

# Deliverable 2

## PCA, CA and Clustering

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## 1 First setups

```
if(!is.null(dev.list())) dev.off() # Clear plots
rm(list=ls())                  # Clean workspace
```

### 1.1 Load Required Packages for this deliverable

We load the necessary packages and set working directory

```
#setwd("~/Documents/uni/FIB-ADEI-LAB/deliverable2")
#filepath<-"~/Documents/uni/FIB-ADEI-LAB/deliverable2"
setwd("C:/Users/Claudia Sánchez/Desktop/FIB/TARDOR 2020-2021/ADEI/DELIVERABLE1/FIB-ADEI-LAB/deliverable2")
filepath<-"C:/Users/Claudia Sánchez/Desktop/FIB/TARDOR 2020-2021/ADEI/DELIVERABLE1/FIB-ADEI-LAB/deliverable2"

# Load Required Packages
options(contrasts=c("contr.treatment", "contr.treatment"))
requiredPackages <- c("missMDA", "chemometrics", "mvoutlier", "effects", "FactoMineR", "car", "factoextra", "F")
missingPackages <- requiredPackages[!(requiredPackages %in% installed.packages()[, "Package"])]
if(length(missingPackages)) install.packages(missingPackages)
lapply(requiredPackages, require, character.only = TRUE)
```

### 1.2 Load processed data from first deliverable

```
load(paste0(filepath, "/Taxi5000_del1.RData"))
```

### 1.3 Clean data

```
# remove some columns
#names(df)
df$lpep_pickup_datetime <- NULL
df$lpep_dropoff_datetime <- NULL
df$Store_and_fwd_flag <- NULL
df$Ehail_fee <- NULL
df$CashTips <- NULL
df$Sum_total_amount <- NULL
```

```
df$yearGt2015 <- NULL

# imputation
library(missMDA)
long_lat<-names(df)[c(3:6)]
imp_long_lat<-imputePCA(df[,long_lat])
df[,long_lat]<-imp_long_lat$completeObs
```

## 2 Principal Component Analysis (PCA)

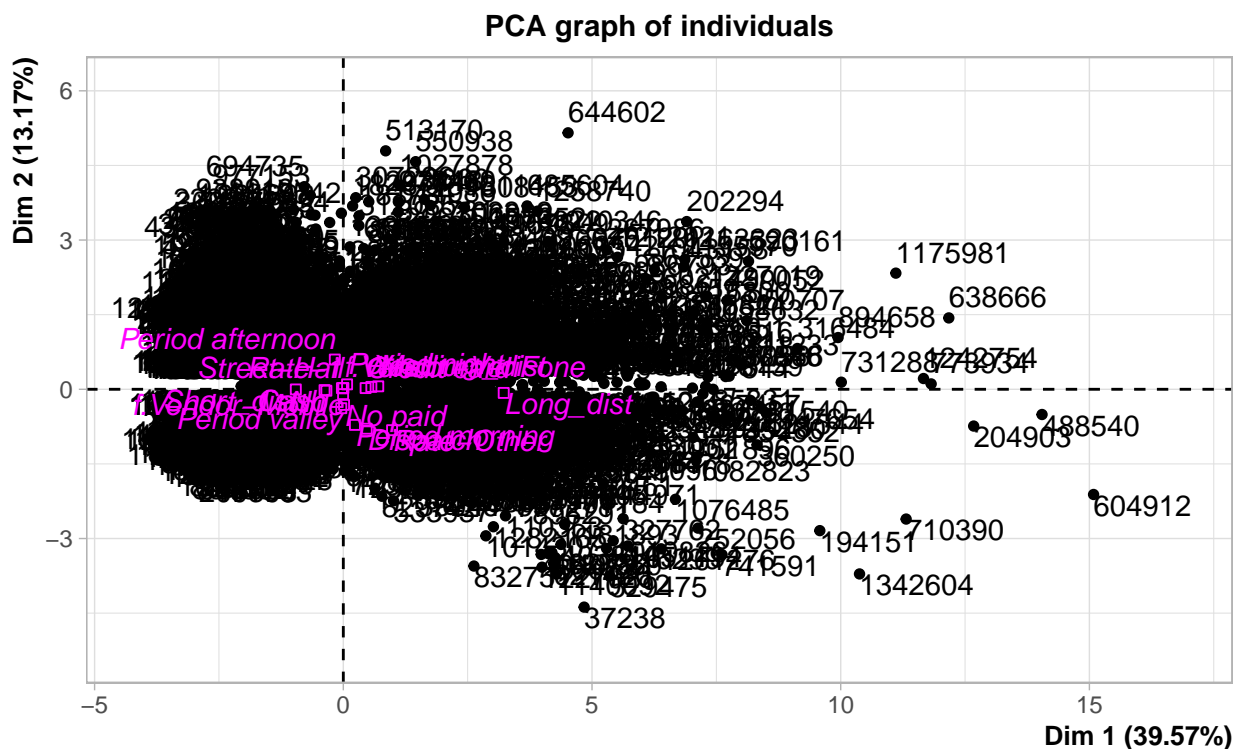
```
names(df)
```

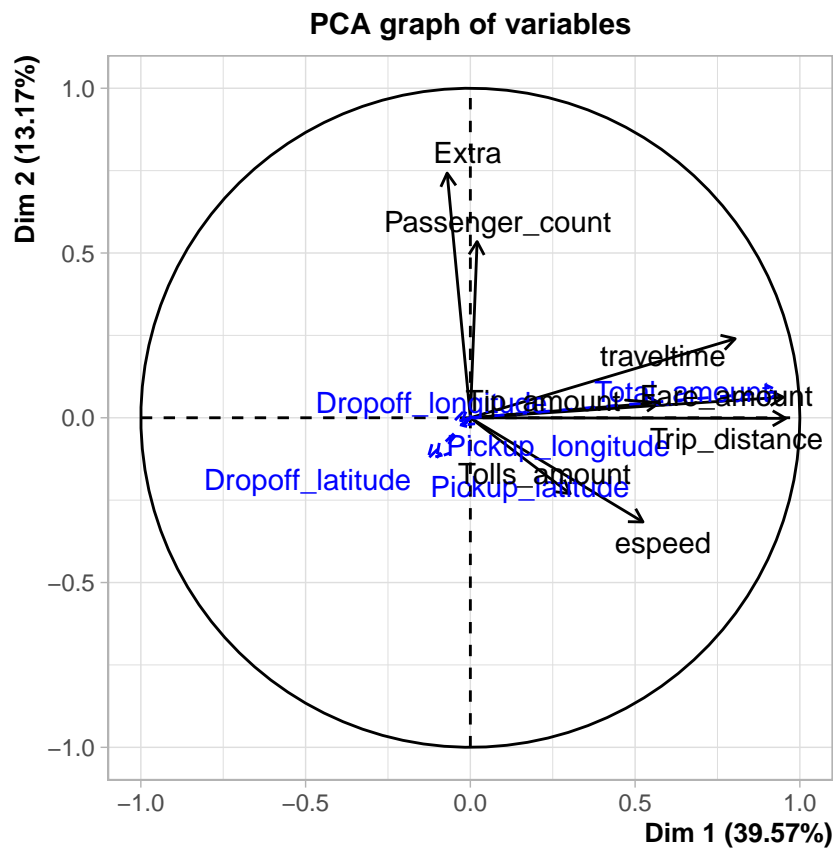
```
## [1] "VendorID"           "RateCodeID"           "Pickup_longitude"
## [4] "Pickup_latitude"    "Dropoff_longitude"     "Dropoff_latitude"
## [7] "Passenger_count"    "Trip_distance"         "Fare_amount"
## [10] "Extra"              "MTA_tax"              "Tip_amount"
## [13] "Tolls_amount"       "improvement_surcharge" "Total_amount"
## [16] "Payment_type"       "Trip_type"            "hour"
## [19] "period"             "tlenkm"               "traveltime"
## [22] "espeed"             "pickup"               "dropoff"
## [25] "Trip_distance_range" "paidTolls"            "TipIsGiven"
## [28] "passenger_groups"
```

```
vars_res<-names(df)[c(15,27)]
vars_quantitatives<-names(df)[c(3:10,12,20:22)]
vars_categorical<-names(df)[c(1,2,16:17,19,25,28)]
```

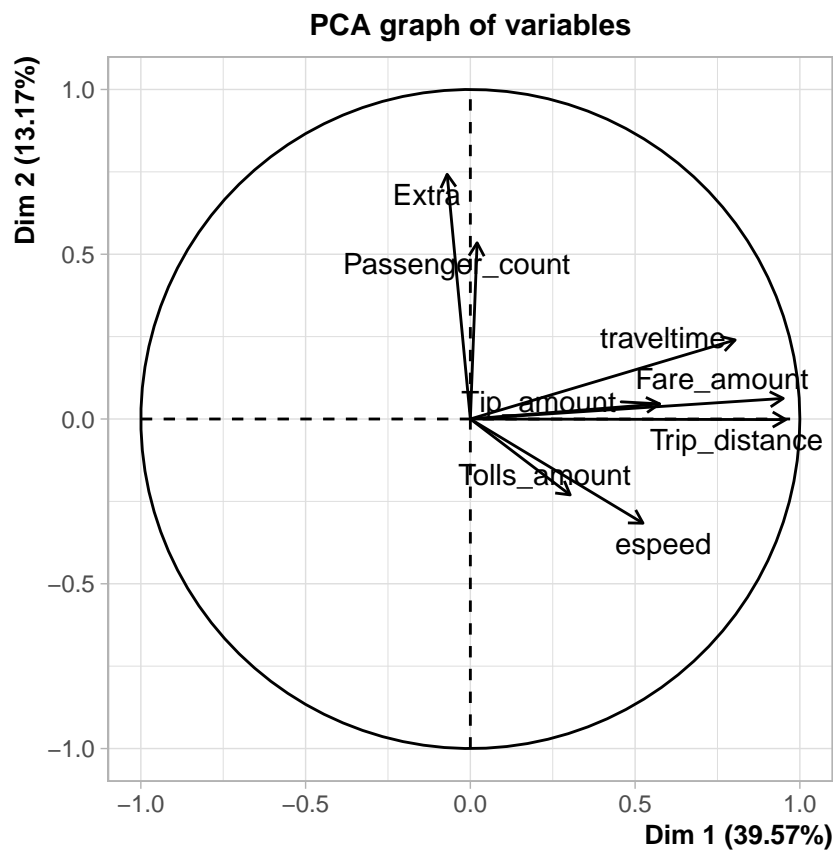
We have already seen profiling in the previous installment. So now, let's proceed to look at the main components.

```
library(FactoMineR)
res.pca <- PCA(df[,c(1:10,12,13,15:17,19,21,22,25,27)], quanti.sup=c(3:6,13), quali.sup=c(1,2,14:16,19:20))
```

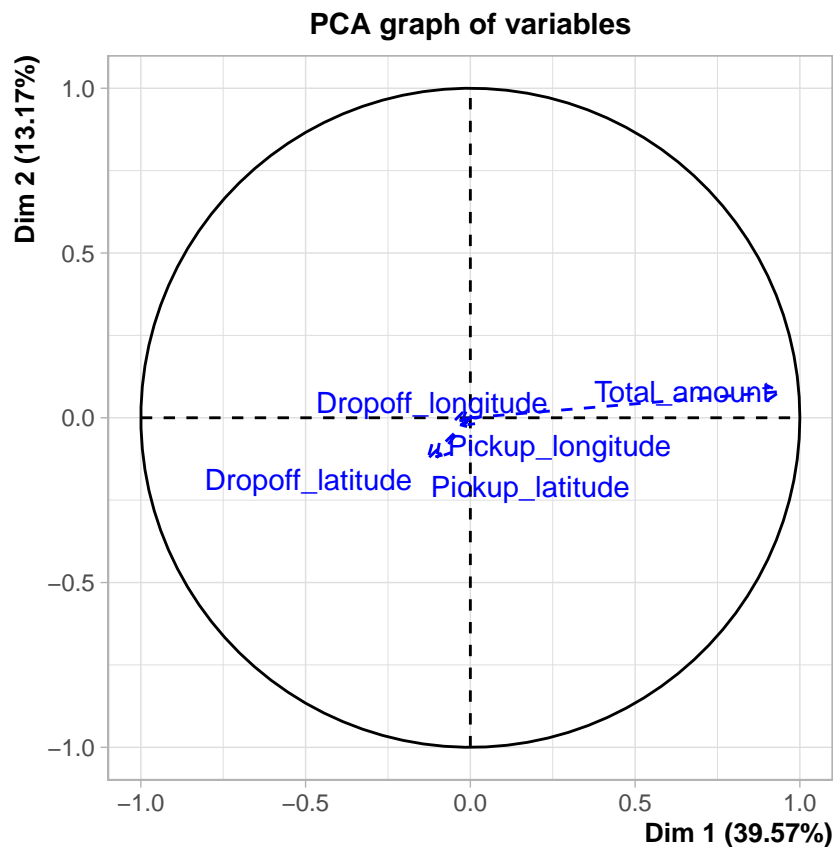




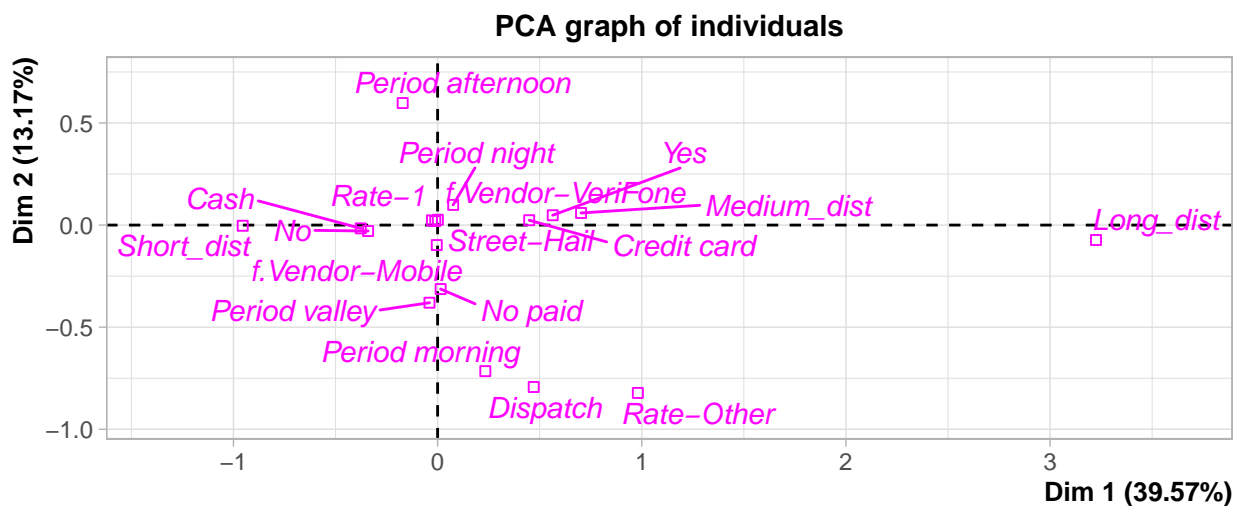
```
plot.PCA(res.pca,choix=c("var"), invisible=c("quanti.sup"))
```



```
plot.PCA(res.pca,choix=c("var"), invisible=c("var"))
```



```
plot.PCA(res.pca,choix=c("ind"), invisible=c("ind"))
```



**Multivariant outliers should be included as supplementary observations:** Since the data set we have is pretty good, we considered that we don't have multivariate outliers

## 2.1 Eigenvalues and dominant axes analysis

Eigenvalues correspond to the amount of the variation explained by each principal component (PC). Eigenvalues are large for the first PC and small for the subsequent PCs.

```
# summary(res.pca, nb.dec=2,nbind=1, nbelements = 1000, ncp=5)
```

### 2.1.1 How many axes we have to interpret according to Kaiser?

A PC with an eigenvalue  $> 1$  indicates that the PC accounts for more variance than accounted by one of the original variables in standardized data. This is commonly used as a cutoff point to determine the number of PCs to retain, using the Kaiser criteria.

```
eigenvalues <- res.pca$eig  
head(eigenvalues[, 1:3])
```

##	eigenvalue	percentage of variance	cumulative percentage of variance
## comp 1	3.1654602	39.568252	39.56825
## comp 2	1.0538386	13.172983	52.74124
## comp 3	1.0394009	12.992511	65.73375
## comp 4	0.9538540	11.923175	77.65692
## comp 5	0.8970712	11.213390	88.87031
## comp 6	0.7211678	9.014597	97.88491

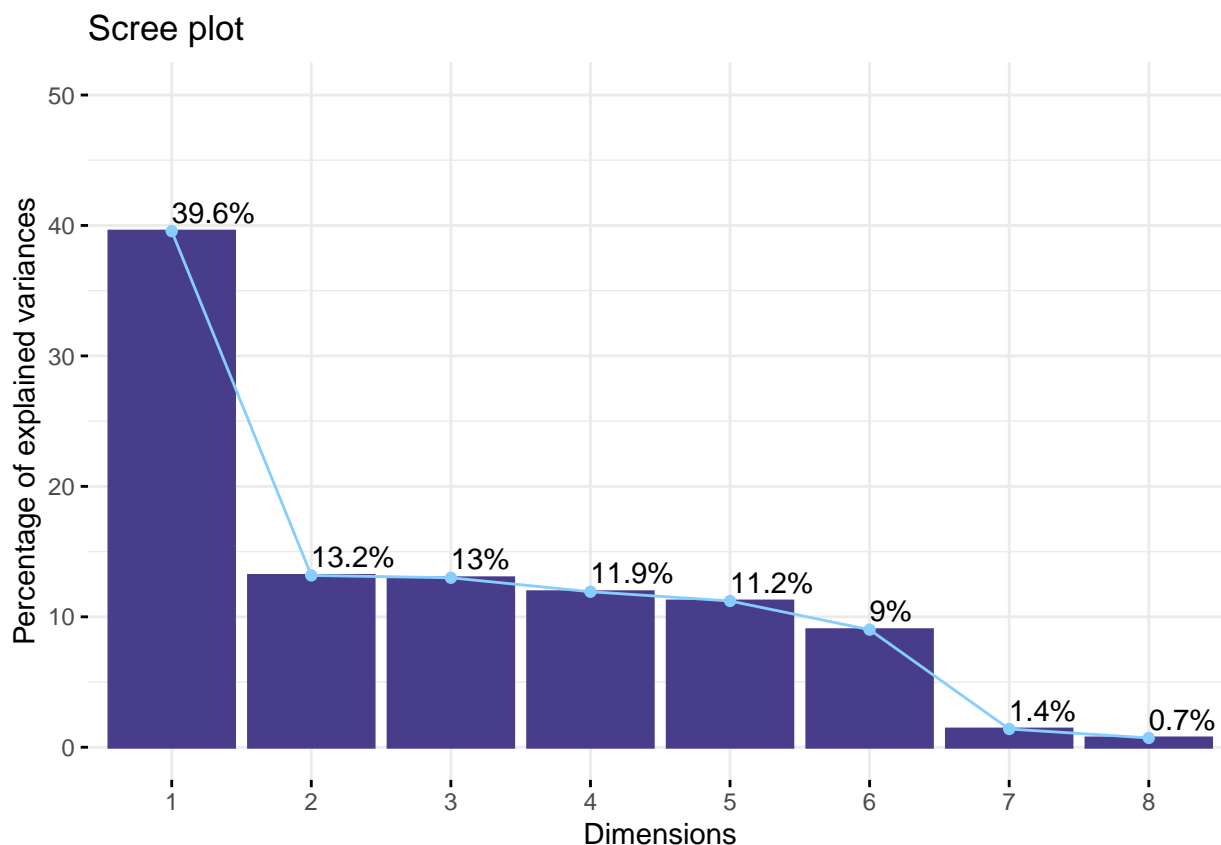
In this case, then, we will use up to dimension 3, and they will explain 65.73% of the total inertia.

### 2.1.2 How many axes we have to interpret according to Elbow's rule?

As a brief definition, we would say that the elbow rule is based on selecting dimensions until the difference in variance of that of the next factorial plane is almost the same as that of the current plane.

