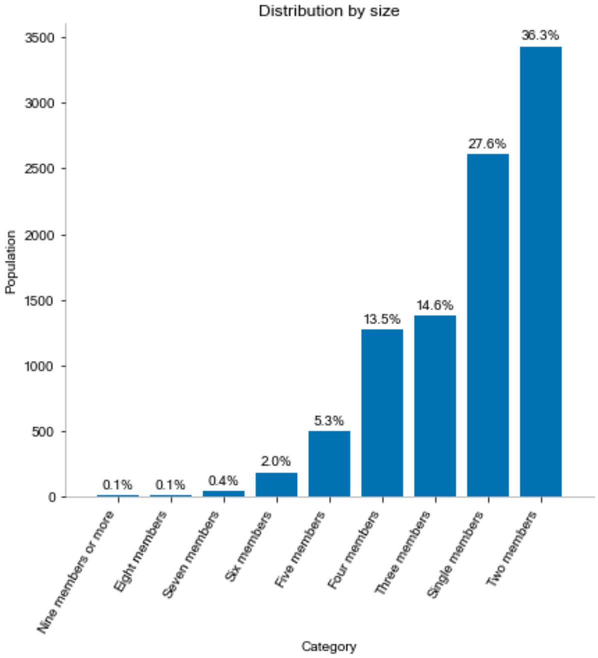
If considering loyalism among 2 retailers and following the definition of loyalism that keeps 80% wallet for 12 months, we will only find **204** households are loyalists, accounting for **0.52%** of the population. However, if we follow our new standard, we can have **19,658** households that account for **49.67%** of the population.

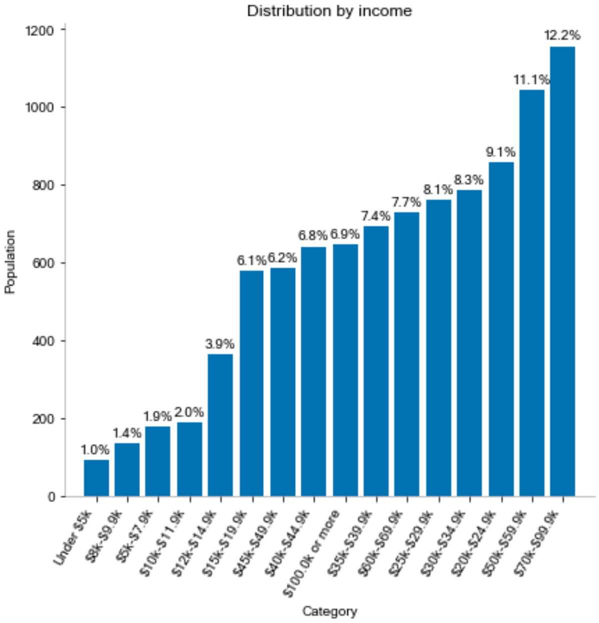
- **i. Are their demographics remarkably different? Are these people richer? Poorer?**

➔ Their demographics appear to be somewhat different in some aspects. In general, they are a group of people who lead comfortable lives.









- **ii. What is the retailer that has more loyalists?**

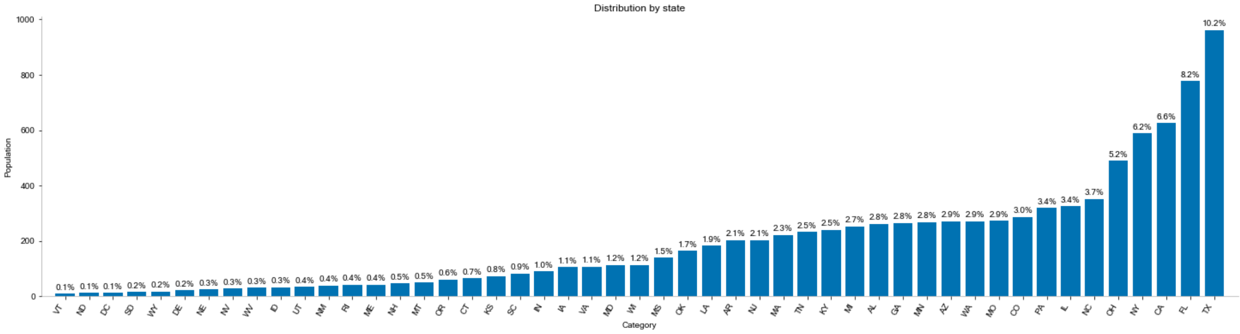
➔ The No.1 is retailer 6920 who has 2,634 loyalism in total.