So let's look at exactly where we have this minimal difference:

```
fviz_screplot(  
  res.pca,  
  addlabels=TRUE,  
  ylim=c(0,50),  
  barfill="darkslateblue",  
  barcolor="darkslateblue",  
  linecolor = "skyblue1"  
)
```



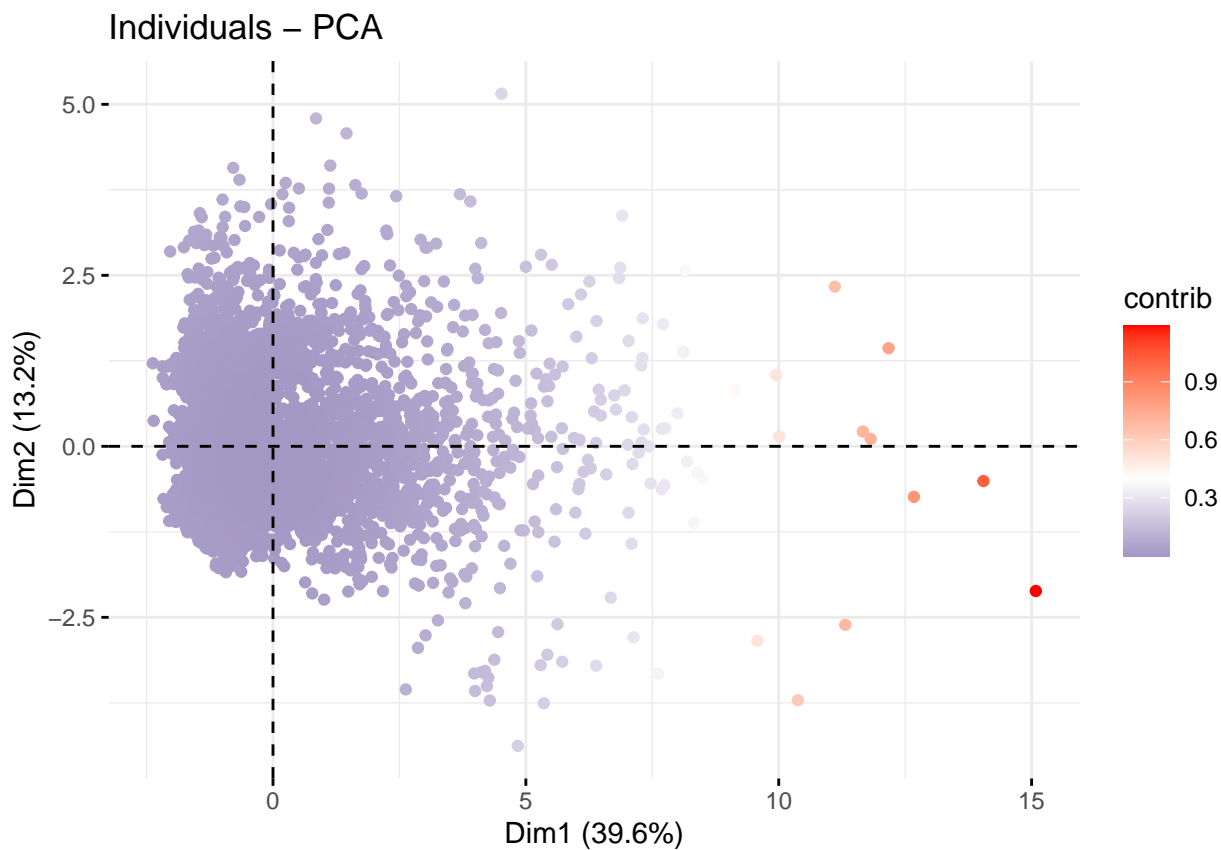
We could say, then, that there is little difference between dimension 3 and 4, or between 5 and 6. Therefore, we

could be left with 3 dimensions (as with Kasier) or 5.

## 2.2 Individuals point of view

### 2.2.1 Contribution

```
# head(res.pca$ind$contrib) # contribution of individuals to the principal components
fviz_pca_ind(res.pca, col.ind="contrib", geom = "point") +
scale_color_gradient2(low="darkslateblue", mid="white",
                      high="red", midpoint=0.40)
```

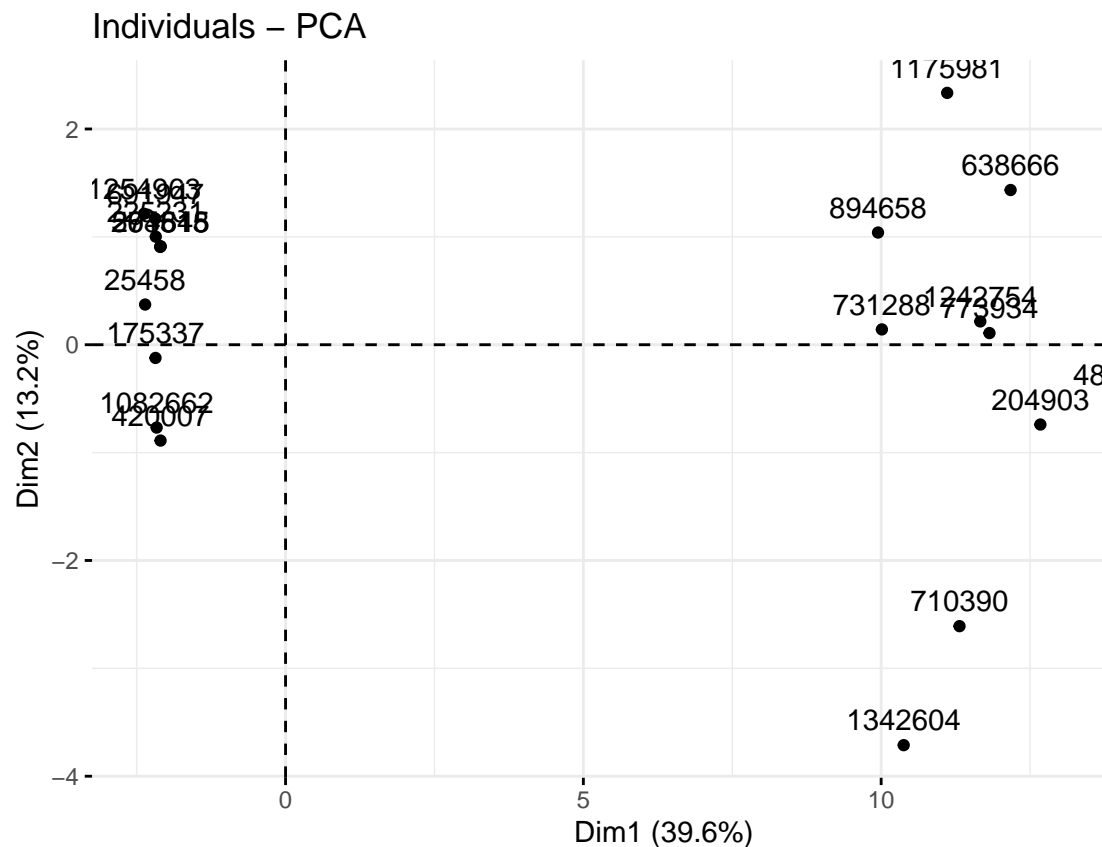


We can see that there are some individuals that are too contributive. So now, let's try to understand them better with extreme individuals.

### 2.2.2 Extreme individuals

```
rang<-order(res.pca$ind$coord[,1])
contrib.extremes<-c(row.names(df)[rang[1]], row.names(df)[rang[length(rang)]])

contrib.extremes<-c(row.names(df)[rang[1:10]], row.names(df)[rang[(length(rang)-10):length(rang)]])
fviz_pca_ind(res.pca, select.ind = list(names=contrib.extremes))
```



#### 2.2.2.1 In dimension 1:

We can now have a look at them:

```
df[which(row.names(df) %in% row.names(df)[rang[(length(rang)-10):length(rang)]), 1:28]
```

##	VendorID	RateCodeID	Pickup_longitude	Pickup_latitude			
##	204903	f.Vendor-Mobile	Rate-1	-73.98677	40.70252		
##	488540	f.Vendor-VeriFone	Rate-1	-73.91121	40.75299		
##	604912	f.Vendor-VeriFone	Rate-1	-73.81548	40.62804		
##	638666	f.Vendor-VeriFone	Rate-Other	-73.80701	40.69907		
##	710390	f.Vendor-VeriFone	Rate-1	-73.93688	40.81975		
##	731288	f.Vendor-VeriFone	Rate-1	-73.94330	40.63695		
##	773934	f.Vendor-VeriFone	Rate-1	-73.95317	40.81768		
##	894658	f.Vendor-Mobile	Rate-1	-73.94506	40.79953		
##	1175981	f.Vendor-VeriFone	Rate-1	-73.92376	40.76116		
##	1242754	f.Vendor-VeriFone	Rate-1	-73.96619	40.58548		
##	1342604	f.Vendor-Mobile	Rate-Other	-73.94370	40.81538		
##	Dropoff_longitude	Dropoff_latitude	Passenger_count	Trip_distance			
##	204903	-73.97940	40.64393	1	27.00000		
##	488540	-73.91345	40.75084	1	30.00000		
##	604912	-73.99866	40.59183	1	27.33295		
##	638666	-73.81952	40.71432	1	18.21000		
##	710390	-73.84977	40.67285	1	19.00000		
##	731288	-73.86108	40.83635	6	19.94000		
##	773934	-73.95087	40.72394	1	24.92000		
##	894658	-73.94336	40.71036	1	25.70000		
##	1175981	-73.90582	40.76783	5	27.76064		
##	1242754	-73.87349	40.77394	1	22.46000		
##	1342604	-73.94130	40.64498	1	18.30000		
##	Fare_amount	Extra	MTA_tax	Tip_amount	Tolls_amount	improvement_surcharge	
##	204903	60.00000	0.0	Yes	14.35	0.000000	Yes
##	488540	60.00000	0.0	Yes	17.00	0.000000	Yes
##	604912	60.00000	0.5	Yes	17.00	5.540000	Yes
##	638666	60.00000	1.0	Yes	17.00	3.020141	Yes
##	710390	50.50000	0.5	Yes	11.47	5.540000	Yes
##	731288	48.79243	0.0	Yes	0.00	5.540000	Yes
##	773934	60.00000	0.5	Yes	13.36	0.000000	Yes



##	894658	60.00000	1.0	Yes	0.00	0.000000	Yes
##	1175981	60.00000	0.5	Yes	0.00	0.000000	Yes
##	1242754	60.00000	0.0	Yes	12.86	0.000000	Yes
##	1342604	52.00000	0.0	Yes	6.00	5.540000	Yes
##		Total_amount	Payment_type	Trip_type	hour	period	tlenkm
##	204903	86.15	Credit card	Street-Hail	7	Period night	43.45229
##	488540	128.76	Credit card	Street-Hail	6	Period night	48.28000
##	604912	108.41	Credit card	Street-Hail	20	Period afternoon	48.28000
##	638666	111.05	Credit card	Street-Hail	16	Period valley	29.30615
##	710390	68.81	Credit card	Street-Hail	23	Period night	30.57754
##	731288	68.84	Credit card	Street-Hail	10	Period morning	32.09032
##	773934	80.16	Credit card	Street-Hail	0	Period night	40.10485
##	894658	72.80	Cash	Street-Hail	18	Period afternoon	41.36014
##	1175981	116.30	Cash	Street-Hail	23	Period night	48.28000
##	1242754	77.16	Credit card	Street-Hail	14	Period valley	36.14587
##	1342604	64.34	Credit card	Street-Hail	6	Period night	29.45100
##		traveltime	espeed	pickup	dropoff	Trip_distance_range	paidTolls
##	204903	41.71667	55.00000	07	08	Long_dist	No
##	488540	49.00000	55.00000	06	07	Short_dist	No
##	604912	43.18333	55.00000	20	21	Short_dist	Yes
##	638666	60.00000	25.41608	16	17	Long_dist	<NA>
##	710390	30.53333	55.00000	23	00	Long_dist	Yes
##	731288	60.00000	31.56425	10	11	Long_dist	Yes
##	773934	36.73333	55.00000	00	01	Long_dist	No
##	894658	46.28333	53.61776	18	19	Long_dist	No
##	1175981	60.00000	55.00000	23	00	Short_dist	No
##	1242754	57.71667	37.57584	14	15	Long_dist	No
##	1342604	30.75000	55.00000	06	06	Long_dist	Yes
##		TipIsGiven	passenger_groups				
##	204903	Yes	Single				
##	488540	Yes	Single				
##	604912	Yes	Single				
##	638666	Yes	Single				
##	710390	Yes	Single				
##	731288	No	Group				
##	773934	Yes	Single				
##	894658	No	Single				
##	1175981	No	Group				
##	1242754	Yes	Single				
##	1342604	Yes	Single				

```
df[which(row.names(df) %in% row.names(df)[rang[1:10]]),1:28]
```

##		VendorID	RateCodeID	Pickup_longitude	Pickup_latitude
##	25458	f.Vendor-VeriFone	Rate-1	-73.89600	40.85568
##	175337	f.Vendor-Mobile	Rate-1	-73.85332	40.72649
##	225231	f.Vendor-VeriFone	Rate-1	-73.94785	40.80964
##	263515	f.Vendor-VeriFone	Rate-1	-73.95492	40.82026
##	274645	f.Vendor-Mobile	Rate-1	-73.94057	40.62366
##	420007	f.Vendor-Mobile	Rate-1	-73.89059	40.74692
##	591818	f.Vendor-VeriFone	Rate-1	-73.97880	40.68356
##	691947	f.Vendor-VeriFone	Rate-1	-73.80762	40.70077
##	1082662	f.Vendor-VeriFone	Rate-1	-73.93958	40.81605
##	1254963	f.Vendor-VeriFone	Rate-1	-73.99031	40.69246
##		Dropoff_longitude	Dropoff_latitude	Passenger_count	Trip_distance
##	25458	-73.89645	40.85497	1	0.05000000
##	175337	-73.85199	40.72478	2	0.10000000
##	225231	-73.94830	40.80927	1	0.04000000
##	263515	-73.95686	40.81767	1	0.03813833
##	274645	-73.94056	40.62366	1	0.03807637
##	420007	-73.89084	40.74857	1	0.10000000
##	591818	-73.97880	40.68356	1	0.03810496
##	691947	-73.80876	40.69843	1	0.16000000
##	1082662	-73.94041	40.81475	1	0.09000000

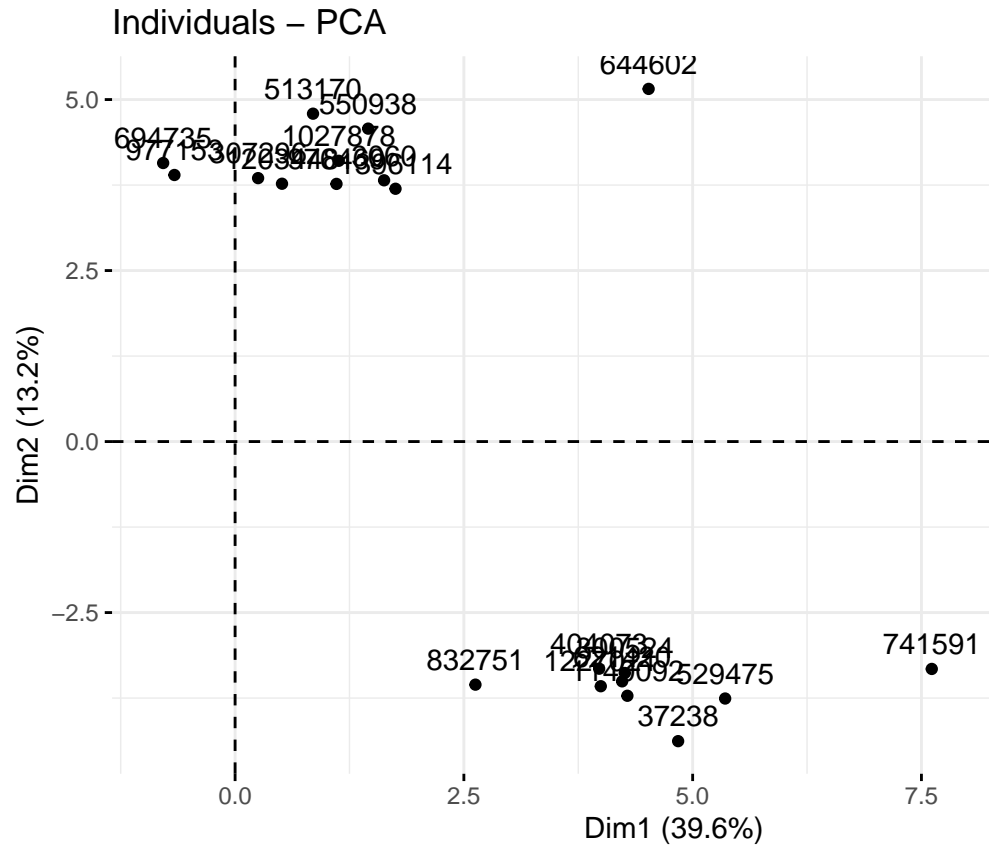
## 1254963	-73.99083	40.69273	1	0.03000000
##	Fare_amount	Extra	MTA_tax	Tip_amount
## 25458	3.0	0.5	Yes	0
## 175337	3.5	0.0	Yes	0
## 225231	2.5	1.0	Yes	0
## 263515	2.5	1.0	Yes	0
## 274645	2.5	1.0	Yes	0
## 420007	2.5	0.0	Yes	0
## 591818	2.5	1.0	Yes	0
## 691947	3.0	1.0	Yes	0
## 1082662	3.0	0.0	Yes	0
## 1254963	2.5	1.0	Yes	0
##	Total_amount	Payment_type	Trip_type	hour
## 25458	4.3	Cash	Street-Hail	4
## 175337	4.3	Cash	Street-Hail	14
## 225231	4.3	Cash	Street-Hail	17
## 263515	4.3	Cash	Street-Hail	16
## 274645	4.3	No paid	Street-Hail	19
## 420007	3.3	Cash	Street-Hail	19
## 591818	4.3	Credit card	Street-Hail	16
## 691947	4.8	Cash	Street-Hail	18
## 1082662	3.8	Cash	Street-Hail	19
## 1254963	4.3	Cash	Street-Hail	18
##	traveltime	espeed	pickup	dropoff
## 25458	1.3500000	3.576320	04	04
## 175337	2.1333333	4.526280	14	14
## 225231	0.3000000	12.874752	17	17
## 263515	0.0500000	15.398313	16	16
## 274645	0.2666667	15.382913	19	19
## 420007	0.8833333	10.931393	19	19
## 591818	0.1666667	15.390021	16	16
## 691947	1.6833333	9.178041	18	19
## 1082662	1.1166667	7.782499	19	19
## 1254963	0.4166667	6.952366	18	18
##	TipIsGiven	passenger_groups	Trip_distance_range	paidTolls
## 25458	No	Single	Short_dist	No
## 175337	No	Couple	Short_dist	No
## 225231	No	Single	Short_dist	No
## 263515	No	Single	Short_dist	No
## 274645	No	Single	Short_dist	No
## 420007	No	Single	Short_dist	No
## 591818	No	Single	Short_dist	No
## 691947	No	Single	Short_dist	No
## 1082662	No	Single	Short_dist	No
## 1254963	No	Single	Short_dist	No

```

rang<-order(res.pca$ind$coord[,2])
contrib.extremes<-c(row.names(df)[rang[1]], row.names(df)[rang[length(rang)]])

contrib.extremes<-c(row.names(df)[rang[1:10]], row.names(df)[rang[(length(rang)-10):length(rang)]])
fviz_pca_ind(res.pca, select.ind = list(names=contrib.extremes))

```



#### 2.2.2.2 In dimension 2:

We can now have a look at them:

```
df[which(row.names(df) %in% row.names(df)[rang[(length(rang)-10):length(rang)]), 1:28]
```

##	VendorID	RateCodeID	Pickup_longitude	Pickup_latitude		
## 3060	f.Vendor-VeriFone	Rate-1	-73.86355	40.73727		
## 307296	f.Vendor-VeriFone	Rate-1	-73.95361	40.78796		
## 513170	f.Vendor-VeriFone	Rate-1	-73.91908	40.75881		
## 550938	f.Vendor-VeriFone	Rate-1	-73.93481	40.74301		
## 644602	f.Vendor-VeriFone	Rate-1	-73.92159	40.76666		
## 694735	f.Vendor-VeriFone	Rate-1	-73.98262	40.66566		
## 976469	f.Vendor-VeriFone	Rate-1	-73.96669	40.80442		
## 977153	f.Vendor-VeriFone	Rate-1	-73.89025	40.74623		
## 1027878	f.Vendor-VeriFone	Rate-1	-73.96809	40.63953		
## 1203448	f.Vendor-VeriFone	Rate-1	-73.97668	40.68291		
## 1396114	f.Vendor-VeriFone	Rate-1	-73.96153	40.71631		
##	Dropoff_longitude	Dropoff_latitude	Passenger_count	Trip_distance		
## 3060	-73.91945	40.74348	5	3.05		
## 307296	-73.96581	40.76854	5	1.68		
## 513170	-73.90479	40.77545	5	1.47		
## 550938	-73.96293	40.75823	6	2.87		
## 644602	-73.98792	40.73801	6	6.26		
## 694735	-73.97092	40.67282	6	0.97		
## 976469	-73.96804	40.76556	5	3.45		
## 977153	-73.92136	40.75252	6	1.81		
## 1027878	-73.98267	40.67964	6	3.58		
## 1203448	-73.93872	40.69656	5	3.11		
## 1396114	-73.98534	40.72356	6	2.49		
##	Fare_amount	Extra	MTA_tax	Tip_amount	Tolls_amount	improvement_surcharge
## 3060	14.0	0.5	Yes	0.00	0	Yes
## 307296	14.0	1.0	Yes	3.16	0	Yes
## 513170	8.0	1.0	Yes	0.00	0	Yes
## 550938	19.0	1.0	Yes	4.16	0	Yes
## 644602	32.5	1.0	Yes	6.86	0	Yes
## 694735	9.0	1.0	Yes	2.16	0	Yes
## 976469	18.0	1.0	Yes	2.50	0	Yes