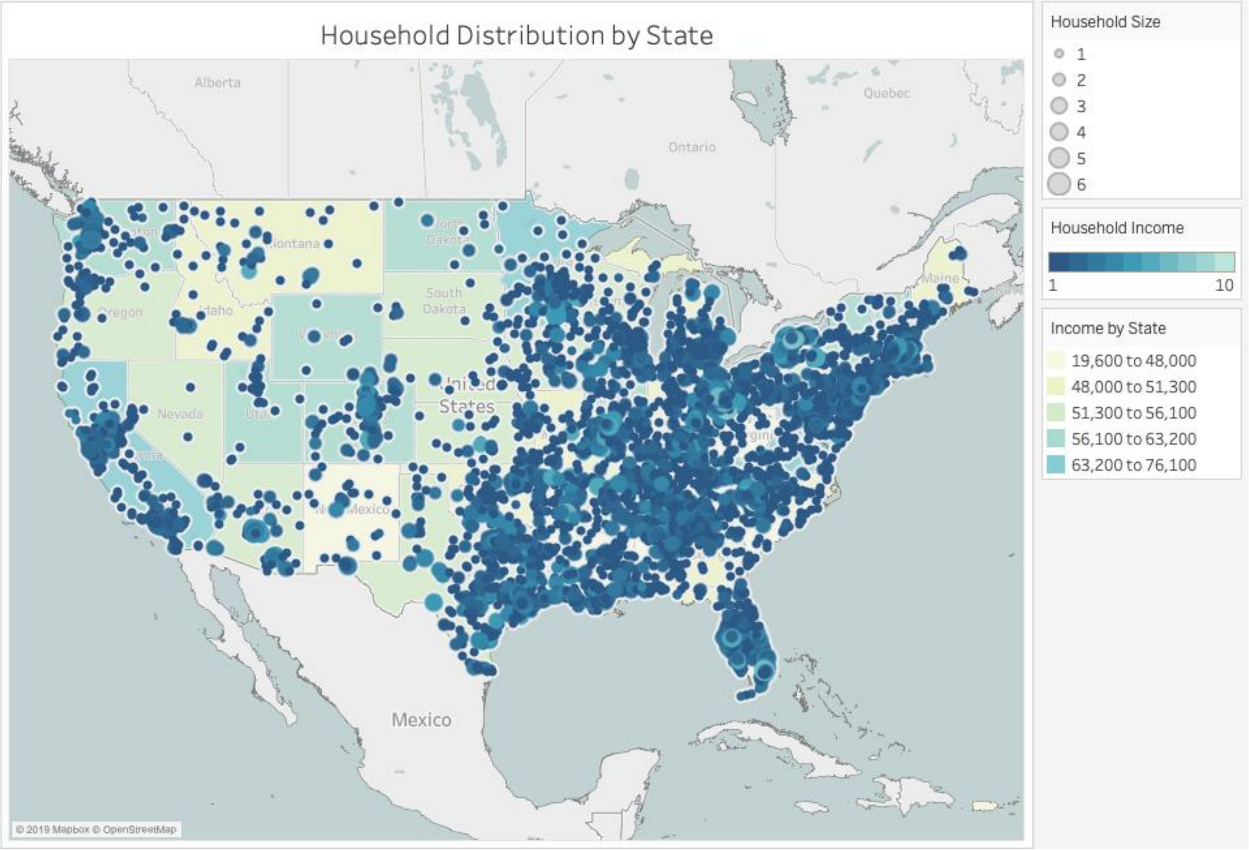
The table below shows the top 9 retailers that has the most loyalists.

Rank	Retail Code	Number of Loyalism
No. 1	**6920**	**2,634**
No. 2	181	459
No. 3	32	282
No. 4	151	266
No. 5	42	256
No. 6	9103	240
No. 7	6905	208
No. 8	294	172
No. 9	3997	171