##	977153	10.5	1.0	Yes	0.00	0	Yes
##	1027878	16.0	1.0	Yes	3.56	0	Yes
##	1203448	17.0	1.0	Yes	0.00	0	Yes
##	1396114	19.0	0.5	Yes	6.09	0	Yes
##		Total_amount	Payment_type	Trip_type	hour	period	tlenkm
##	3060	15.30	Cash	Street-Hail	0	Period night	4.908499
##	307296	18.96	Credit card	Street-Hail	16	Period valley	2.703698
##	513170	9.80	Cash	Street-Hail	18	Period afternoon	2.365736
##	550938	24.96	Credit card	Street-Hail	17	Period afternoon	4.618817
##	644602	41.16	Credit card	Street-Hail	18	Period afternoon	10.074493
##	694735	12.96	Credit card	Street-Hail	19	Period afternoon	1.561064
##	976469	22.30	Credit card	Street-Hail	16	Period valley	5.552237
##	977153	12.30	Cash	Street-Hail	17	Period afternoon	2.912913
##	1027878	21.36	Credit card	Street-Hail	16	Period valley	5.761452
##	1203448	18.80	Credit card	Street-Hail	17	Period afternoon	5.005060
##	1396114	26.39	Credit card	Street-Hail	0	Period night	4.007267
##		traveltime	espeed	pickup	dropoff	Trip_distance_range	paidTolls
##	3060	60.00000	3.864960	00	01	Medium_dist	No
##	307296	21.35000	7.598214	16	16	Short_dist	No
##	513170	60.00000	3.000000	18	18	Short_dist	No
##	550938	30.50000	9.086198	17	17	Medium_dist	No
##	644602	52.20000	11.579878	18	19	Long_dist	No
##	694735	12.08333	7.751489	19	19	Short_dist	No
##	976469	25.50000	13.064087	16	17	Medium_dist	No
##	977153	13.81667	12.649560	17	18	Short_dist	No
##	1027878	21.98333	15.724962	16	16	Medium_dist	No
##	1203448	26.13333	11.491209	17	18	Medium_dist	No
##	1396114	31.03333	7.747669	00	00	Short_dist	No
##		TipIsGiven	passenger_groups				
##	3060	No	Group				
##	307296	Yes	Group				
##	513170	No	Group				
##	550938	Yes	Group				
##	644602	Yes	Group				
##	694735	Yes	Group				
##	976469	Yes	Group				
##	977153	No	Group				
##	1027878	Yes	Group				
##	1203448	No	Group				
##	1396114	Yes	Group				

```
df[which(row.names(df) %in% row.names(df)[rang[1:10]]),1:28]
```

##		VendorID	RateCodeID	Pickup_longitude	Pickup_latitude
##	37238	f.Vendor-VeriFone	Rate-1	-73.94037	40.79722
##	300524	f.Vendor-VeriFone	Rate-1	-73.95204	40.79805
##	404073	f.Vendor-VeriFone	Rate-1	-73.92345	40.80943
##	529475	f.Vendor-VeriFone	Rate-1	-73.95724	40.81275
##	621420	f.Vendor-VeriFone	Rate-1	-73.93903	40.81678
##	741591	f.Vendor-VeriFone	Rate-1	-73.89080	40.74696
##	832751	f.Vendor-VeriFone	Rate-1	-73.98846	40.67025
##	1140092	f.Vendor-Mobile	Rate-1	-73.91059	40.76953
##	1227021	f.Vendor-VeriFone	Rate-1	-73.89172	40.74702
##	1342604	f.Vendor-Mobile	Rate-Other	-73.94370	40.81538
##		Dropoff_longitude	Dropoff_latitude	Passenger_count	Trip_distance
##	37238	-73.87116	40.77416	1	6.29
##	300524	-73.87309	40.77436	2	7.44
##	404073	-73.87628	40.76842	1	6.70
##	529475	-73.86170	40.76838	1	7.85
##	621420	-73.87211	40.77211	1	7.33
##	741591	-74.01478	40.71557	1	11.47
##	832751	-74.01384	40.71449	1	3.66
##	1140092	-73.86433	40.84798	1	7.50
##	1227021	-73.91472	40.80377	1	6.62

## 1342604	-73.94130	40.64498	1	18.30		
##	Fare_amount	Extra	MTA_tax	Tip_amount	Tolls_amount	improvement_surcharge
## 37238	19.0	0.0	Yes	5.07	5.54	Yes
## 300524	22.5	0.0	Yes	0.00	5.54	Yes
## 404073	23.5	0.0	Yes	0.00	5.54	Yes
## 529475	24.0	0.0	Yes	5.00	5.54	Yes
## 621420	24.0	0.0	Yes	0.00	5.54	Yes
## 741591	34.0	0.0	Yes	8.07	5.54	Yes
## 832751	13.5	0.0	Yes	2.00	5.54	Yes
## 1140092	23.5	0.0	Yes	0.00	5.54	Yes
## 1227021	19.5	0.5	Yes	0.00	5.54	Yes
## 1342604	52.0	0.0	Yes	6.00	5.54	Yes
##	Total_amount	Payment_type	Trip_type	hour	period	tlenkm
## 37238	30.41	Credit card	Street-Hail	9	Period morning	10.122774
## 300524	28.84	Credit card	Street-Hail	13	Period valley	11.973519
## 404073	29.84	Credit card	Street-Hail	14	Period valley	10.782605
## 529475	35.34	Credit card	Street-Hail	6	Period night	12.633350
## 621420	30.34	Cash	Street-Hail	8	Period morning	11.796492
## 741591	48.41	Credit card	Street-Hail	15	Period valley	18.459176
## 832751	21.84	Credit card	Street-Hail	9	Period morning	5.890199
## 1140092	29.84	Cash	Street-Hail	8	Period morning	12.070080
## 1227021	26.34	Cash	Street-Hail	5	Period night	10.653857
## 1342604	64.34	Credit card	Street-Hail	6	Period night	29.450995
##	traveltime	espeed	pickup	dropoff	Trip_distance_range	paidTolls
## 37238	11.30000	53.74924	09	09	Long_dist	Yes
## 300524	17.48333	41.09120	13	13	Long_dist	Yes
## 404073	22.56667	28.66867	14	14	Long_dist	Yes
## 529475	18.20000	41.64841	06	07	Long_dist	Yes
## 621420	21.33333	33.17763	08	09	Long_dist	Yes
## 741591	27.78333	39.86385	15	15	Long_dist	Yes
## 832751	12.60000	28.04857	09	09	Medium_dist	Yes
## 1140092	19.23333	37.65363	08	09	Long_dist	Yes
## 1227021	10.46667	55.00000	05	05	Long_dist	Yes
## 1342604	30.75000	55.00000	06	06	Long_dist	Yes
##	TipIsGiven	passenger_groups				
## 37238	Yes	Single				
## 300524	No	Couple				
## 404073	No	Single				
## 529475	Yes	Single				
## 621420	No	Single				
## 741591	Yes	Single				
## 832751	Yes	Single				
## 1140092	No	Single				
## 1227021	No	Single				
## 1342604	Yes	Single				

### 2.2.3 Detection of multivariant outliers and influent data.

Since we've commented before that we don't consider multivariate outliers, no action should be taken here.

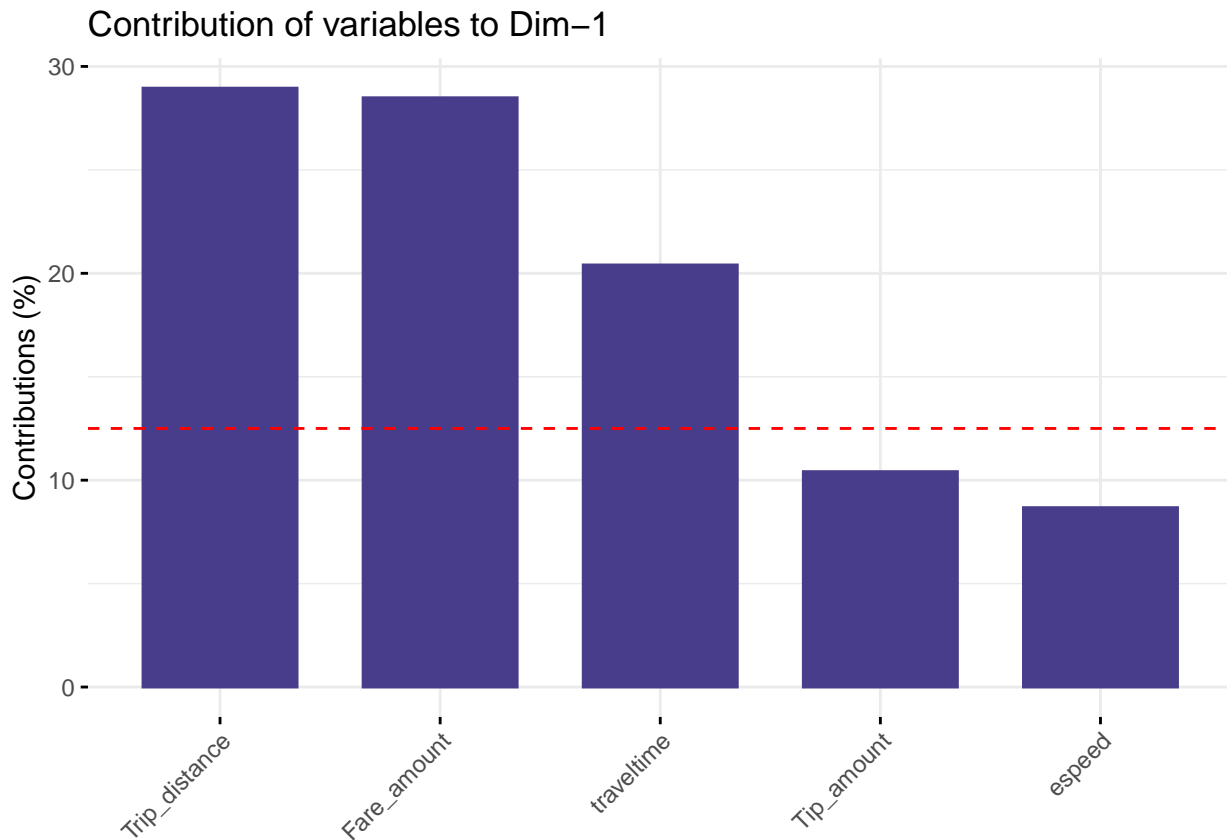
## 2.3 Interpreting the axes: Variables point of view coordinates, quality of representation, contribution of the variables

```
res.des <- dimdesc(res.pca)
```

### 2.3.1 First dimension

```
fviz_contrib( # contributions of variables to PC1
  res.pca,
  fill = "darkslateblue",
  color = "darkslateblue",
  choice = "var",
```

```
axes = 1,
top = 5)
```



```
res.des$Dim.1
```

```
## $quanti
##               correlation      p.value
## Trip_distance    0.95730706 0.000000e+00
## Fare_amount      0.94960484 0.000000e+00
## Total_amount     0.93942001 0.000000e+00
## traveltime       0.80368337 0.000000e+00
## Tip_amount       0.57415837 0.000000e+00
## espeed           0.52394674 0.000000e+00
## Tolls_amount     0.30300105 9.013310e-99
## Pickup_longitude -0.03125024 3.360908e-02
## Dropoff_longitude -0.05426961 2.227979e-04
## Extra            -0.07041780 1.646768e-06
## Pickup_latitude  -0.10228377 3.148028e-12
## Dropoff_latitude -0.12894697 1.345881e-18
##
## $quali
##               R2      p.value
## Trip_distance_range 0.691017128 0.000000e+00
## TipIsGiven          0.060653567 7.774385e-65
## Payment_type        0.053034123 2.149327e-55
## RateCodeID          0.008583339 2.769847e-10
## period              0.005169311 2.569159e-05
## Trip_type           0.001738152 4.580306e-03
##
## $category
##               Estimate      p.value
## Trip_distance_range=Long_dist 2.23397417 0.000000e+00
## TipIsGiven=Yes                0.45216207 7.774385e-65
## Payment_type=Credit card     0.41968655 2.271313e-56
## RateCodeID=Rate-Other        0.50422625 2.769847e-10
## period=Period morning        0.20884328 1.137211e-03
```

```
## Trip_type=Dispatch          0.24121859 4.580306e-03
## period=Period night        0.05154686 3.047979e-02
## Trip_type=Street-Hail      -0.24121859 4.580306e-03
## period=Period afternoon    -0.19586260 1.290974e-04
## RateCodeID=Rate-1          -0.50422625 2.769847e-10
## Trip_distance_range=Medium_dist -0.28824012 2.452911e-45
## Payment_type=Cash          -0.40559005 2.694846e-56
## TipIsGiven=No              -0.45216207 7.774385e-65
## Trip_distance_range=Short_dist -1.94573405 0.000000e+00
##
## attr(,"class")
## [1] "condes" "list"
```

In the first dimension we see that for the **quantitative** variables the most positively related, from more to less, are:

- Trip\_distance (0.95)
- Fare\_amount (0.94)
- Total\_amount (0.93)
- traveltime (0.80)

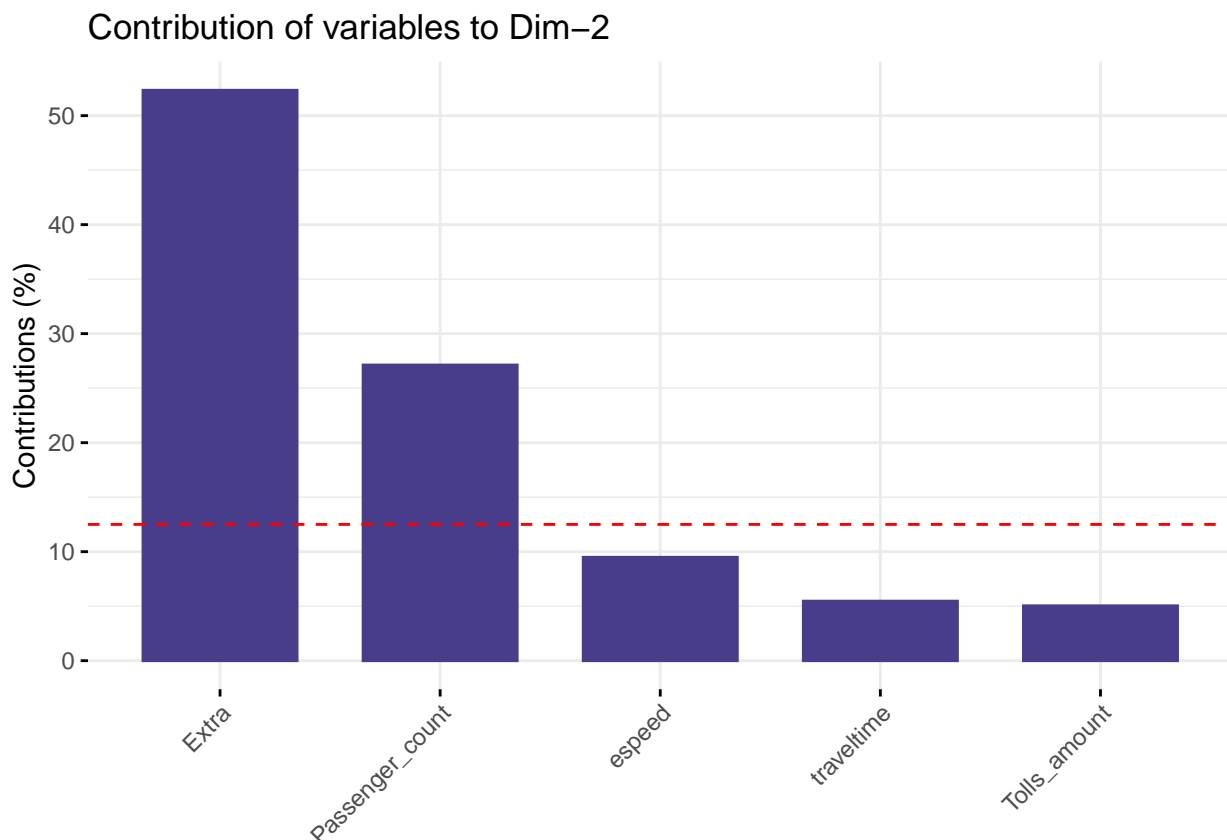
If we take look at the **qualitatives** ones, we that the most related is

- Trip\_distance\_range (0.69)

Finally, if we take a look at the **categories** we see that for the Trip\_distance\_range category long distance trips show a mean 2.23 units over the global mean and short distance ones show a mean -1.94 units under the global mean, so we can reject the H0 done in the t.Student test.

### 2.3.2 Second dimension

```
fviz_contrib( # contributions of variables to PC1
  res.pca,
  fill = "darkslateblue",
  color = "darkslateblue",
  choice = "var",
  axes = 2,
  top = 5)
```





```
res.des$Dim.2
```

```
## $quanti
##               correlation      p.value
## Extra          0.74258866 0.000000e+00
## Passenger_count 0.53463310 0.000000e+00
## traveltime      0.23990250 1.615918e-61
## Total_amount    0.07947291 6.278874e-08
## Fare_amount     0.06251197 2.105822e-05
## Tip_amount      0.04580469 1.838358e-03
## Pickup_latitude -0.12147081 1.155632e-16
## Dropoff_latitude -0.12411309 2.469588e-17
## Tolls_amount    -0.23032359 1.024002e-56
## espeed          -0.31615982 7.834681e-108
##
## $quali
##               R2      p.value
## period          0.184068800 2.143099e-203
## RateCodeID      0.018119629 3.862505e-20
## Trip_type       0.014819256 9.922508e-17
## VendorID        0.002425023 8.098907e-04
## TipIsGiven      0.001332968 1.304433e-02
## Trip_distance_range 0.001446882 3.527015e-02
##
## $category
##               Estimate      p.value
## period=Period afternoon 0.69741738 6.273330e-126
## RateCodeID=Rate-1      0.42270813 3.862505e-20
## Trip_type=Street-Hail  0.40639535 9.922508e-17
## period=Period night    0.19868760 1.141234e-06
## VendorID=f.Vendor-VeriFone 0.06200633 8.098907e-04
## TipIsGiven=Yes         0.03867626 1.304433e-02
## Trip_distance_range=Medium_dist 0.06499883 4.081973e-02
## Trip_distance_range=Long_dist -0.06734957 4.739997e-02
## TipIsGiven=No          -0.03867626 1.304433e-02
## VendorID=f.Vendor-Mobile -0.06200633 8.098907e-04
## Trip_type=Dispatch     -0.40639535 9.922508e-17
## RateCodeID=Rate-Other  -0.42270813 3.862505e-20
## period=Period valley   -0.28051232 5.465420e-55
## period=Period morning  -0.61559267 5.765919e-69
##
## attr(,"class")
## [1] "condes" "list"
```

For the second dimension we see that or the **quantitative** variables Extra and Passenger\_count are the most positively related ones with 0.74 and 0.53 respectively.

If we see the **qualitative** variables we notice that period is the most related with 0.18 even though it is not a very remarkable data.

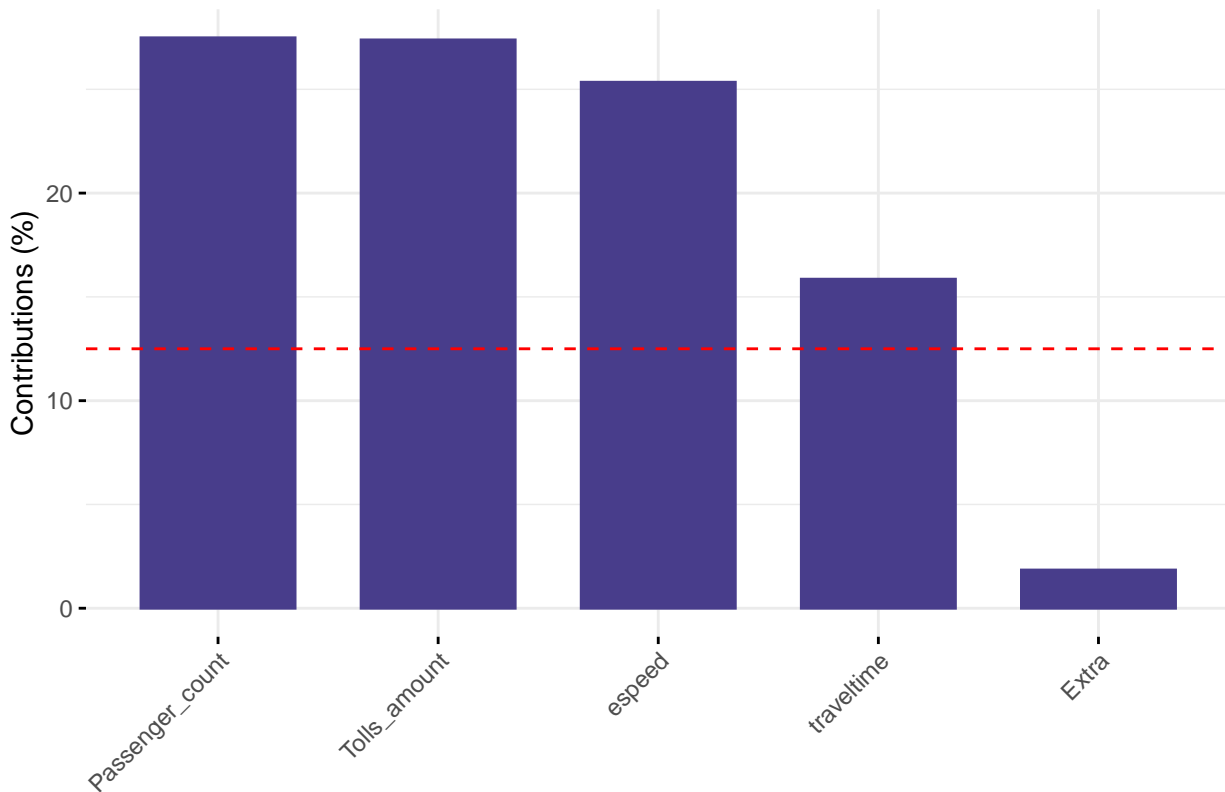
And we see that for this **category**, period afternoon mean is 0.69 units over the global mean and period morning mean, on the contrary, is -0.61 units under the global mean, so we can reject the H0 done in the t.Student test.

### 2.3.3 Third dimension

```
fviz_contrib( # contributions of variables to PC1
  res.pca,
  fill = "darkslateblue",
  color = "darkslateblue",
  choice = "var",
  axes = 3,
  top = 5)
```



### Contribution of variables to Dim-3



```
res.des$Dim.3
```

```
## $ quanti
##               correlation      p.value
## Passenger_count  0.53445793 0.000000e+00
## Tolls_amount     0.53348146 0.000000e+00
## espeed           0.51322530 3.958881e-309
## Extra            0.13832221 3.460374e-21
## Dropoff_longitude 0.08626112 4.241523e-09
## Pickup_longitude  0.07649050 1.919027e-07
## Tip_amount        0.05620014 1.317391e-04
## Dropoff_latitude  0.04007164 6.431426e-03
## Pickup_latitude    0.03744970 1.088064e-02
## Total_amount      -0.06349286 1.558600e-05
## Fare_amount       -0.13644926 1.178290e-20
## traveltime        -0.40591753 6.233710e-183
##
## $ quali
##               R2      p.value
## period         0.035886226 2.283135e-36
## Trip_distance_range 0.007909240 1.080799e-08
## TipIsGiven       0.004524510 4.707055e-06
## Payment_type      0.003949701 1.070864e-04
## VendorID         0.001086215 2.503325e-02
##
## $ category
##               Estimate      p.value
## period=Period night  0.282886526 4.247490e-30
## TipIsGiven=Yes        0.070766034 4.707055e-06
## Payment_type=Credit card 0.121518708 2.298510e-05
## Trip_distance_range=Short_dist 0.064024746 1.353427e-04
## VendorID=f.Vendor-VeriFone 0.041213596 2.503325e-02
## VendorID=f.Vendor-Mobile -0.041213596 2.503325e-02
## Payment_type=Cash      -0.004578138 4.465703e-05
## TipIsGiven=No         -0.070766034 4.707055e-06
## Trip_distance_range=Medium_dist -0.152026208 1.617657e-09
```

```
## period=Period morning          -0.205703946 2.492716e-10
## period=Period valley          -0.144508011 4.079781e-16
##
## attr(,"class")
## [1] "condes" "list "
```

For the last dimension we took into account, the third one, we see that the most related **quantitative** variables are:

- Passenger\_count (0.53)
- Tolls\_amount (0.53)
- espeed (0.51),

For the inversely related one, we also see that traveltime time (-0.40).

For the **quantitatives**, we see that period is the category that is more related with 0.36, even though it is not a big relation.

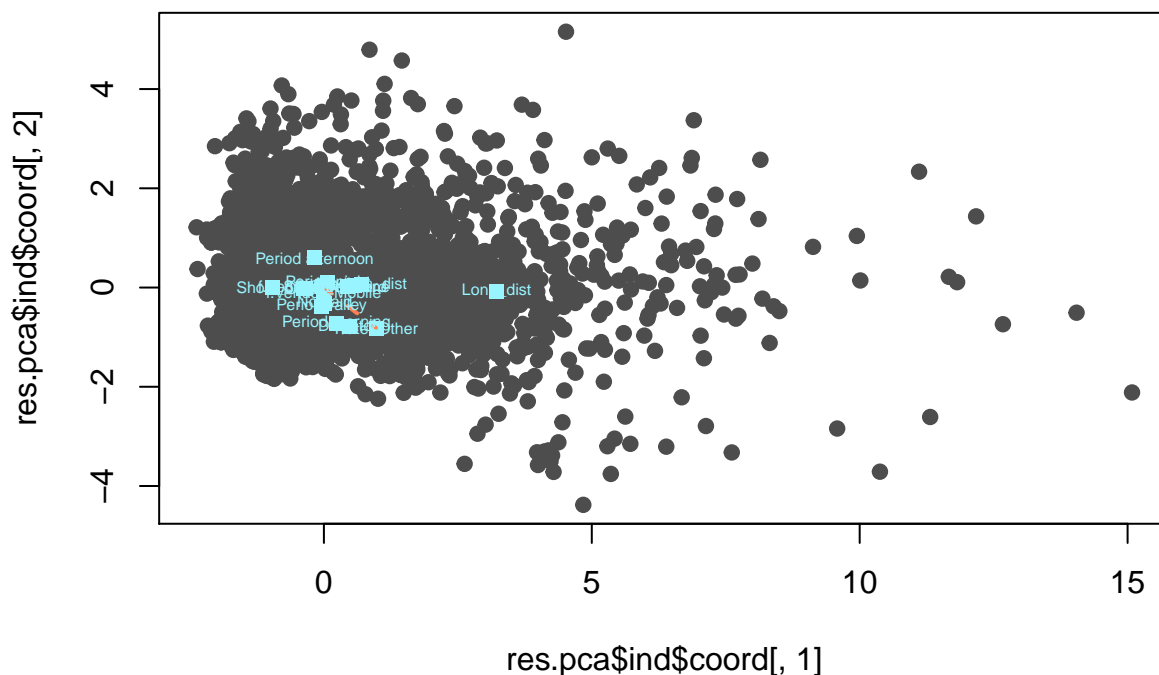
And we see that for this **category**, period afternoon mean is 0.28 units over the global mean and period valley mean, on the contrary, is -0.14 units under the global mean, hough it is not either a big relation.

We can conclude, then, that the first dimension is the one with the biggest correlations.

## 2.4 Perform a PCA taking into account also supplementary variables the supplementary variables can be quantitative and/or categorical

We want to take analyze the supplementary factor **kind of rate**, so we want to add lines that join the categories of this factor for the first factorial plane. With the following plot we can see it.

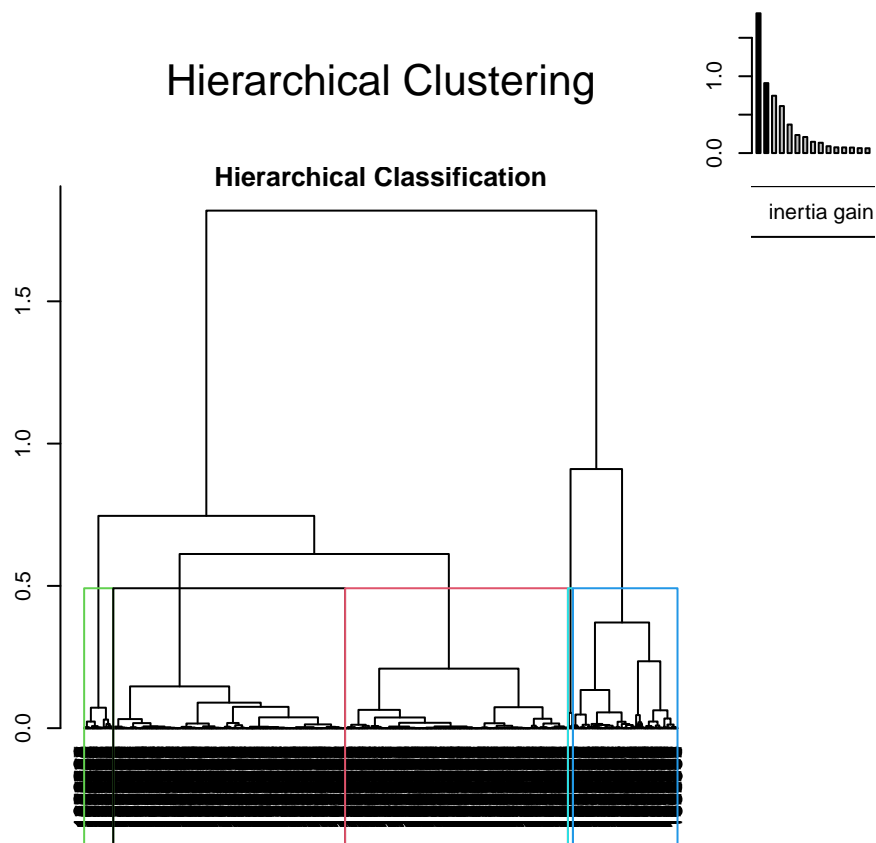
```
plot(res.pca$ind$coord[,1],res.pca$ind$coord[,2],pch=19,col="grey30") #draw all the individuals in grey
points(res.pca$quali.sup$coord[,1],res.pca$quali.sup$coord[,2],pch=15,col="cadetblue1") # points associ
lines(res.pca$quali.sup$coord[3:4,1],res.pca$quali.sup$coord[3:4,2],lwd=2,lty=2,col="coral") # draw a l
text(res.pca$quali.sup$coord[,1],res.pca$quali.sup$coord[,2],labels=names(res.pca$quali.sup$coord[,1]),c
```



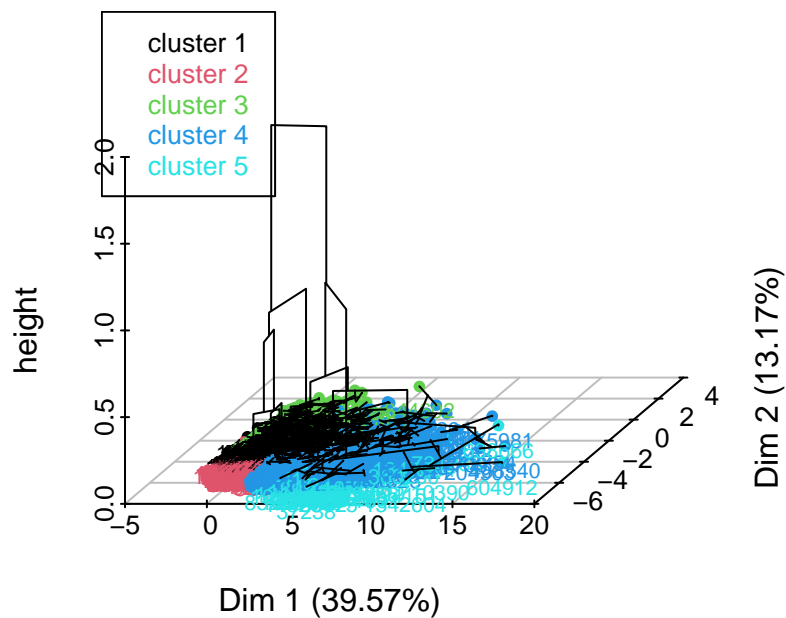
```
# res.pca$quali.sup$coord
```

### 3 Hierarchical Clustering

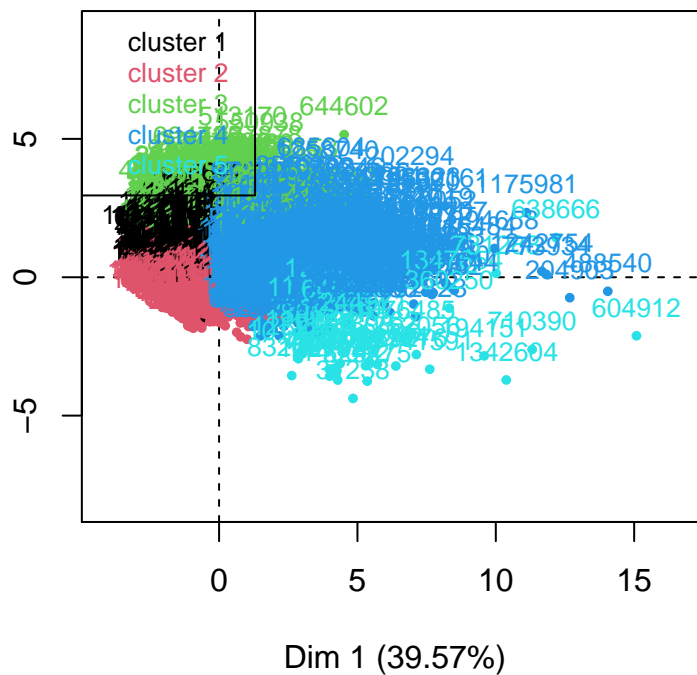
```
res.hcpc <- HCPC(res.pca,nb.clust = 5, order = TRUE)
```



#### Hierarchical clustering on the factor map



## Factor map



*Note:* If we chose the default number of cluster it would be 3, as we can guess from the inertia reduction plot, that follows the Elbow's rule (number of black lines plus 1). In our case, due to the amount of data we have, the reason why we chose 5 as the number of clusters is because, after trying different numbers, we thought it was the best way to distribute the data.

### 3.1 Description of clusters

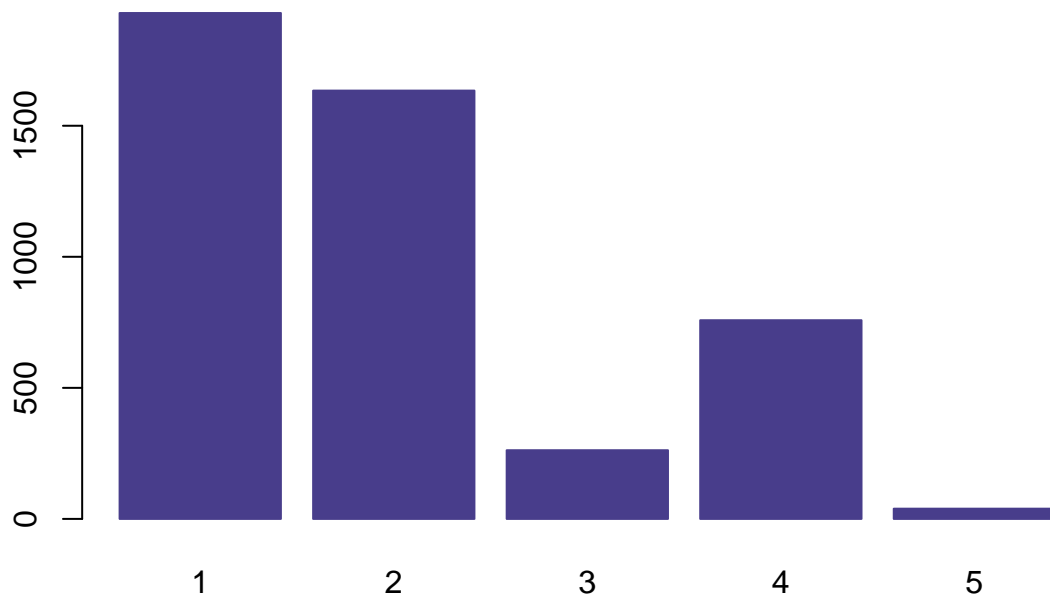
Number of observations in each cluster:

```
table(res.hcpc$data.clust$clust)
```

```
##
##   1   2   3   4   5
## 1930 1634 262 758 39
```

```
barplot(table(res.hcpc$data.clust$clust), col="darkslateblue", border="darkslateblue", main="[hierarchic
```

## [hierarchical] #observations/cluster



## 3.2 Interpret the results of the classification

### 3.2.1 The description of the clusters by the variables

```
names(res.hcpc$desc.var)
```

```
## [1] "test.chi2" "category" "quanti.var" "quanti" "call"
```

```
res.hcpc$desc.var$test.chi2 # categorical variables which characterizes the clusters
```

```
##                p.value df
## period          0.000000e+00 12
## Trip_distance_range 0.000000e+00 8
## TipIsGiven        4.279197e-36 4
## Payment_type      1.274689e-28 8
## RateCodeID        4.483773e-23 4
## Trip_type         1.609776e-21 4
## VendorID         2.096463e-08 4
```

We start with the description of the categorical variables that characterize the clusters, so in this output we do not have dimensions because it is the total association. We can see the intensity of the variables, in our case the variables that affect more to the clustering are **period** and **Trip\_distance\_range** because they are the ones with the smallest p-value. The variables associated to the clusters are the ones that appear on the output.