○ **iii. Where do they live? Plot the distribution by state.**

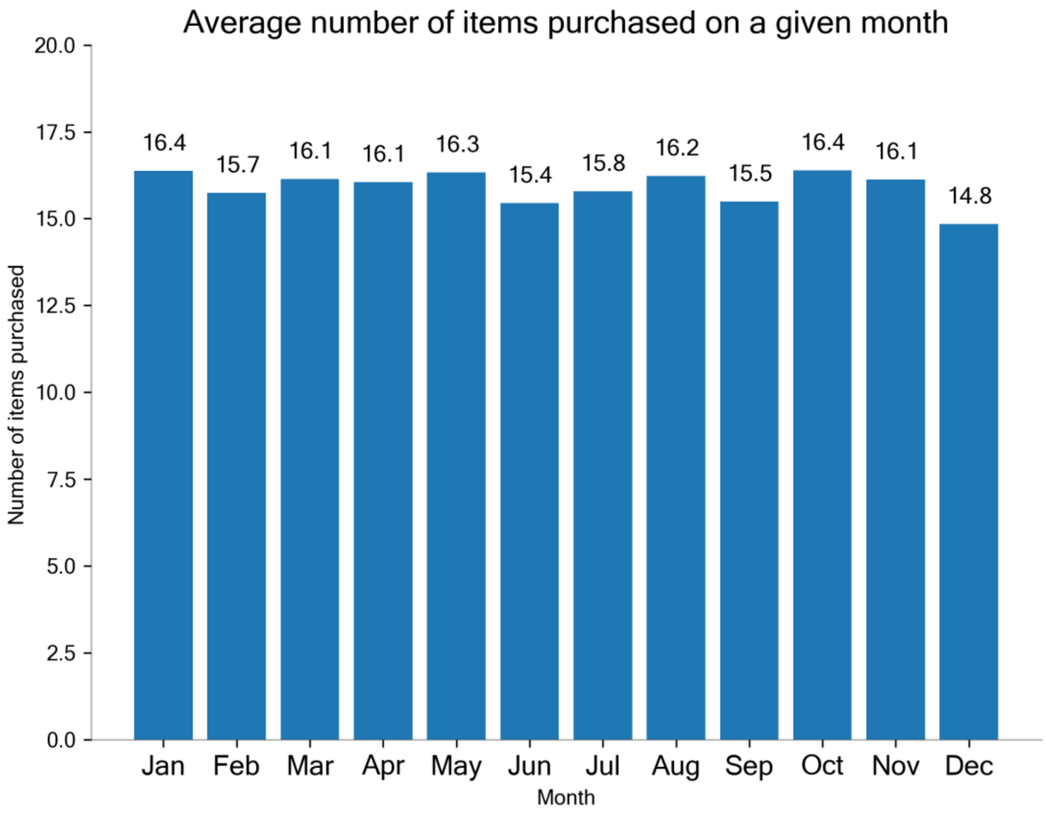
➔ The majority of households recorded live in the east of the US.





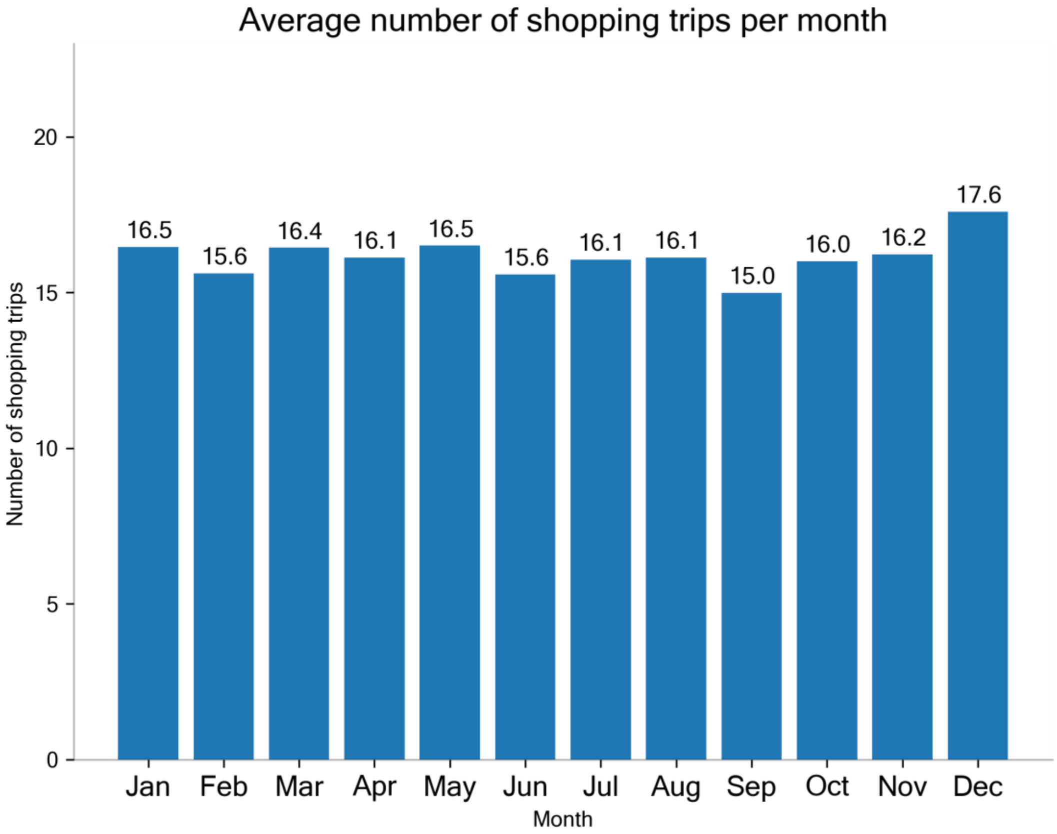
The majority of households recorded live in the east of the US and there is remarkable households density in the southeast. Texas household number is the largest, taking up 10.2% of the data entries. The statistics of California is also significant, ranked third place among the country and first place in the west.

- **Plot with the distribution:**
  - **i. Average number of items purchased on a given month.**



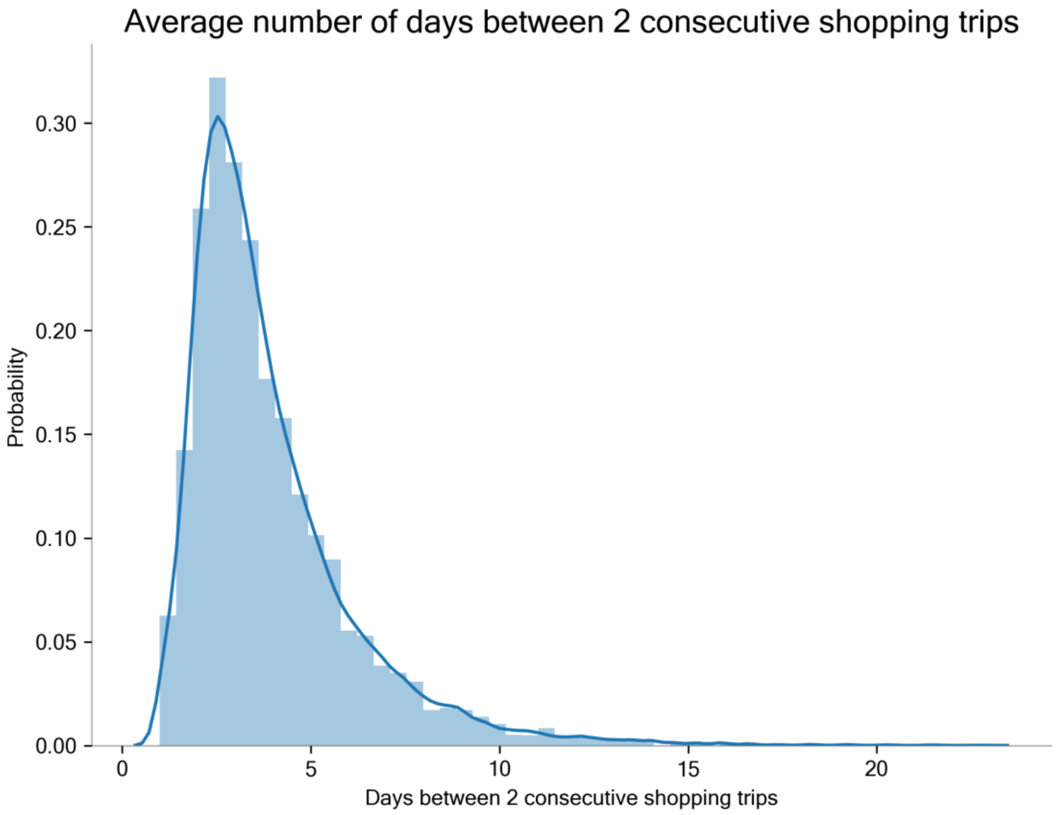
Average number of items purchased fluctuates on a monthly basis, with a range of fewer than 2 units.

- **ii. Average number of shopping trips per month.**



Average number of shopping trips per month slightly varies. It witnesses a peak value in December which is **17.6 trips**. One possible reason can be that **households tend to buy more groceries and gifts for Christmas and New Year.**