Next, we want to see for each cluster which are the categories that characterize them. The clusters that contain more individuals are the first, the second and the fourth one. Cluster number 4 has less individuals. We proceed to analyze them.

```
res.hcpc$desc.var$category # description of each cluster by the categories
```

```
## $`1`
##                Cla/Mod      Mod/Cla      Global      p.value
## period=Period night      64.0682095  54.50777202 35.518062 7.770495e-116
## Trip_distance_range=Short_dist 50.7065949  78.08290155 64.287259 1.280121e-63
## period=Period afternoon  60.8142494  37.15025907 25.502920 6.952752e-53
## RateCodeID=Rate-1        42.9048043  99.94818653 97.252866 4.277657e-29
## Trip_type=Street-Hail    42.7843050 100.00000000 97.577331 1.936966e-27
## Payment_type=Cash        44.0128154  56.94300518 54.012546 7.116030e-04
```

```

## TipIsGiven=No 43.6502429 65.18134715 62.340472 7.289207e-04
## Payment_type=Credit card 39.0744275 42.43523316 45.338525 7.859632e-04
## TipIsGiven=Yes 38.5985066 34.81865285 37.659528 7.289207e-04
## Trip_type=Dispatch 0.0000000 0.00000000 2.422669 1.936966e-27
## RateCodeID=Rate-Other 0.7874016 0.05181347 2.747134 4.277657e-29
## period=Period morning 0.7380074 0.20725389 11.723989 1.260284e-129
## period=Period valley 12.4603175 8.13471503 27.255029 2.922636e-150
## Trip_distance_range=Long_dist 0.4511278 0.15544041 14.384599 2.585616e-166
## v.test
## period=Period night 22.877574
## Trip_distance_range=Short_dist 16.838228
## period=Period afternoon 15.306182
## RateCodeID=Rate-1 11.195750
## Trip_type=Street-Hail 10.852664
## Payment_type=Cash 3.385069
## TipIsGiven=No 3.378464
## Payment_type=Credit card -3.357691
## TipIsGiven=Yes -3.378464
## Trip_type=Dispatch -10.852664
## RateCodeID=Rate-Other -11.195750
## period=Period morning -24.223432
## period=Period valley -26.108457
## Trip_distance_range=Long_dist -27.485937
##
## $`2`
## Cla/Mod Mod/Cla Global p.value
## period=Period valley 66.587302 51.346389 27.255029 7.063369e-159
## period=Period morning 74.723247 24.785802 11.723989 1.245802e-88
## Trip_distance_range=Short_dist 42.698520 77.662179 64.287259 1.943824e-46
## Trip_type=Dispatch 73.214286 5.018360 2.422669 1.854170e-16
## RateCodeID=Rate-Other 66.141732 5.140759 2.747134 1.024771e-12
## TipIsGiven=No 38.965996 68.727050 62.340472 2.645583e-11
## Payment_type=Cash 39.006808 59.608323 54.012546 1.570437e-08
## Payment_type=Credit card 30.963740 39.718482 45.338525 1.300378e-08
## TipIsGiven=Yes 29.350948 31.272950 37.659528 2.645583e-11
## RateCodeID=Rate-1 34.475089 94.859241 97.252866 1.024771e-12
## Trip_type=Street-Hail 34.404788 94.981640 97.577331 1.854170e-16
## period=Period afternoon 18.999152 13.708690 25.502920 5.030711e-45
## Trip_distance_range=Long_dist 3.157895 1.285190 14.384599 1.831233e-103
## period=Period night 10.109622 10.159119 35.518062 2.015359e-175
## v.test
## period=Period valley 26.856598
## period=Period morning 19.959245
## Trip_distance_range=Short_dist 14.308236
## Trip_type=Dispatch 8.231155
## RateCodeID=Rate-Other 7.127138
## TipIsGiven=No 6.665059
## Payment_type=Cash 5.653685
## Payment_type=Credit card -5.686015
## TipIsGiven=Yes -6.665059
## RateCodeID=Rate-1 -7.127138
## Trip_type=Street-Hail -8.231155
## period=Period afternoon -14.080144
## Trip_distance_range=Long_dist -21.599106
## period=Period night -28.237702
##
## $`3`
## Cla/Mod Mod/Cla Global p.value v.test
## VendorID=f.Vendor-VeriFone 6.767123 94.2748092 78.953061 1.557606e-12 7.069261
## period=Period night 6.942753 43.5114504 35.518062 6.033525e-03 2.745954
## RateCodeID=Rate-1 5.782918 99.2366412 97.252866 2.625621e-02 2.222401
## RateCodeID=Rate-Other 1.574803 0.7633588 2.747134 2.625621e-02 -2.222401
## period=Period valley 4.365079 20.9923664 27.255029 1.697607e-02 -2.387226
## period=Period morning 2.767528 5.7251908 11.723989 8.241798e-04 -3.344544

```

```

## VendorID=f.Vendor-Mobile    1.541624    5.7251908    21.046939    1.557606e-12    -7.069261
##
## $`4`
##
## Cla/Mod    Mod/Cla    Global    p.value
## Trip_distance_range=Long_dist    87.5187970    76.781003    14.384599    0.000000e+00
## TipIsGiven=Yes    24.6984492    56.728232    37.659528    2.002989e-31
## Payment_type=Credit card    22.8530534    63.192612    45.338525    3.776109e-27
## RateCodeID=Rate-Other    28.3464567    4.749340    2.747134    6.121937e-04
## period=Period night    18.2095006    39.445910    35.518062    1.401893e-02
## Trip_type=Dispatch    25.0000000    3.693931    2.422669    1.829357e-02
## period=Period morning    19.7416974    14.116095    11.723989    2.804593e-02
## VendorID=f.Vendor-Mobile    18.4994861    23.746702    21.046939    4.833228e-02
## VendorID=f.Vendor-VeriFone    15.8356164    76.253298    78.953061    4.833228e-02
## Trip_type=Street-Hail    16.1826646    96.306069    97.577331    1.829357e-02
## RateCodeID=Rate-1    16.0587189    95.250660    97.252866    6.121937e-04
## period=Period afternoon    12.9770992    20.184697    25.502920    1.834710e-04
## Payment_type=Cash    10.8930717    35.883905    54.012546    5.912321e-28
## TipIsGiven=No    11.3809854    43.271768    62.340472    2.002989e-31
## Trip_distance_range=Short_dist    0.4710633    1.846966    64.287259    0.000000e+00
##
## v.test
## Trip_distance_range=Long_dist    Inf
## TipIsGiven=Yes    11.661577
## Payment_type=Credit card    10.791491
## RateCodeID=Rate-Other    3.426154
## period=Period night    2.456778
## Trip_type=Dispatch    2.359622
## period=Period morning    2.196643
## VendorID=f.Vendor-Mobile    1.974435
## VendorID=f.Vendor-VeriFone    -1.974435
## Trip_type=Street-Hail    -2.359622
## RateCodeID=Rate-1    -3.426154
## period=Period afternoon    -3.740751
## Payment_type=Cash    -10.960574
## TipIsGiven=No    -11.661577
## Trip_distance_range=Short_dist    -Inf
##
## $`5`
##
## Cla/Mod    Mod/Cla    Global    p.value
## Trip_distance_range=Long_dist    4.51127820    76.923077    14.384599    1.878553e-18
## Payment_type=Credit card    1.52671756    82.051282    45.338525    2.937287e-06
## TipIsGiven=Yes    1.60827111    71.794872    37.659528    1.783365e-05
## period=Period morning    2.02952030    28.205128    11.723989    5.186239e-03
## RateCodeID=Rate-Other    3.14960630    10.256410    2.747134    2.519752e-02
## RateCodeID=Rate-1    0.77846975    89.743590    97.252866    2.519752e-02
## TipIsGiven=No    0.38167939    28.205128    62.340472    1.783365e-05
## Payment_type=Cash    0.28033640    17.948718    54.012546    4.309549e-06
## Trip_distance_range=Short_dist    0.03364738    2.564103    64.287259    2.003816e-16
##
## v.test
## Trip_distance_range=Long_dist    8.764351
## Payment_type=Credit card    4.675157
## TipIsGiven=Yes    4.290419
## period=Period morning    2.795233
## RateCodeID=Rate-Other    2.238361
## RateCodeID=Rate-1    -2.238361
## TipIsGiven=No    -4.290419
## Payment_type=Cash    -4.595866
## Trip_distance_range=Short_dist    -8.221854

```

## Cluster 1

The first thing we can notice from this cluster is that **Trip\_type=Street-Hail** that intervenes in the 97.58% from the sample, in this cluster is the 100% of the observations, which means that all the observations in this cluster have this type of trip. We have 42.78% from the Trip\_type=Street-Hail observations in this cluster. As we can see and expect, from the other trip\_type that we have in this cluster is that **Trip\_type=Dispatch** that intervenes in the 2.42% from the sample, in this cluster is not represented, we get 0% of the observations.

Then, we can notice is the kind of rate. We can see that **RateCodeID=Rate-1**, the one that represents the standard rate, and means the 97.25% of our sample, in this cluster is the 99.95% of the observations, almost every observation from this cluster is a standard rate trip. In this cluster we have 42.90% of the observations from this category. In the other hand, we have the kind of rate, that contains the other options, represents the 2.75% of our sample, in this cluster is the 0.05% of the observations. In this cluster, we have the 0.79% of the observations from this category.

## Cluster 2

The first thing we can notice from this cluster is that **RateCodeID=Rate-1** (standard rate) and **Trip\_type=Street-Hail** are the most represented in the cluster. We have 94.98% of the observations in the cluster that represent street-hail trips, and we also have 94.86% of the observations in the cluster that represent the standard rate trips. We have 74.72% of the morning period trips of the observations in the sample represented in this cluster, 73.21% of the dispatch type trips of the observations in the sample represented in this cluster, 66.59% of the valley period trips of the observations in the sample represented in this cluster, we also have the 66.14% of the other kind of rates f the observations in the sample represented in this cluster. In the other hand, we only have 3.16% of the long distance trips in the sample represented in this cluster and this category only means the 1.29% of the observations in the cluster of this category. We have 10.11% of the night period trips in the sample represented in this cluster and we have almost 19% of the afternoon period trips in the sample represented in this cluster.

## Cluster 3

The first thing we can notice from this cluster is that almost every observation is from standard rate kind. We can see that 99.24% of the observations in the cluster are **RateCodeID=Rate-1**, and the cluster contains the 5.78% of the observations in the sample of this kind. The rest of observations in the cluster are from **RateCodeID=Rate-Other** kind. The next thing we can notice from this cluster is that, also, almost every observation is from Verifone kind of vendor. We have the 94.27% of the observations in this cluster of **VendorID=f.Vendor-VeriFone** category. This categories represents the 78.95% from our sample, and the cluster contains the 6.77% of observations of this kind. For the other kind of vendor, **VendorID=f.Vendor-Mobile**, that represents the 21.05% of our sample, we have that in this cluster, 5.73% of the observations are from this vendor, and the cluster contains 1.54% of observations of this kind. If we take a look at the period categories, we see that **period=Period night** represents 43.51% of the observations in the cluster, and we have the 6.94% of the observations of this kind from the sample. In this cluster the night period is over represented because this kind of period represents the 35.52% of observations from our sample. For the **period=Period valley**, we have 20.99% of the observations in the cluster of this kind of period. We have in this cluster 4.37% of the observations of this kind from our sample. The last kind of period that we have in this cluster is the moring one, that represents the 5.73% of the observations in the cluster and we have 2.77% of the observations from the sample of this kind in this cluster.

## Cluster 4

In this cluster, we can see that the category more represented is **Trip\_type=Street-Hail** with 96.31% of the observations in the cluster. We get 16.18% of the observations of this kind from the sample in the cluster. Another category that is very represented is the standard rate, **RateCodeID=Rate-1**, with 95.25% of the observations in the cluster. From the sample, we get in this cluster, 16.06% of the observations of this kind. We can notice that we have 87.52% of long distance trip observations from the sample in this cluster. We can see that this category is over represented in this cluster because this category represents the 14.38% of the sample, and 76.78% of the observations in the cluster are of this category. In the other hand, we can see that short distance trips that represents 1.85% of the observations in the cluster and we only got 0.47% of the observations of this kind from the sample.

## Cluster 5

This cluster is the smallest one, we only have 39 observations from the sample. We can see in this cluster is that the **RateCodeID=Rate-1** represents the 89.75% of the observations in this cluster. In this cluster we only have 0.78% of the observations from the sample of this kind. The rest 10.25% are the **RateCodeID=Rate-Other** observtions in the cluster. In this case, we have a 3.15% of the observations from the sample of this kind in this cluster. Then we have that 82.05% of the observations in the cluster that paid credit card, and we got 1.53% of the observations from sample sample of this kind this cluster. The other 17.95% of the observations in the cluster paid in cash, and we got less representation from the sample in this cluster for this category, we only got 0.28% of the observations from the sample.

We now proceed to see the quantitatives variables that characterizes the clusters.

```
res.hcpc$desc.var$quanti.var # quantitative variables which characterizes the clusters
```

##	Eta2	P-value
## Passenger_count	0.781083003	0.000000e+00
## Trip_distance	0.578106343	0.000000e+00



```
## Fare_amount      0.575439601  0.000000e+00
## Extra            0.632538094  0.000000e+00
## Tolls_amount     0.981954788  0.000000e+00
## Total_amount     0.539522699  0.000000e+00
## traveltime       0.419905351  0.000000e+00
## espeed           0.205381252  1.391829e-228
## Tip_amount       0.202596695  4.421382e-225
## Dropoff_latitude 0.018549311  7.346910e-18
## Pickup_latitude  0.016472560  8.618675e-16
## Dropoff_longitude 0.009820162  3.006725e-09
## Pickup_longitude 0.004646807  2.504182e-04
```

We can see in the output that all the variables that appear are slightly over represented in the clusters. We can notice that the greatest represented is the Total\_amount with 0.98 units over the global mean, we can also remark the Passenger\_count with 0.78 units over the mean and the Extra variable with 0.63 units over the mean. The least over represented are the Pickup\_longitude with 0.004 units over the mean, the Dropoff\_longitude with 0.01 units over the mean, the Pickup\_latitude with 0.016 units over the mean and the Dropoff\_latitude with 0.02 units over the total mean.

We want to know now which variables are associated with the quantitative variables.

```
res.hcpc$desc.var$quanti      # description of each cluster by the quantitative variables
```

```
## $`1`
##               v.test Mean in category Overall mean sd in category
## Extra          48.725143      0.6626943   0.35226044   0.23425993
## Dropoff_longitude  5.981195     -73.9299781 -73.93460830   0.04395684
## Pickup_longitude   3.321671     -73.9325877 -73.93496823   0.04237046
## Dropoff_latitude  -4.282820     40.7409033  40.74500568   0.05287830
## Pickup_latitude   -4.735737     40.7422169  40.74676502   0.05237977
## Tolls_amount      -5.433312      0.0000000   0.04769564   0.00000000
## espeed            -8.810257     19.0031003  20.33575305   6.29787224
## Tip_amount        -10.443222     0.6893179   1.02203842   1.08615941
## Passenger_count    -12.789408     1.1409326   1.37107208   0.41827819
## Total_amount      -18.789110     10.6471503  13.92640493   4.50875619
## traveltime        -19.049278     9.1670035  12.48732425   5.94179824
## Trip_distance     -20.757190     1.7205850   2.72449524   1.03949364
## Fare_amount       -22.244878     8.4204663  11.61104706   3.53352131
##               Overall sd      p.value
## Extra          0.36668354  0.000000e+00
## Dropoff_longitude 0.04455396  2.215059e-09
## Pickup_longitude  0.04124656  8.948012e-04
## Dropoff_latitude  0.05512875  1.845399e-05
## Pickup_latitude   0.05527371  2.182601e-06
## Tolls_amount      0.50523041  5.531755e-08
## espeed            8.70570362  1.248593e-18
## Tip_amount        1.83366715  1.573775e-25
## Passenger_count    1.03565723  1.878993e-37
## Total_amount      10.04487145  9.272116e-79
## traveltime        10.03175633  6.661465e-81
## Trip_distance      2.78356770  1.055625e-95
## Fare_amount       8.25496368  1.264366e-109
##
## $`2`
##               v.test Mean in category Overall mean sd in category
## Dropoff_latitude   8.827382     40.7546869  40.74500568   0.05701522
## Pickup_latitude    8.406078     40.7560085  40.74676502   0.05684751
## Dropoff_longitude  -2.581594    -73.9368965 -73.93460830   0.04060069
## Tolls_amount       -4.745339      0.0000000   0.04769564   0.00000000
## Tip_amount        -11.980225     0.5850122   1.02203842   0.99664574
## Passenger_count    -12.679469     1.1098324   1.37107208   0.37470104
## espeed            -13.935697     17.9222129  20.33575305   6.35570993
## traveltime        -14.229130     9.6475928  12.48732425   6.01107875
## Fare_amount       -16.360397     8.9242741  11.61104706   4.11025949
## Trip_distance     -17.849175     1.7360744   2.72449524   1.07373082
```

```

## Total_amount      -18.266469      10.2761689  13.92640493      4.94499736
## Extra              -48.289253       0.0000000   0.35226044      0.00000000
##
## Overall sd      p.value
## Dropoff_latitude  0.05512875  1.071545e-18
## Pickup_latitude   0.05527371  4.239492e-17
## Dropoff_longitude 0.04455396  9.834518e-03
## Tolls_amount      0.50523041  2.081575e-06
## Tip_amount        1.83366715  4.510961e-33
## Passenger_count    1.03565723  7.685081e-37
## espeed            8.70570362  3.844308e-44
## traveltime        10.03175633  6.042928e-46
## Fare_amount        8.25496368  3.667285e-60
## Trip_distance      2.78356770  2.933368e-71
## Total_amount      10.04487145  1.530386e-74
## Extra              0.36668354  0.000000e+00
##
## $`3`
##
## v.test Mean in category Overall mean sd in category
## Passenger_count 59.986235      5.0992366  1.3710721  0.6863440
## Extra           3.765260      0.4351145  0.3522604  0.3543457
## Total_amount   -2.537392     12.3968702  13.9264049  6.8282336
## Fare_amount    -2.616552     10.3148473  11.6110471  6.3920807
## Trip_distance  -2.945418      2.2324828  2.7244952  1.8662661
##
## Overall sd      p.value
## Passenger_count 1.0356572 0.0000000000
## Extra           0.3666835 0.0001663758
## Total_amount   10.0448715 0.0111681899
## Fare_amount     8.2549637 0.0088822891
## Trip_distance   2.7835677 0.0032251885
##
## $`4`
##
## v.test Mean in category Overall mean sd in category
## Trip_distance   49.106302      7.26458247  2.72449524  3.47580089
## Fare_amount     49.067121     25.06441195  11.61104706  9.24177619
## Total_amount    45.821920     29.21412929  13.92640493  11.86369386
## traveltime      42.874587     26.77304310  12.48732425  12.32002615
## espeed          28.378179     28.54141415  20.33575305  12.17319710
## Tip_amount      27.211285      2.67931398  1.02203842  3.09282254
## Tolls_amount    -2.295339      0.00917784  0.04769564  0.14117624
## Pickup_longitude -3.443125    -73.93968523 -73.93496823  0.04283372
## Pickup_latitude  -4.158084     40.73913128  40.74676502  0.05714529
## Passenger_count  -4.305896      1.22295515  1.37107208  0.65713115
## Extra           -4.496790      0.29749340  0.35226044  0.33420886
## Dropoff_longitude -4.799514    -73.94171076 -73.93460830  0.05184553
## Dropoff_latitude -5.180004     40.73552077  40.74500568  0.05408675
##
## Overall sd      p.value
## Trip_distance   2.78356770 0.000000e+00
## Fare_amount      8.25496368 0.000000e+00
## Total_amount    10.04487145 0.000000e+00
## traveltime      10.03175633 0.000000e+00
## espeed          8.70570362 3.759899e-177
## Tip_amount      1.83366715 4.775939e-163
## Tolls_amount     0.50523041 2.171371e-02
## Pickup_longitude 0.04124656 5.750332e-04
## Pickup_latitude  0.05527371 3.209275e-05
## Passenger_count  1.03565723 1.663115e-05
## Extra            0.36668354 6.898701e-06
## Dropoff_longitude 0.04455396 1.590515e-06
## Dropoff_latitude 0.05512875 2.218809e-07
##
## $`5`
##
## v.test Mean in category Overall mean sd in category
## Tolls_amount    67.367546      5.475388  0.04769564  0.39829372
## Total_amount    17.705432     42.287692  13.92640493  20.69332947

```

```
## Trip_distance      13.871930          8.882127   2.72449524    5.24509423
## Fare_amount        13.439098          29.302370  11.61104706   13.01003029
## Tip_amount         12.655167           4.722564   1.02203842    4.52414418
## espeed             10.141705          34.415339  20.33575305   11.95705914
## traveltime         7.719334           24.836325  12.48732425   11.22620743
## Pickup_longitude   1.961840          -73.922064 -73.93496823   0.04269607
##
## Overall sd      p.value
## Tolls_amount    0.50523041 0.000000e+00
## Total_amount    10.04487145 3.807483e-70
## Trip_distance   2.78356770 9.372098e-44
## Fare_amount     8.25496368 3.567598e-41
## Tip_amount      1.83366715 1.047523e-36
## espeed          8.70570362 3.607463e-24
## traveltime      10.03175633 1.169396e-14
## Pickup_longitude 0.04124656 4.978116e-02
```

### Cluster 1

For this cluster, we can see that the **traveltime** is around 3 units under the overall mean, the **Fare\_amount** as well and the **Total\_amount** too. We can also see that the **Trip\_distance** is 1 unit under the overall mean and the **espeed** as well. We see that the only variable that is over the overall mean is the variable **Extra** with less than 0.3 units over it.

### Cluster 2

For the second cluster, happens something similar as with the first one. We see that the **Total\_amount** is around 3.7 units under the overall mean, **espeed** around 2 units under as well, **Tip\_amount** around 0.5 under the overall mean too, **traveltime** and **Fare\_amount** around 3 units under the overall mean as well, **Trip\_distance** around 1 unit under the mean. In this clusters the only variables ver the overall mean are **Dropoff\_latitude** and **Pickup\_latitude** but they are not remarkable since the increase is super light.

### Cluster 3

In this cluster we can see that the most remarkable variable is **Passenger\_count** with almost 4 units over the overall mean, then we also have **Total\_amount** with 0.1 units over the meant. In the other hand, we have **Total\_amount** and **Fare\_amount** with around 1 unit under the overall mean. **Trip\_distance** is around 0.5 units under the overall mean.

### Cluster 4

In this cluster we can see clearly the most remarkable vairables. We have 5 variables cleary over the overall mean. These are: **Total\_amount** with 26 units over the mean, **Fare\_amount** and **traveltime** with 14 units over the mean, **espeed** with 8 units over the mean and **Trip\_distance** with 5 units over the overall mean.