- **iii. Average number of days between 2 consecutive shopping trips.**



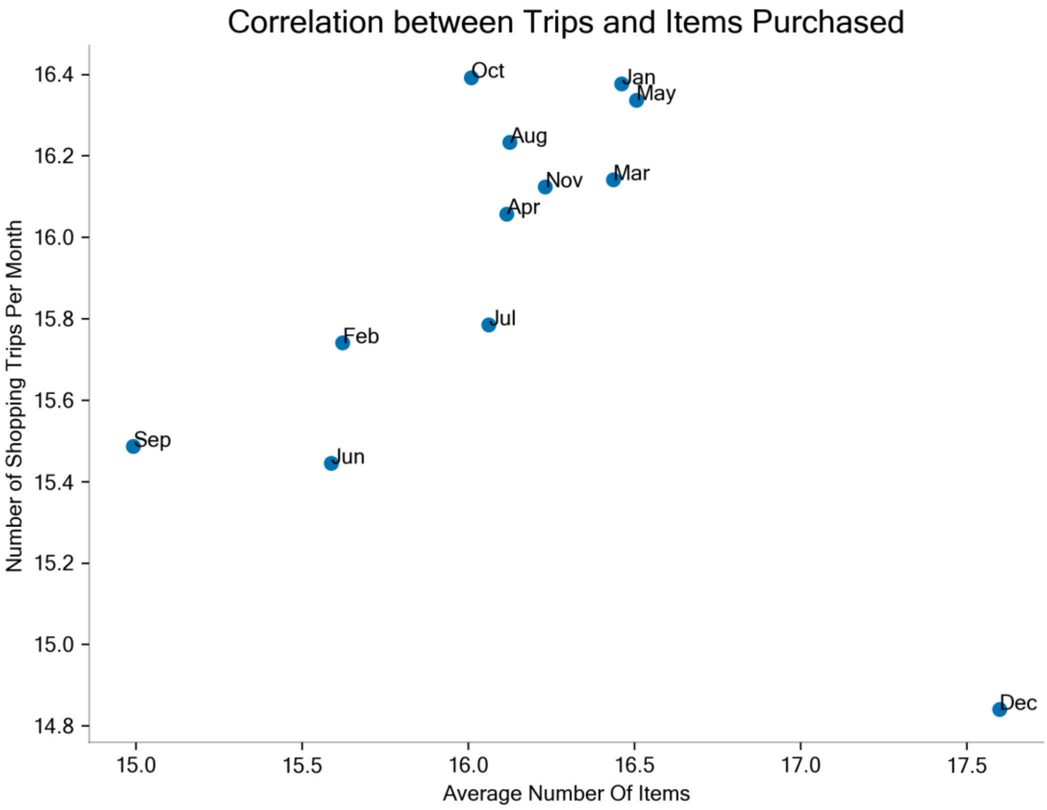
In terms of shopping frequency, most of the households shop in **every 1-5 days**. The distribution has a right tail, with a few households go for another shopping after more than 10 days.

Problem C.

Answer and reason the following questions: (Make informative visualizations)

- **Is the number of shopping trips per month correlated with the average number of items purchased?**

➔ Based on initial analysis, they are not strongly correlated with each other.

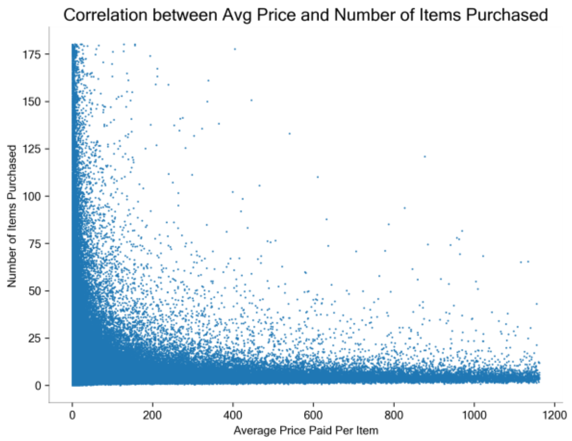


The average number of shopping trips per month has a somewhat positive correlation with the average number of items purchased, but **they are not strongly correlated with each other.** We still need more data, such as the past three years' data, to clarify the relationship between them. From the graph, except the case in December, as the average number of trips goes up, the average number of items purchased would increase. To be more specific, people are more likely to make impulsive purchases as shopping trip progresses. **The higher the frequency we go to supermarkets per month, to some degree, it not only implies the more time we take browsing in the store in total but also the higher possibility that people will come up with new unplanned selections.** Hence, we conclude that the more significant number of shopping trips per month would boost the average number of items purchased. As for the special case in December, our best guess is that because of the Christmas holiday, people are less willing to go shopping, but once they go shopping, they purchase more items than usual during the trip.

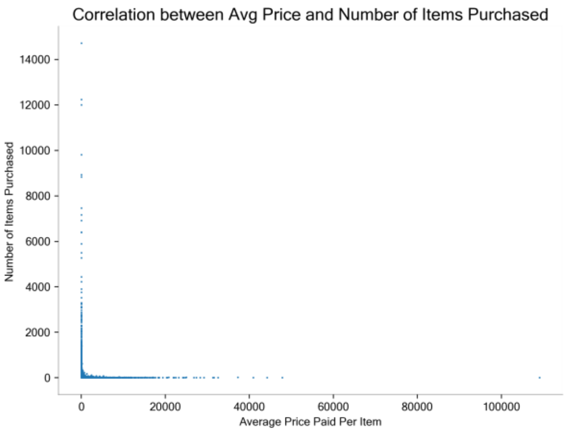
- **Is the average price paid per item correlated with the number of items purchased?**

➔ Yes, there's a negative nonlinear correlation between the number of items purchased and the average price paid per item.

Zoom-In graph



Original graph

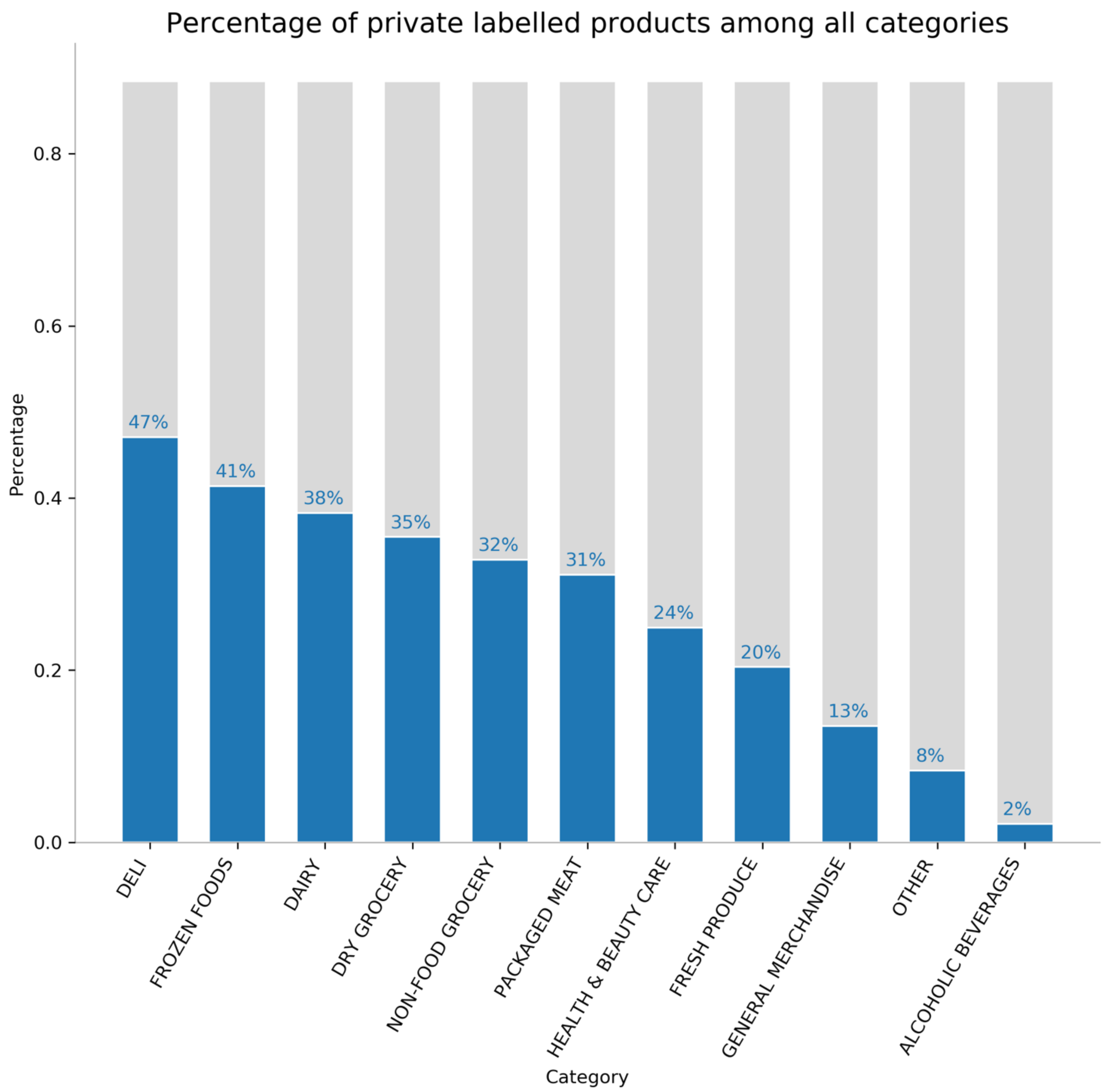


There two things we would like to clarify before interpreting the graph. Firstly, numerous data points lie in the bottom-left corner of the graph, which suggests either the measure errors or the appearance of window shoppers (people who go to a store and, instead of buying stuff, they just browsed around). Secondly, to better look into the behavior patterns, we decide to exclude the outliers, which are not only misleading but make little sense.