### Cluster 5

In this cluster every variable is over the overall mean. Every variable except **Pickup\_longitude** are remarkably over the overall mean. Firstly, we have the **Total\_amount** around 30 units over, then we have **Fare\_amount** 18 units over, **espeed** 14 units over, **traveltime** 12 units over, **Trip\_distance** 6 units over, **Tolls\_amount** 5 units over and **Tip\_amount** 3.7 units over the overall mean.

## 3.2.2 The description of the clusters by the individuals

```
res.hcpc$desc.ind$para # representative individuals of each cluster
```

```
## Cluster: 1
##      697423      442213      365332      655407      945065
## 0.4551377 0.4585094 0.4624702 0.4675288 0.4733316
## -----
## Cluster: 2
##      665209      677545      343231      743541      473945
## 0.1500605 0.1502214 0.1520744 0.1533864 0.1668652
## -----
## Cluster: 3
##      952205      21675      1090746      607516      1397283
## 0.2651094 0.3722646 0.5401477 0.5498816 0.5620526
## -----
## Cluster: 4
##      1040597      1272173      10891      1445033      693126
```

```
## 0.5534480 0.6419473 0.6769121 0.7137618 0.7296941
## -----
## Cluster: 5
## 1261276 1016299 327762 1010826 529475
## 1.151077 1.224596 1.305726 1.472585 1.482492
```

What we obtain are the more representative individuals, paragons, for each cluster. We get the rownames of each paragon in every single cluster.

```
res.hcpc$desc.ind$dist # individuals distant from each cluster
```

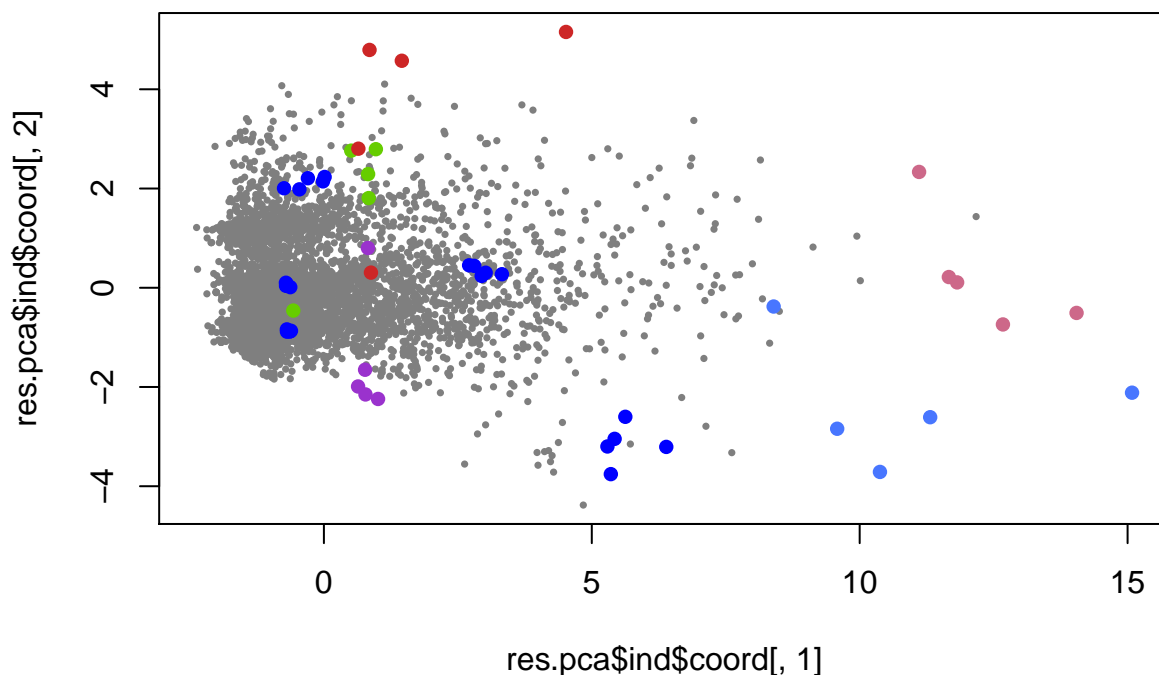
```
## Cluster: 1
## 886530 642379 71268 1393691 560933
## 4.878069 4.760057 4.577272 4.506090 4.465229
## -----
## Cluster: 2
## 36606 533937 535041 829742 1418974
## 4.641497 4.283722 4.264553 4.177470 3.770009
## -----
## Cluster: 3
## 169380 644602 513170 550938 871576
## 6.214858 6.161465 5.875364 5.669044 5.651629
## -----
## Cluster: 4
## 488540 204903 773934 1242754 1175981
## 13.32453 12.61924 12.27617 12.27616 11.95419
## -----
## Cluster: 5
## 604912 710390 194151 1347654 1342604
## 15.93179 13.33560 12.81720 12.39681 12.21009
```

What we obtain are those individuals of each cluster that that far away in the same cluster from the rest of the individuals. We also obtain the rownames of each individual with the bigger distance respect the other ones in the cluster.

**3.2.2.1 Examine the values of individuals that characterize classes** We get the graphical representation for the individuals that characterize classes (para and dist).

```
# characteristic individuals
para1<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$para[[1]]))
dist1<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$dist[[1]]))
para2<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$para[[2]]))
dist2<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$dist[[2]]))
para3<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$para[[3]]))
dist3<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$dist[[3]]))
para4<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$para[[4]]))
dist4<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$dist[[4]]))
para5<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$para[[5]]))
dist5<-which(rownames(res.pca$ind$coord)%in%names(res.hcpc$desc.ind$dist[[5]]))

plot(res.pca$ind$coord[,1],res.pca$ind$coord[,2],col="grey50",cex=0.5,pch=16)
points(res.pca$ind$coord[para1,1],res.pca$ind$coord[para1,2],col="blue",cex=1,pch=16)
points(res.pca$ind$coord[dist1,1],res.pca$ind$coord[dist1,2],col="chartreuse3",cex=1,pch=16)
points(res.pca$ind$coord[para2,1],res.pca$ind$coord[para2,2],col="blue",cex=1,pch=16)
points(res.pca$ind$coord[dist2,1],res.pca$ind$coord[dist2,2],col="darkorchid3",cex=1,pch=16)
points(res.pca$ind$coord[para3,1],res.pca$ind$coord[para3,2],col="blue",cex=1,pch=16)
points(res.pca$ind$coord[dist3,1],res.pca$ind$coord[dist3,2],col="firebrick3",cex=1,pch=16)
points(res.pca$ind$coord[para4,1],res.pca$ind$coord[para4,2],col="blue",cex=1,pch=16)
points(res.pca$ind$coord[dist4,1],res.pca$ind$coord[dist4,2],col="palevioletred3",cex=1,pch=16)
points(res.pca$ind$coord[para5,1],res.pca$ind$coord[para5,2],col="blue",cex=1,pch=16)
points(res.pca$ind$coord[dist5,1],res.pca$ind$coord[dist5,2],col="royalblue1",cex=1,pch=16)
```



### 3.2.3 Partition quality

We are going to evaluate the partition quality.

```
#res.hcpc$call$t$within[1] = Total sum of squares
#(res.hcpc$call$t$within[1]-res.hcpc$call$t$within[5] = between sum of squares
((res.hcpc$call$t$within[1]-res.hcpc$call$t$within[5])/res.hcpc$call$t$within[1])*100
```

#### 3.2.3.1 Gain in inertia (in %)

```
## [1] 57.49171
```

The quality of this reduction is of 57.49%.

In case we wanted to achieve an 80% of the clustering representativity we would need 18 clusters.

```
((res.hcpc$call$t$within[1]-res.hcpc$call$t$within[18])/res.hcpc$call$t$within[1])*100
```

```
## [1] 80.59951
```

### 3.2.4 Save the results into dataframe

```
res.hcpc$call$t$inert.gain[1:5]
```

```
## [1] 1.8187697 0.9105858 0.7460223 0.6120673 0.3712993
```

```
df$hcpc<-res.hcpc$data.clust$clust
```

## 4 K-Means Classification

### 4.1 Description of clusters

```
res.pca <- PCA(df[,c(1:10,12,13,15:17,19,21,22,25,27)],quanti.sup=c(3:6,13),quali.sup=c(1,2,14:16,19:20))
ppcc<-res.pca$ind$coord[,1:3] # 3 components principals (kaiser)
dim(ppcc)
```

```
## [1] 4623    3
```

#### 4.1.1 Optimal number of clusters

```
library("factoextra")  
#fviz_nbclust(ppcc, kmeans, method = "gap_stat")
```

According to the previous plot, the optimal number of clusters per k-means is 1, so we guess maybe something is wrong or missing.

## 4.2 Classification

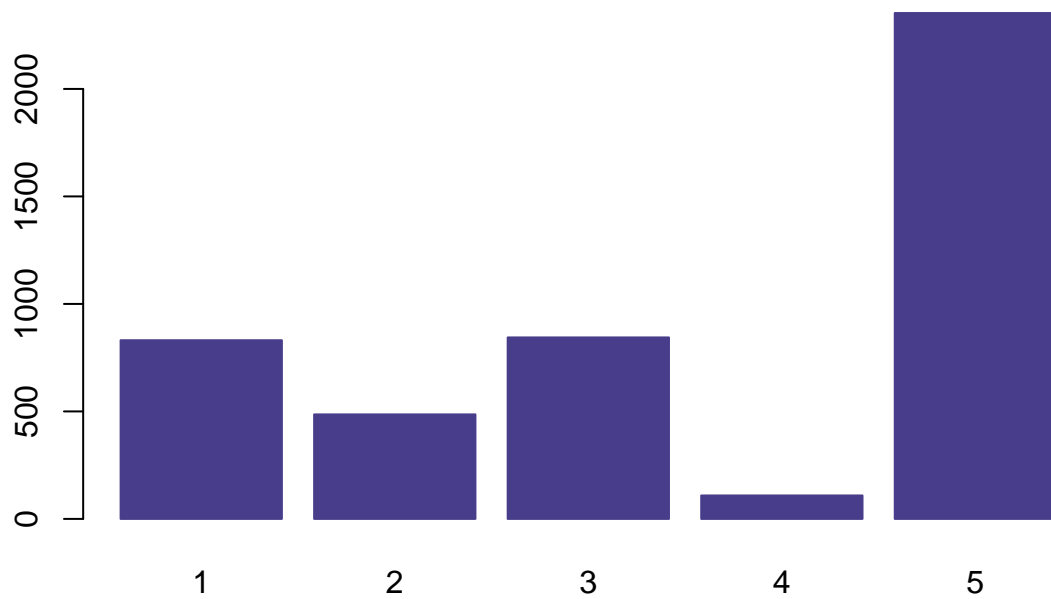
```
dist<-dist(ppcc) # coordinates are real - Euclidean metric  
kc<-kmeans(dist, 5, iter.max=30, trace=TRUE) #calculate the distances, it turns into a matrix
```

```
## KMNS(*, k=5): iter= 1, indx=3  
## QTRAN(): istep=4623, icoun=0  
## QTRAN(): istep=9246, icoun=52  
## QTRAN(): istep=13869, icoun=6  
## QTRAN(): istep=18492, icoun=13  
## QTRAN(): istep=23115, icoun=1  
## QTRAN(): istep=27738, icoun=9  
## QTRAN(): istep=32361, icoun=27  
## QTRAN(): istep=36984, icoun=7  
## QTRAN(): istep=41607, icoun=49  
## QTRAN(): istep=46230, icoun=1  
## QTRAN(): istep=50853, icoun=6  
## QTRAN(): istep=55476, icoun=2  
## QTRAN(): istep=60099, icoun=777  
## KMNS(*, k=5): iter= 2, indx=3  
## QTRAN(): istep=4623, icoun=25  
## QTRAN(): istep=9246, icoun=1  
## QTRAN(): istep=13869, icoun=5  
## QTRAN(): istep=18492, icoun=21  
## QTRAN(): istep=23115, icoun=226  
## QTRAN(): istep=27738, icoun=926  
## QTRAN(): istep=32361, icoun=3  
## QTRAN(): istep=36984, icoun=483  
## QTRAN(): istep=41607, icoun=4591  
## KMNS(*, k=5): iter= 3, indx=3  
## QTRAN(): istep=4623, icoun=225  
## QTRAN(): istep=9246, icoun=690  
## QTRAN(): istep=13869, icoun=3645  
## KMNS(*, k=5): iter= 4, indx=4623
```

We see from the output that in 4 iterations it has converged. We now proceed to save in the data frame the number of clusters.

```
df$claKM<-0  
df$claKM<-kc$cluster  
df$claKM<-factor(df$claKM)  
barplot(table(df$claKM), col="darkslateblue", border="darkslateblue", main="[k-means]#observations/cluster")
```

## [k-means]#observations/cluster



### 4.2.1 Gain in inertia (in %)

The american school does the partition quality evaluation in 5 clusters is done very fast, and after executing the following chunk we get an explicability of the 77.99%

```
100*(kc$betweenss/kc$totss)
```

```
## [1] 79.40953
```

### 4.2.2 k-means clusters characteristics

If we want to know the characteristics of each cluster, as we did with the hierarchical, we need to execute a catdes to obtain these characteristics. In the following output we get them, ?????? WE NEED TO EXPLAIN IT!!!! (but we are not going to explain them because the process is the same as we already did in the hierarchical.)

```
dim(df)
```

```
## [1] 4623 30
```

```
res.cat <-catdes(df,30)
```

```
res.cat
```

```
##
## Link between the cluster variable and the categorical variables (chi-square test)
## =====
##               p.value df
## Trip_distance_range 0.000000e+00 8
## paidTolls           0.000000e+00 8
## hcpck                0.000000e+00 16
## pickup              1.114117e-215 92
## dropoff             4.738913e-206 92
## passenger_groups    1.560774e-177 8
## period              8.756108e-127 12
## TipIsGiven          4.163217e-45 4
## Payment_type        4.711245e-34 8
## RateCodeID          5.628907e-08 4
## MTA_tax             4.996468e-06 4
## improvement_surcharge 3.086294e-05 4
## Trip_type           4.421007e-05 4
```

```

##
## Description of each cluster by the categories
## =====
## $`1`
##
## Cla/Mod Mod/Cla Global p.value
## Trip_distance_range=Medium_dist 59.736308 70.8784597 21.328142 9.830260e-273
## hcpck=4 42.612137 38.8688327 16.396279 5.795841e-70
## Trip_distance_range=Long_dist 30.827068 24.6690734 14.384599 1.510254e-18
## TipIsGiven=Yes 23.721999 49.6991576 37.659528 5.633107e-15
## Payment_type=Credit card 22.185115 55.9566787 45.338525 1.283731e-11
## paidTolls=No 18.138112 99.8796631 98.983344 1.064902e-03
## passenger_groups=Single 18.738739 87.6052948 84.036340 1.519643e-03
## pickup=10 26.701571 6.1371841 4.131516 2.257993e-03
## period=Period night 20.219245 39.9518652 35.518062 3.394570e-03
## pickup=06 33.333333 2.2864019 1.232966 5.171005e-03
## dropoff=11 25.396825 5.7761733 4.088254 9.253274e-03
## VendorID=f.Vendor-Mobile 20.452210 23.9470517 21.046939 2.509928e-02
## dropoff=21 22.932331 7.3405535 5.753839 3.468393e-02
## VendorID=f.Vendor-VeriFone 17.315068 76.0529483 78.953061 2.509928e-02
## pickup=17 12.749004 3.8507822 5.429375 2.247023e-02
## dropoff=17 12.648221 3.8507822 5.472637 1.935138e-02
## hcpck=2 15.973072 31.4079422 35.345014 8.402245e-03
## pickup=16 12.323944 4.2117930 6.143197 8.066705e-03
## hcpck=5 0.000000 0.0000000 0.843608 4.250924e-04
## paidTolls=Yes 0.000000 0.0000000 0.865239 3.480305e-04
## dropoff=18 10.289389 3.8507822 6.727233 1.117498e-04
## pickup=18 10.191083 3.8507822 6.792126 8.236661e-05
## period=Period afternoon 13.910093 19.7352587 25.502920 1.740057e-05
## passenger_groups=Group 7.848101 3.7304452 8.544235 2.569581e-09
## Payment_type=Cash 14.457349 43.4416366 54.012546 1.612540e-11
## hcpck=3 3.053435 0.9626955 5.667316 3.045013e-14
## TipIsGiven=No 14.503817 50.3008424 62.340472 5.633107e-15
## hcpck=1 12.383420 28.7605295 41.747783 1.603615e-17
## Trip_distance_range=Short_dist 1.244953 4.4524669 64.287259 0.000000e+00
##
## v.test
## Trip_distance_range=Medium_dist 35.285413
## hcpck=4 17.681760
## Trip_distance_range=Long_dist 8.788904
## TipIsGiven=Yes 7.811903
## Payment_type=Credit card 6.770461
## paidTolls=No 3.272794
## passenger_groups=Single 3.170906
## pickup=10 3.054017
## period=Period night 2.929547
## pickup=06 2.796183
## dropoff=11 2.602552
## VendorID=f.Vendor-Mobile 2.239871
## dropoff=21 2.112029
## VendorID=f.Vendor-VeriFone -2.239871
## pickup=17 -2.282324
## dropoff=17 -2.338692
## hcpck=2 -2.635464
## pickup=16 -2.649265
## hcpck=5 -3.523995
## paidTolls=Yes -3.576646
## dropoff=18 -3.863553
## pickup=18 -3.937408
## period=Period afternoon -4.295875
## passenger_groups=Group -5.956970
## Payment_type=Cash -6.737393
## hcpck=3 -7.596392
## TipIsGiven=No -7.811903
## hcpck=1 -8.519415
## Trip_distance_range=Short_dist -Inf

```



```

##
## $`2`
##
## Cla/Mod Mod/Cla Global p.value
## hcpck=4 48.2849604 75.3086420 16.396279 1.021557e-216
## Trip_distance_range=Long_dist 51.4285714 70.3703704 14.384599 2.789031e-208
## hcpck=3 42.3664122 22.8395062 5.667316 4.166709e-44
## passenger_groups=Group 34.1772152 27.7777778 8.544235 1.987956e-41
## TipIsGiven=Yes 15.6232051 55.9670782 37.659528 5.218460e-18
## Payment_type=Credit card 14.5038168 62.5514403 45.338525 8.678931e-16
## RateCodeID=Rate-Other 19.6850394 5.1440329 2.747134 1.867120e-03
## dropoff=17 16.6007905 8.6419753 5.472637 2.315914e-03
## MTA_tax=No 19.3277311 4.7325103 2.574086 3.719873e-03
## Trip_type=Dispatch 17.8571429 4.1152263 2.422669 1.738247e-02
## improvement_surcharge=No 16.9491525 4.1152263 2.552455 3.059642e-02
## pickup=01 15.4320988 5.1440329 3.504218 4.788939e-02
## dropoff=12 5.9523810 2.0576132 3.634004 3.970823e-02
## improvement_surcharge=Yes 10.3440622 95.8847737 97.447545 3.059642e-02
## period=Period valley 8.8888889 23.0452675 27.255029 2.592855e-02
## Trip_type=Street-Hail 10.3303037 95.8847737 97.577331 1.738247e-02
## hcpck=5 0.0000000 0.0000000 0.843608 1.289666e-02
## MTA_tax=Yes 10.2797513 95.2674897 97.425914 3.719873e-03
## pickup=12 4.4444444 1.6460905 3.893576 3.252368e-03
## RateCodeID=Rate-1 10.2535587 94.8559671 97.252866 1.867120e-03
## pickup=20 5.5555556 3.4979424 6.619079 1.788241e-03
## dropoff=14 4.5662100 2.0576132 4.737184 1.391931e-03
## Trip_distance_range=Medium_dist 6.9979716 14.1975309 21.328142 2.510501e-05
## Payment_type=Cash 7.1285543 36.6255144 54.012546 4.368131e-16
## TipIsGiven=No 7.4253990 44.0329218 62.340472 5.218460e-18
## passenger_groups=Single 8.3397683 66.6666667 84.036340 6.471313e-24
## hcpck=2 0.1223990 0.4115226 35.345014 1.010014e-94
## hcpck=1 0.3626943 1.4403292 41.747783 6.925515e-109
## Trip_distance_range=Short_dist 2.5235532 15.4320988 64.287259 1.499111e-122
##
## v.test
## hcpck=4 31.421736
## Trip_distance_range=Long_dist 30.797978
## hcpck=3 13.929946
## passenger_groups=Group 13.482306
## TipIsGiven=Yes 8.648492
## Payment_type=Credit card 8.044230
## RateCodeID=Rate-Other 3.110593
## dropoff=17 3.046410
## MTA_tax=No 2.900989
## Trip_type=Dispatch 2.378516
## improvement_surcharge=No 2.162282
## pickup=01 1.978349
## dropoff=12 -2.056771
## improvement_surcharge=Yes -2.162282
## period=Period valley -2.227280
## Trip_type=Street-Hail -2.378516
## hcpck=5 -2.486610
## MTA_tax=Yes -2.900989
## pickup=12 -2.942821
## RateCodeID=Rate-1 -3.110593
## pickup=20 -3.123319
## dropoff=14 -3.196319
## Trip_distance_range=Medium_dist -4.213854
## Payment_type=Cash -8.127894
## TipIsGiven=No -8.648492
## passenger_groups=Single -10.084471
## hcpck=2 -20.648355
## hcpck=1 -22.168450
## Trip_distance_range=Short_dist -23.542477
##
## $`3`