From the graph, in general, we can see that there's a **negative nonlinear correlation between the number of items purchased and the average price paid per item**. In this scatter plot, when the number of items purchased is relatively high, the cluster of these data stays in low 'average price paid per item' area. In contrast, when the amount of 'average price paid per item' becomes higher, the number of items purchased can be extremely low, can be approximated to 0. This result actually meets the law of demand, which is an economic principle that explains the negative correlation between the price of a good or service and its demand. **When the price of one item becomes extremely high, people would tend to buy less, since the budget is relatively the same.**

- **Private Labeled products are the products with the same brand as the supermarket. In the data set they appear labeled as 'CTL BR'**
    - **i. What are the product categories that have proven to be more "Private labelled"**

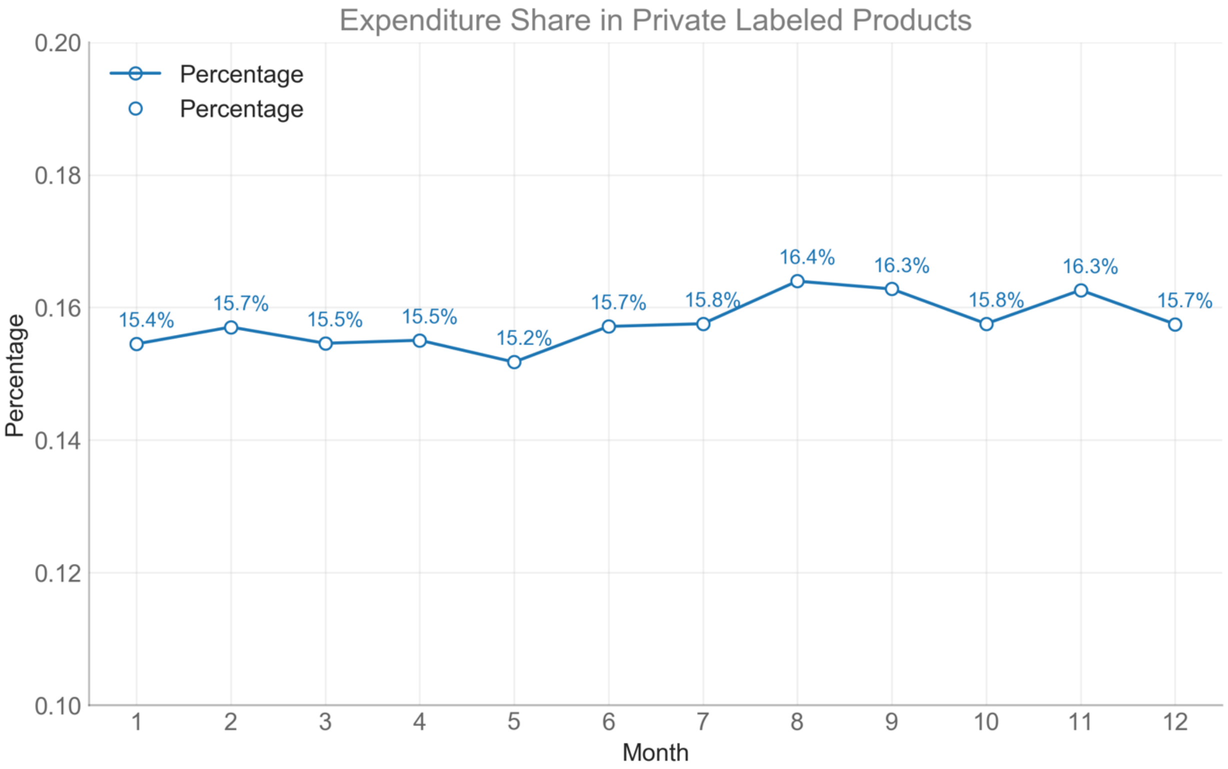
➔ DELI.



We can observe from the graph above that **DELI is the category that has the highest percentage of private-label products**. On the other hand, the category of ALCOHOLIC BEVERAGE has the lowest percentage of private-label products.

○ **ii. Is the expenditure share in Private Labeled products constant across months?**

➔ Yes, according to the graph, the expenditure share in Private Labeled products does not fluctuate much across months.

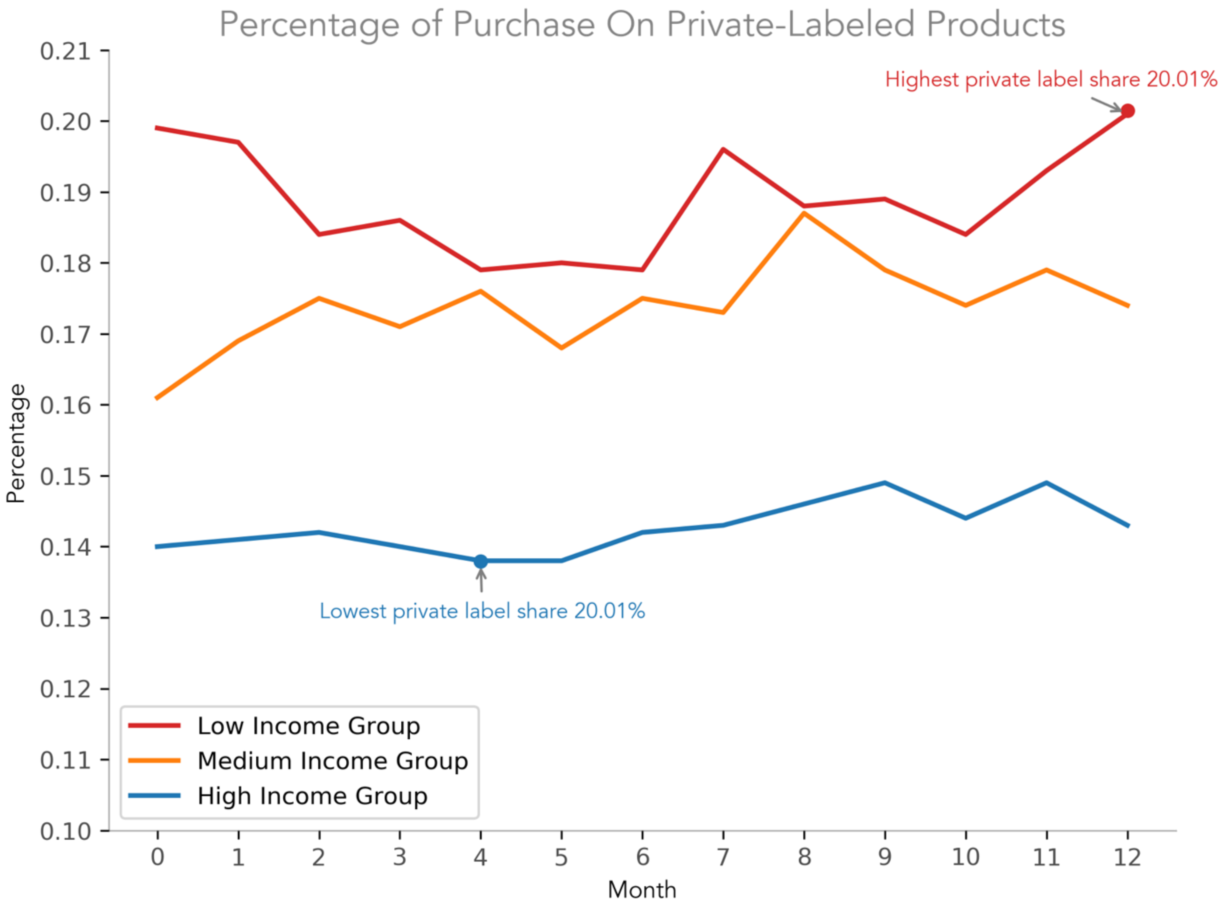


(0 in the x-axis denotes December 2003.)

In addition, the most considerable difference between the highest month and the lowest month is **1.2%**, which is subtle and ignorable in the case.

- **iii. Cluster households in three income groups, Low, Medium and High. Report the average monthly expenditure on the grocery. Study the % of private label share in their monthly expenditures. Use visuals to represent the intuition you are suggesting.**

➔ People with less financial advantage are more likely to purchase private-label products.



The graph clearly suggests that there is a vast difference in terms of shopping patterns across three income groups. **People belonging to the high-income group tend not to purchase private-label products. On the contrary, people in the low-income group favor private-label products when shopping**.

But why so? There are two possible reasons for this phenomenon. At first glance, the quality of private-label products seems not making any income group stand out from others. However, further research reveals that private-label products tend to be much cheaper than their major competitors, thus are more appealing to people with low income. Secondly, consumers are more inclined to purchase products based on familiarity. For instance, Whole Foods Market is one of the best-known supermarkets in the US. Just as the case with other giants in the retail industry, It has its own private label line, 365 EVERYDAY VALUE, which sells both natural and organic selections at a competitive price. In other words, people have faith in the quality of products offered by Whole Foods Market. When the product line of 365 EVERYDAY VALUE comes out, people with less income, who often have a tight budget and are more sensitive to price, are able to purchase organic groceries at an affordable price with a trustworthy brand.