```

##	Cla/Mod	Mod/Cla	Global	p.value
## hcpck=1	35.9585492	82.2274882	41.7477828	2.590084e-157
## period=Period afternoon	41.4758270	57.9383886	25.5029202	1.523397e-112
## Trip_distance_range=Short_dist	25.3364738	89.2180095	64.2872594	1.347784e-72
## passenger_groups=Group	50.1265823	23.4597156	8.5442353	3.342170e-52
## dropoff=18	54.3408360	20.0236967	6.7272334	1.875281e-50
## pickup=18	53.5031847	19.9052133	6.7921263	7.274603e-49
## hcpck=3	54.1984733	16.8246445	5.6673156	7.896015e-42
## dropoff=19	50.1607717	18.4834123	6.7272334	1.779927e-40
## pickup=17	52.1912351	15.5213270	5.4293749	3.955139e-36
## pickup=16	49.2957746	16.5876777	6.1431971	4.664129e-35
## pickup=19	47.7272727	17.4170616	6.6623405	8.386326e-35
## dropoff=17	48.6166008	14.5734597	5.4726368	6.125909e-30
## dropoff=16	45.9074733	15.2843602	6.0783041	2.700838e-28
## passenger_groups=Couple	39.6501458	16.1137441	7.4194246	3.433183e-22
## RateCodeID=Rate-1	18.7277580	99.7630332	97.2528661	2.499491e-09
## MTA_tax=Yes	18.6944938	99.7630332	97.4259139	1.160586e-08
## improvement_surcharge=Yes	18.6903441	99.7630332	97.4475449	1.405074e-08
## Trip_type=Street-Hail	18.6654844	99.7630332	97.5773307	4.407526e-08
## paidTolls=No	18.4440559	100.0000000	98.9833441	7.285175e-05
## TipIsGiven=No	19.5697432	66.8246445	62.3404716	2.794274e-03
## Payment_type=Cash	19.7837405	58.5308057	54.0125460	3.530940e-03
## pickup=20	14.0522876	5.0947867	6.6190785	4.445448e-02
## pickup=00	13.0630631	3.4360190	4.8020766	3.503728e-02
## dropoff=22	13.0252101	3.6729858	5.1481722	2.744997e-02
## pickup=05	6.0000000	0.3554502	1.0815488	1.485557e-02
## dropoff=05	5.8823529	0.3554502	1.1031798	1.275707e-02
## Payment_type=Credit card	16.5553435	41.1137441	45.3385248	6.314097e-03
## pickup=22	11.7886179	3.4360190	5.3212200	4.957197e-03
## dropoff=01	10.1190476	2.0142180	3.6340039	3.321822e-03
## TipIsGiven=Yes	16.0827111	33.1753555	37.6595284	2.794274e-03
## pickup=01	9.2592593	1.7772512	3.5042180	1.300278e-03
## pickup=23	10.0961538	2.4881517	4.4992429	9.689147e-04
## hcpck=5	0.0000000	0.0000000	0.8436080	3.715552e-04
## paidTolls=Yes	0.0000000	0.0000000	0.8652390	3.031450e-04
## dropoff=06	0.0000000	0.0000000	0.9301319	1.645898e-04
## dropoff=21	9.3984962	2.9620853	5.7538395	3.865807e-05
## pickup=21	8.8607595	2.4881517	5.1265412	3.633993e-05
## dropoff=23	8.0717489	2.1327014	4.8237075	1.214810e-05
## pickup=06	0.0000000	0.0000000	1.2329656	9.463000e-06
## period=Period valley	13.8888889	20.7345972	27.2550292	1.568281e-06
## pickup=15	6.6371681	1.7772512	4.8886005	3.029225e-07
## dropoff=08	4.5161290	0.8293839	3.3528012	2.967543e-07
## Trip_type=Dispatch	1.7857143	0.2369668	2.4226693	4.407526e-08
## improvement_surcharge=No	1.6949153	0.2369668	2.5524551	1.405074e-08
## MTA_tax=No	1.6806723	0.2369668	2.5740861	1.160586e-08
## dropoff=07	0.9433962	0.1184834	2.2928834	1.052048e-08
## pickup=08	3.6144578	0.7109005	3.5907419	8.563816e-09
## pickup=07	1.6528926	0.2369668	2.6173480	7.914224e-09
## dropoff=12	3.5714286	0.7109005	3.6340039	6.049325e-09
## RateCodeID=Rate-Other	1.5748031	0.2369668	2.7471339	2.499491e-09
## dropoff=10	3.7433155	0.8293839	4.0449924	1.342739e-09
## pickup=11	2.9761905	0.5924171	3.6340039	9.095265e-10
## dropoff=15	4.5454545	1.1848341	4.7588146	7.656623e-10
## pickup=12	3.3333333	0.7109005	3.8935756	7.364870e-10
## pickup=10	3.6649215	0.8293839	4.1315163	6.711789e-10
## dropoff=13	2.2222222	0.4739336	3.8935756	1.197572e-11
## pickup=13	1.7241379	0.3554502	3.7637897	3.526453e-12
## dropoff=11	2.1164021	0.4739336	4.0882544	2.186471e-12
## dropoff=14	2.7397260	0.7109005	4.7371836	6.370576e-13
## dropoff=09	1.6216216	0.3554502	4.0017305	4.183562e-13
## pickup=09	1.6216216	0.3554502	4.0017305	4.183562e-13
## pickup=14	2.6315789	0.7109005	4.9318624	1.202828e-13
## Trip_distance_range=Medium_dist	9.1277890	10.6635071	21.3281419	6.109449e-19

## period=Period night	9.9878197	19.4312796	35.5180619	3.460442e-29
## period=Period morning	2.9520295	1.8957346	11.7239888	1.532512e-30
## Trip_distance_range=Long_dist	0.1503759	0.1184834	14.3845987	7.046119e-62
## hcpck=4	0.0000000	0.0000000	16.3962795	5.906224e-74
## passenger_groups=Single	13.1274131	60.4265403	84.0363400	1.731005e-79
## hcpck=2	0.4895961	0.9478673	35.3450141	1.859514e-164
##	v.test			
## hcpck=1	26.722331			
## period=Period afternoon	22.544416			
## Trip_distance_range=Short_dist	18.020395			
## passenger_groups=Group	15.203697			
## dropoff=18	14.937630			
## pickup=18	14.691808			
## hcpck=3	13.550251			
## dropoff=19	13.319628			
## pickup=17	12.550399			
## pickup=16	12.353493			
## pickup=19	12.306217			
## dropoff=17	11.366701			
## dropoff=16	11.031250			
## passenger_groups=Couple	9.686738			
## RateCodeID=Rate-1	5.961489			
## MTA_tax=Yes	5.705417			
## improvement_surcharge=Yes	5.672769			
## Trip_type=Street-Hail	5.473693			
## paidTolls=No	3.966775			
## TipIsGiven=No	2.989508			
## Payment_type=Cash	2.917284			
## pickup=20	-2.009780			
## pickup=00	-2.107927			
## dropoff=22	-2.205059			
## pickup=05	-2.435881			
## dropoff=05	-2.490480			
## Payment_type=Credit card	-2.731008			
## pickup=22	-2.809802			
## dropoff=01	-2.936273			
## TipIsGiven=Yes	-2.989508			
## pickup=01	-3.215918			
## pickup=23	-3.299401			
## hcpck=5	-3.559504			
## paidTolls=Yes	-3.612598			
## dropoff=06	-3.767956			
## dropoff=21	-4.115357			
## pickup=21	-4.129597			
## dropoff=23	-4.374913			
## pickup=06	-4.429093			
## period=Period valley	-4.802332			
## pickup=15	-5.121620			
## dropoff=08	-5.125497			
## Trip_type=Dispatch	-5.473693			
## improvement_surcharge=No	-5.672769			
## MTA_tax=No	-5.705417			
## dropoff=07	-5.722117			
## pickup=08	-5.756968			
## pickup=07	-5.770275			
## dropoff=12	-5.815388			
## RateCodeID=Rate-Other	-5.961489			
## dropoff=10	-6.062198			
## pickup=11	-6.124528			
## dropoff=15	-6.151887			
## pickup=12	-6.158044			
## pickup=10	-6.172737			
## dropoff=13	-6.780504			
## pickup=13	-6.954967			

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## dropoff=11 -7.022043
## dropoff=14 -7.192307
## dropoff=09 -7.249486
## pickup=09 -7.249486
## pickup=14 -7.416470
## Trip_distance_range=Medium_dist -8.890026
## period=Period night -11.214524
## period=Period morning -11.487053
## Trip_distance_range=Long_dist -16.599340
## hcpck=4 -18.192608
## passenger_groups=Single -18.877974
## hcpck=2 -27.330149
##
## $`4`
## Cla/Mod Mod/Cla Global p.value
## Trip_distance_range=Long_dist 14.7368421 89.9082569 14.3845987 4.103928e-72
## hcpck=5 100.0000000 35.7798165 0.8436080 1.655363e-67
## paidTolls=Yes 95.0000000 34.8623853 0.8652390 8.094914e-63
## hcpck=4 9.1029024 63.3027523 16.3962795 7.818532e-29
## TipIsGiven=Yes 3.9058013 62.3853211 37.6595284 1.424189e-07
## Payment_type=Credit card 3.6259542 69.7247706 45.3385248 2.269663e-07
## paidTolls=NA 57.1428571 3.6697248 0.1514168 9.830213e-06
## dropoff=05 9.8039216 4.5871560 1.1031798 7.727506e-03
## RateCodeID=Rate-Other 6.2992126 7.3394495 2.7471339 1.250518e-02
## pickup=05 8.0000000 3.6697248 1.0815488 3.539482e-02
## dropoff=02 0.0000000 0.0000000 2.7687649 4.516816e-02
## pickup=21 0.4219409 0.9174312 5.1265412 2.418729e-02
## dropoff=22 0.4201681 0.9174312 5.1481722 2.366511e-02
## hcpck=3 0.3816794 0.9174312 5.6673156 1.395311e-02
## RateCodeID=Rate-1 2.2464413 92.6605505 97.2528661 1.250518e-02
## Trip_distance_range=Medium_dist 0.8113590 7.3394495 21.3281419 7.343759e-05
## Payment_type=Cash 1.2815378 29.3577982 54.0125460 1.612428e-07
## TipIsGiven=No 1.4226232 37.6146789 62.3404716 1.424189e-07
## hcpck=2 0.0000000 0.0000000 35.3450141 1.114755e-21
## hcpck=1 0.0000000 0.0000000 41.7477828 1.033106e-26
## Trip_distance_range=Short_dist 0.1009421 2.7522936 64.2872594 2.624922e-44
## paidTolls=No 1.4641608 61.4678899 98.9833441 8.076067e-67
## v.test
## Trip_distance_range=Long_dist 17.958688
## hcpck=5 17.360065
## paidTolls=Yes 16.728728
## hcpck=4 11.142176
## TipIsGiven=Yes 5.262100
## Payment_type=Credit card 5.175775
## paidTolls=NA 4.420875
## dropoff=05 2.663750
## RateCodeID=Rate-Other 2.497558
## pickup=05 2.103812
## dropoff=02 -2.003085
## pickup=21 -2.254141
## dropoff=22 -2.262523
## hcpck=3 -2.458468
## RateCodeID=Rate-1 -2.497558
## Trip_distance_range=Medium_dist -3.964865
## Payment_type=Cash -5.239236
## TipIsGiven=No -5.262100
## hcpck=2 -9.565671
## hcpck=1 -10.698615
## Trip_distance_range=Short_dist -13.962910
## paidTolls=No -17.268832
##
## $`5`
## Cla/Mod Mod/Cla Global p.value
## Trip_distance_range=Short_dist 70.794078 89.4177646 64.2872594 9.651284e-310

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## hcpck=2	83.414933	57.9260518	35.3450141	2.733939e-250
## passenger_groups=Single	57.503218	94.9426264	84.0363400	2.755721e-101
## TipIsGiven=No	57.078418	69.9107522	62.3404716	2.371984e-27
## Payment_type=Cash	57.348819	60.8584785	54.0125460	1.744648e-21
## paidTolls=No	51.420455	100.0000000	98.9833441	2.373794e-15
## dropoff=14	69.863014	6.5023374	4.7371836	5.963055e-09
## pickup=14	69.298246	6.7148321	4.9318624	8.357817e-09
## period=Period night	56.516443	39.4390140	35.5180619	1.386893e-08
## pickup=12	70.555556	5.3973651	3.8935756	5.154684e-08
## dropoff=12	70.238095	5.0148746	3.6340039	2.395181e-07
## period=Period morning	61.254613	14.1096473	11.7239888	2.614236e-07
## period=Period valley	56.507937	30.2592435	27.2550292	2.961664e-06
## dropoff=13	67.777778	5.1848704	3.8935756	3.191718e-06
## dropoff=08	67.096774	4.4198895	3.3528012	3.613675e-05
## pickup=20	61.764706	8.0322992	6.6190785	7.936518e-05
## pickup=08	65.662651	4.6323842	3.5907419	9.795433e-05
## pickup=15	63.274336	6.0773481	4.8886005	1.281302e-04
## pickup=13	64.942529	4.8023799	3.7637897	1.477385e-04
## dropoff=15	62.727273	5.8648534	4.7588146	3.094087e-04
## dropoff=09	63.243243	4.9723757	4.0017305	5.848407e-04
## pickup=07	66.115702	3.3999150	2.6173480	6.540118e-04
## dropoff=07	66.981132	3.0174246	2.2928834	7.601315e-04
## pickup=11	63.095238	4.5048874	3.6340039	1.238666e-03
## pickup=09	62.162162	4.8873778	4.0017305	1.722289e-03
## pickup=21	59.493671	5.9923502	5.1265412	6.539225e-03
## dropoff=10	60.427807	4.8023799	4.0449924	7.744511e-03
## dropoff=20	57.876712	7.1823204	6.3162449	1.370576e-02
## improvement_surcharge=No	61.864407	3.1024224	2.5524551	1.578392e-02
## dropoff=22	58.403361	5.9073523	5.1481722	1.740070e-02
## dropoff=21	57.518797	6.5023374	5.7538395	2.612277e-02
## pickup=23	58.173077	5.1423714	4.4992429	3.182685e-02
## MTA_tax=No	60.504202	3.0599235	2.5740861	3.388949e-02
## Trip_type=Dispatch	60.714286	2.8899278	2.4226693	3.563260e-02
## dropoff=23	57.399103	5.4398640	4.8237075	4.669475e-02
## pickup=02	59.398496	3.3574161	2.8769197	4.691042e-02
## Trip_type=Street-Hail	50.653957	97.1100722	97.5773307	3.563260e-02
## MTA_tax=Yes	50.643872	96.9400765	97.4259139	3.388949e-02
## improvement_surcharge=Yes	50.610433	96.8975776	97.4475449	1.578392e-02
## paidTolls=NA	0.000000	0.0000000	0.1514168	6.849611e-03
## hcpck=5	0.000000	0.0000000	0.8436080	7.589373e-13
## paidTolls=Yes	0.000000	0.0000000	0.8652390	3.693694e-13
## dropoff=16	28.825623	3.4424139	6.0783041	1.123668e-14
## passenger_groups=Couple	28.862974	4.2073948	7.4194246	9.285954e-18
## Payment_type=Credit card	43.129771	38.4190395	45.3385248	5.816687e-22
## pickup=16	22.887324	2.7624309	6.1431971	2.305954e-23
## dropoff=19	24.115756	3.1874203	6.7272334	2.013643e-23
## dropoff=17	20.553360	2.2099448	5.4726368	2.042389e-24
## pickup=19	23.376623	3.0599235	6.6623405	1.809388e-24
## pickup=17	20.318725	2.1674458	5.4293749	1.333510e-24
## TipIsGiven=Yes	40.666284	30.0892478	37.6595284	2.371984e-27
## pickup=18	21.974522	2.9324267	6.7921263	1.574639e-27
## dropoff=18	20.257235	2.6774331	6.7272334	1.293445e-30
## period=Period afternoon	32.315522	16.1920952	25.5029202	3.634586e-50
## hcpck=3	0.000000	0.0000000	5.6673156	3.426844e-85
## Trip_distance_range=Medium_dist	23.326572	9.7747556	21.3281419	3.883089e-88
## passenger_groups=Group	5.063291	0.8499788	8.5442353	8.681102e-96
## Trip_distance_range=Long_dist	2.857143	0.8074798	14.3845987	6.703159e-192
## hcpck=4	0.000000	0.0000000	16.3962795	1.365785e-268
##	v.test			
## Trip_distance_range=Short_dist	37.621276			
## hcpck=2	33.790344			
## passenger_groups=Single	21.366218			
## TipIsGiven=No	10.834134			
## Payment_type=Cash	9.519231			

```

## paidTolls=No 7.920069
## dropoff=14 5.817791
## pickup=14 5.761078
## period=Period night 5.674999
## pickup=12 5.445891
## dropoff=12 5.165718
## period=Period morning 5.149326
## period=Period valley 4.673461
## dropoff=13 4.658080
## dropoff=08 4.130886
## pickup=20 3.946309
## pickup=08 3.895604
## pickup=15 3.830025
## pickup=13 3.794840
## dropoff=15 3.607293
## dropoff=09 3.438549
## pickup=07 3.408166
## dropoff=07 3.366918
## pickup=11 3.229824
## pickup=09 3.134361
## pickup=21 2.719442
## dropoff=10 2.663010
## dropoff=20 2.464884
## improvement_surcharge=No 2.413874
## dropoff=22 2.378130
## dropoff=21 2.224382
## pickup=23 2.146579
## MTA_tax=No 2.121384
## Trip_type=Dispatch 2.101095
## dropoff=23 1.989058
## pickup=02 1.987108
## Trip_type=Street-Hail -2.101095
## MTA_tax=Yes -2.121384
## improvement_surcharge=Yes -2.413874
## paidTolls=NA -2.704069
## hcpck=5 -7.168374
## paidTolls=Yes -7.266336
## dropoff=16 -7.724417
## passenger_groups=Couple -8.582467
## Payment_type=Credit card -9.632724
## pickup=16 -9.958902
## dropoff=19 -9.972371
## dropoff=17 -10.197120
## pickup=19 -10.208881
## pickup=17 -10.238453
## TipIsGiven=Yes -10.834134
## pickup=18 -10.871572
## dropoff=18 -11.501699
## period=Period afternoon -14.893461
## hcpck=3 -19.559460
## Trip_distance_range=Medium_dist -19.902348
## passenger_groups=Group -20.766588
## Trip_distance_range=Long_dist -29.549307
## hcpck=4 -35.014246
##
##
## Link between the cluster variable and the quantitative variables
## =====
##
##          Eta2      P-value
## Trip_distance 0.682333867 0.000000e+00
## Fare_amount 0.700072899 0.000000e+00
## Extra 0.346854642 0.000000e+00
## Tolls_amount 0.347118692 0.000000e+00
## Total_amount 0.688303660 0.000000e+00

```

```

## tlenkm          0.672008922  0.000000e+00
## traveltime      0.555354040  0.000000e+00
## Tip_amount      0.246746337  4.109487e-282
## espeed          0.199180783  8.408988e-221
## Passenger_count 0.175757629  6.029127e-192
## hour            0.032768593  2.980266e-32
## Dropoff_latitude 0.013838854  3.496069e-13
## Pickup_latitude 0.008063685  1.491934e-07
## Dropoff_longitude 0.006916752  1.860293e-06
## Pickup_longitude 0.005886284  1.753776e-05
##
## Description of each cluster by quantitative variables
## =====
## $`1`
##          v.test Mean in category Overall mean sd in category
## Fare_amount      20.042407      16.8096151  11.61104706  3.74747126
## traveltime       19.432544      18.6125953  12.48732425  5.92050797
## Trip_distance    17.591543       4.2630905  2.72449524  1.21907679
## tlenkm           17.577688       6.8373493  4.34905091  2.00322478
## Total_amount     17.328080      19.3954753  13.92640493  3.88246513
## espeed           13.362174      23.9908565  20.33575305  9.09332230
## Tip_amount        9.087511       1.5456197  1.02203842  1.76395923
## hour             -2.085754      12.9530686  13.39757733  6.92604649
## Tolls_amount     -3.004488       0.0000000  0.04769564  0.00000000
## Pickup_latitude  -4.220712      40.7394347  40.74676502  0.05593978
## Pickup_longitude -4.602008     -73.9409325 -73.93496823  0.04162304
## Dropoff_longitude -4.902556     -73.9414715 -73.93460830  0.04690465
## Extra            -5.246122       0.2918171  0.35226044  0.32723242
## Dropoff_latitude -5.362187      40.7357173  40.74500568  0.05465058
## Passenger_count  -6.078029       1.1732852  1.37107208  0.52270578
##          Overall sd      p.value
## Fare_amount      8.25496368 2.351166e-89
## traveltime       10.03175633 4.095543e-84
## Trip_distance     2.78356770 2.859844e-69
## tlenkm            4.50528246 3.651657e-69
## Total_amount     10.04487145 2.888095e-67
## espeed            8.70570362 1.005835e-40
## Tip_amount        1.83366715 1.013320e-19
## hour              6.78263699 3.700093e-02
## Tolls_amount      0.50523041 2.660280e-03
## Pickup_latitude   0.05527371 2.435315e-05
## Pickup_longitude  0.04124656 4.184366e-06
## Dropoff_longitude 0.04455396 9.459752e-07
## Extra             0.36668354 1.553337e-07
## Dropoff_latitude  0.05512875 8.222053e-08
## Passenger_count   1.03565723 1.216689e-09
##
## $`2`
##          v.test Mean in category Overall mean sd in category
## Fare_amount      31.618439      22.8122649  11.6110471  9.22680134
## traveltime       31.356926      25.9868999  12.4873242  14.03897959
## Trip_distance    31.015924       6.4295631  2.7244952  3.06837162
## tlenkm           30.335416      10.2142348  4.3490509  5.06506125
## Total_amount     29.183431      26.5066872  13.9264049  9.88546826
## Tip_amount       18.948178       2.5131070  1.0220384  2.90146068
## Passenger_count  18.548676       2.1954733  1.3710721  1.88366928
## espeed           17.970433      27.0496099  20.3357531  13.80572702
## Extra            2.000758       0.3837449  0.3522604  0.37865254
## hour             -1.966744      12.8251029  13.3975773  7.02701046
## Dropoff_latitude -2.235052      40.7397179  40.7450057  0.05038104
## Pickup_latitude  -2.283116      40.7413493  40.7467650  0.05618931
##          Overall sd      p.value
## Fare_amount      8.25496368 2.060133e-219
## traveltime       10.03175633 7.828132e-216

```

```

## Trip_distance      2.78356770 3.288235e-211
## tlenkm             4.50528246 3.912848e-202
## Total_amount       10.04487145 3.147246e-187
## Tip_amount         1.83366715 4.571378e-80
## Passenger_count    1.03565723 8.358632e-77
## espeed             8.70570362 3.321124e-72
## Extra              0.36668354 4.541845e-02
## hour              6.78263699 4.921271e-02
## Dropoff_latitude   0.05512875 2.541391e-02
## Pickup_latitude    0.05527371 2.242356e-02
##
## $`3`
##               v.test Mean in category Overall mean sd in category
## Extra          38.691376      0.7938389  0.35226044  0.32313622
## Passenger_count 17.820318      1.9454976  1.37107208  1.46017142
## hour          12.277044     15.9893365  13.39757733  5.49158167
## Dropoff_longitude 2.293129    -73.9314284 -73.93460830  0.04406971
## Tolls_amount   -3.033102      0.0000000  0.04769564  0.00000000
## Tip_amount     -7.445308      0.5971201  1.02203842  0.94944352
## traveltime    -12.103859      8.7080964  12.48732425  4.76347424
## Total_amount   -12.119349     10.1373934  13.92640493  4.45694924
## espeed        -13.436913     16.6948791  20.33575305  5.45449827
## tlenkm        -14.668192      2.2922093  4.34905091  1.23050317
## Fare_amount    -14.695506      7.8353081  11.61104706  2.95164582
## Trip_distance  -14.966258      1.4278617  2.72449524  0.76358087
##               Overall sd      p.value
## Extra          0.36668354 0.000000e+00
## Passenger_count 1.03565723 4.915602e-71
## hour          6.78263699 1.203142e-34
## Dropoff_longitude 0.04455396 2.184058e-02
## Tolls_amount   0.50523041 2.420542e-03
## Tip_amount     1.83366715 9.671838e-14
## traveltime    10.03175633 1.007608e-33
## Total_amount   10.04487145 8.341900e-34
## espeed         8.70570362 3.674477e-41
## tlenkm         4.50528246 1.030547e-48
## Fare_amount    8.25496368 6.888191e-49
## Trip_distance  2.78356770 1.219954e-50
##
## $`4`
##               v.test Mean in category Overall mean sd in category
## Tolls_amount    40.05093      1.963074  0.04769564  2.63278950
## Total_amount    39.12185     51.124128  13.92640493  18.90835873
## tlenkm          37.16394     20.197849  4.34905091  9.64419649
## Trip_distance   37.12125     12.505354  2.72449524  5.86941865
## Fare_amount     35.87332     39.642089  11.61104706  12.56020461
## traveltime     27.17098     38.288226  12.48732425  14.95322699
## Tip_amount      22.93020      5.002018  1.02203842  4.90894443
## espeed         15.01648     32.710163  20.33575305  13.86530272
## Pickup_latitude -2.51323     40.733616  40.74676502  0.06075561
## Dropoff_latitude -4.24057     40.722877  40.74500568  0.06697507
##               Overall sd      p.value
## Tolls_amount    0.50523041 0.000000e+00
## Total_amount    10.04487145 0.000000e+00
## tlenkm          4.50528246 2.610729e-302
## Trip_distance   2.78356770 1.275899e-301
## Fare_amount     8.25496368 7.964808e-282
## traveltime     10.03175633 1.430929e-162
## Tip_amount      1.83366715 2.322683e-116
## espeed         8.70570362 5.727137e-51
## Pickup_latitude 0.05527371 1.196314e-02
## Dropoff_latitude 0.05512875 2.229528e-05
##
## $`5`

```



```
##          v.test Mean in category Overall mean sd in category
## Dropoff_latitude 5.958416      40.7497513 40.74500568 0.05498413
## Pickup_latitude  4.803646      40.7506010 40.74676502 0.05450429
## Dropoff_longitude 3.210705     -73.9325416 -73.93460830 0.04115731
## Pickup_longitude  2.570962     -73.9334362 -73.93496823 0.03988268
## hour             -6.221468      12.7879303 13.39757733 6.90562873
## Tolls_amount     -6.534347       0.0000000 0.04769564 0.00000000
## espeed           -15.463075     18.3909003 20.33575305 5.57665243
## Tip_amount       -19.811493      0.4972011 1.02203842 0.83589332
## Passenger_count  -20.838846      1.0592717 1.37107208 0.26946914
## Extra            -26.784004      0.2103697 0.35226044 0.24683890
## tlenkm           -32.057736      2.2624381 4.34905091 1.22971408
## Trip_distance    -32.242607      1.4278567 2.72449524 0.74929076
## traveltime       -33.057788      7.6961963 12.48732425 4.04125063
## Total_amount     -33.723082      9.0324649 13.92640493 3.54907115
## Fare_amount      -34.325210      7.5173531 11.61104706 2.67938944
##          Overall sd      p.value
## Dropoff_latitude 0.05512875 2.546951e-09
## Pickup_latitude  0.05527371 1.558026e-06
## Dropoff_longitude 0.04455396 1.324096e-03
## Pickup_longitude  0.04124656 1.014166e-02
## hour             6.78263699 4.925237e-10
## Tolls_amount     0.50523041 6.388760e-11
## espeed           8.70570362 6.158740e-54
## Tip_amount       1.83366715 2.369546e-87
## Passenger_count  1.03565723 1.924230e-96
## Extra            0.36668354 4.963017e-158
## tlenkm           4.50528246 1.712776e-225
## Trip_distance    2.78356770 4.466041e-228
## traveltime       10.03175633 1.202241e-239
## Total_amount     10.04487145 2.653016e-249
## Fare_amount      8.25496368 3.301578e-258
```

### 4.2.3 Comparison of clusters (confusion table)

We want to compare the hierarchical clustering, previously done, and the kmeans clustering, so proceed to do the following.

```
table(df$hcpck,df$claKM)

##          1      2      3      4      5
## 1 239      7 694      0 990
## 2 261      2      8      0 1363
## 3      8 111 142      1      0
## 4 323 366      0 69      0
## 5      0      0      0 39      0

# we must do a relabel
df$hcpck<-factor(df$hcpck,labels=c("kHP-1","kHP-2","kHP-3","kHP-4","kHP-5"))
df$claKM<-factor(df$claKM,levels=c(3,5,2,1,4),labels=c("kKM-3","kKM-5","kKM-2","kKM-1","kKM-4"))
tt<-table(df$hcpck,df$claKM); tt

##          kKM-3 kKM-5 kKM-2 kKM-1 kKM-4
## kHP-1      694  990      7  239      0
## kHP-2        8 1363      2  261      0
## kHP-3      142      0  111      8      1
## kHP-4        0      0  366  323      69
## kHP-5        0      0      0      0      39

100*sum(diag(tt)/sum(tt))

## [1] 54.72637
```

We have a concordance of the 54.73% so we can say that they are different, if we had a greater concordance, this would mean that they would be more similar.

---

## 5 CA analysis

### 5.1 Are there any row categories that can be combined/avoided to explain the discretization of the numeric target.

#### 5.1.1 CA analysis for your data should contain your factor version of the numeric target (previous) in K= 7 (maximum 10) levels and 2 factors.

The first thing we need to do is factor our numeric target variable, Total\_amount, and name it f.cost. We are going to set 6 different categories.

```
df$f.cost[df$Total_amount<=8] = "[0,8]"
df$f.cost[(df$Total_amount>8) & (df$Total_amount<=11)] = "(8,11]"
df$f.cost[(df$Total_amount>11) & (df$Total_amount<=18)] = "(11,18]"
df$f.cost[(df$Total_amount>18) & (df$Total_amount<= 30)] = "(18,30]"
df$f.cost[(df$Total_amount>30) & (df$Total_amount<= 50)] = "(30,50]"
df$f.cost[df$Total_amount>50] = "(50,129]"
df$f.cost<-factor(df$f.cost)
table(df$f.cost)
```

```
##
##  (11,18]  (18,30]  (30,50]  (50,129]  (8,11]  [0,8]
##      1188      724      221      63      1151      1276
```

Once we have this factor, proceed to create a variable that associates the cost with the passenger groups, and we we a contingency table with 5 rows, one per kind of cost and 3 columns, one per each kind of group.

```
tt<-table(df[,c("f.cost", "passenger_groups")]);tt
```

```
##           passenger_groups
## f.cost      Couple Group Single
##  (11,18]         77    89   1022
##  (18,30]         58    72    594
##  (30,50]         20    20    181
##  (50,129]         5     7     51
##  (8,11]          81   104    966
##  [0,8]          102   103   1071
```

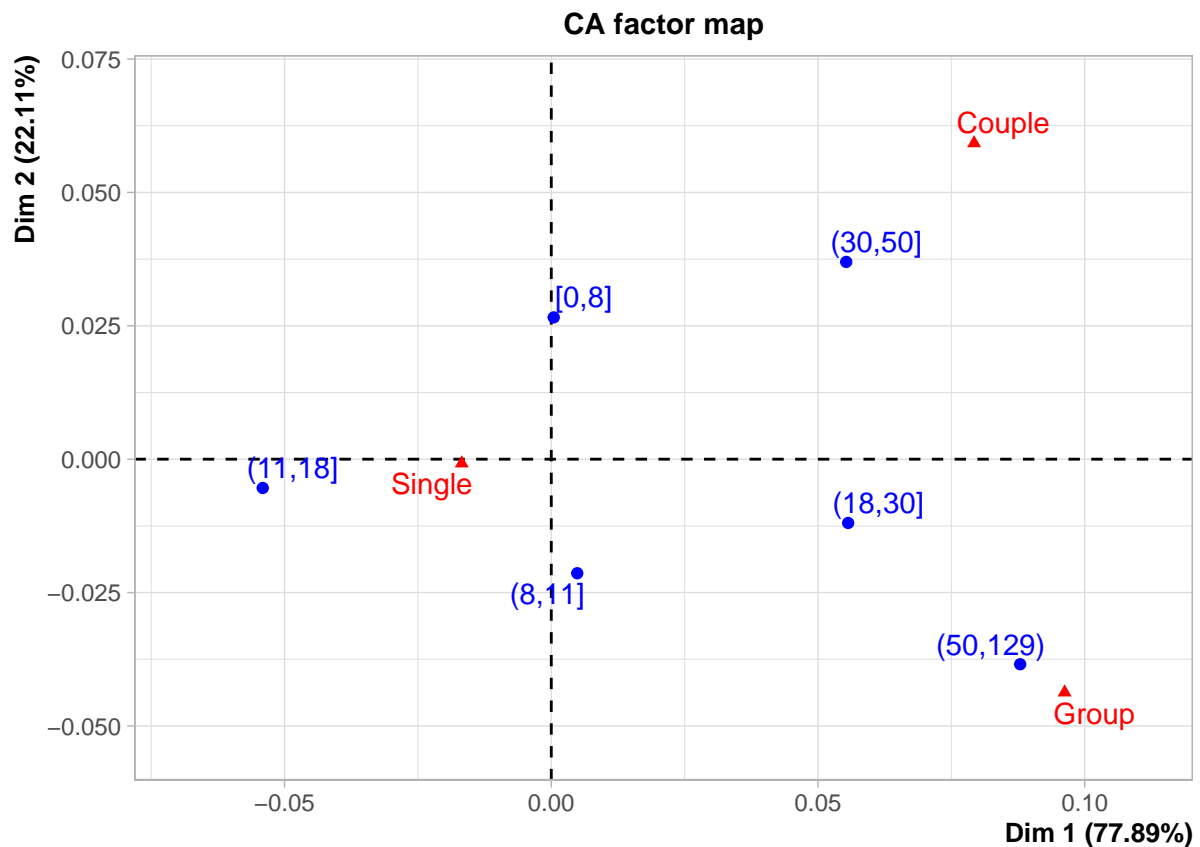
```
chisq.test(tt, simulate.p.value = TRUE) #to see if the rows and columns are independents. H0: Rows and
```

```
##
## Pearson's Chi-squared test with simulated p-value (based on 2000
## replicates)
##
## data:  tt
## X-squared = 8.8677, df = NA, p-value = 0.5212
```

We get a p-value greater than 0.05 so we can assume the H0. ( $0.5217 < 0.05 = \text{FALSE}$ ).

We are now going to take a look to the simple correspondences.

```
res.ca <- CA(tt)
```



Those observations far away from the gravity center will mean that represent less observations on the sample. If rows and columns are nearby, this will mean that there is a correspondence between them, which means that they occur simultaneously in the sample.

```
summary(res.ca)
```

```
##
## Call:
## CA(X = tt)
##
## The chi square of independence between the two variables is equal to 8.867721 (p-value = 0.5447017 )
##
## Eigenvalues
##           Dim.1   Dim.2
## Variance      0.001   0.000
## % of var.     77.890  22.110
## Cumulative % of var. 77.890 100.000
##
## Rows
##           Iner*1000   Dim.1   ctr   cos2   Dim.2   ctr   cos2
## (11,18] |      0.759 | -0.054 50.310 0.990 | -0.005 1.763 0.010 |
## (18,30] |      0.507 | 0.056 32.461 0.956 | -0.012 5.273 0.044 |
## (30,50] |      0.212 | 0.055 9.782 0.691 | 0.037 15.413 0.309 |
## (50,129) |     0.125 | 0.088 7.047 0.839 | -0.038 4.746 0.161 |
## (8,11] |      0.120 | 0.005 0.396 0.049 | -0.021 26.828 0.951 |
## [0,8] |      0.195 | 0.000 0.004 0.000 | 0.027 45.976 1.000 |
##
## Columns
##           Iner*1000   Dim.1   ctr   cos2   Dim.2   ctr   cos2
## Couple |      0.726 | 0.079 31.197 0.642 | 0.059 61.383 0.358 |
## Group |      0.955 | 0.096 52.961 0.829 | -0.044 38.494 0.171 |
## Single |      0.237 | -0.017 15.841 0.998 | -0.001 0.122 0.002 |
```

We conclude that we can not reject the H0 for these pair of factors, and now we are going to see if we can see if there is independence between the cost and the travel time, so the first thing we are going to do is factor the travel time.

```
df$f.tt[df$traveltime<=5] = "[0,5]"
df$f.tt[(df$traveltime>5) & (df$traveltime<=10)] = "(5,10]"
df$f.tt[(df$traveltime>10) & (df$traveltime<=15)] = "(10,15]"
df$f.tt[(df$traveltime>15) & (df$traveltime<= 20)] = "(15,20]"
df$f.tt[(df$traveltime>20) & (df$traveltime<= 50)] = "(20,50]"
df$f.tt<-factor(df$f.tt)
table(df$f.tt)
```

```
##
## (10,15] (15,20] (20,50] (5,10] [0,5]
##      913      549      694      1511      894
```

Once we have this factor, proceed to create a variable that associates the cost with the traveltime.

```
tt<-table(df[,c("f.cost", "f.tt")]);tt
```

```
##          f.tt
## f.cost    (10,15] (15,20] (20,50] (5,10] [0,5]
## (11,18]      613      314      88      156      8
## (18,30]      106      205     388       3     15
## (30,50]         1       23     175       2      4
## (50,129)        1        1      35       0      7
## (8,11]       189       3       4     864     85
## [0,8]         3        3       4     486    775
```

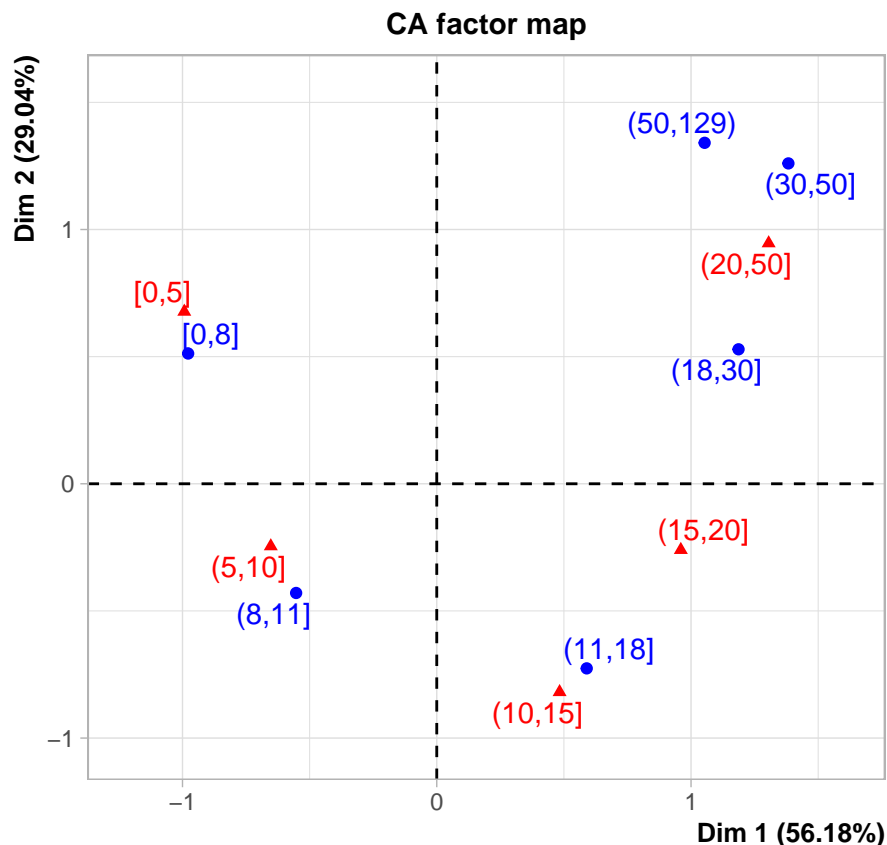
```
chisq.test(tt) #to see if the rows and columns are independents. H0: Rows and columns are independent
```

```
##
## Pearson's Chi-squared test
##
## data:  tt
## X-squared = 6099.3, df = 20, p-value < 2.2e-16
```

We get a p-value smaller than 0.05 so we can reject the H0. ( $< 2.2e-16 < 0.05$ ). So there is dependence between the traveltime and the cost, as we suspected.

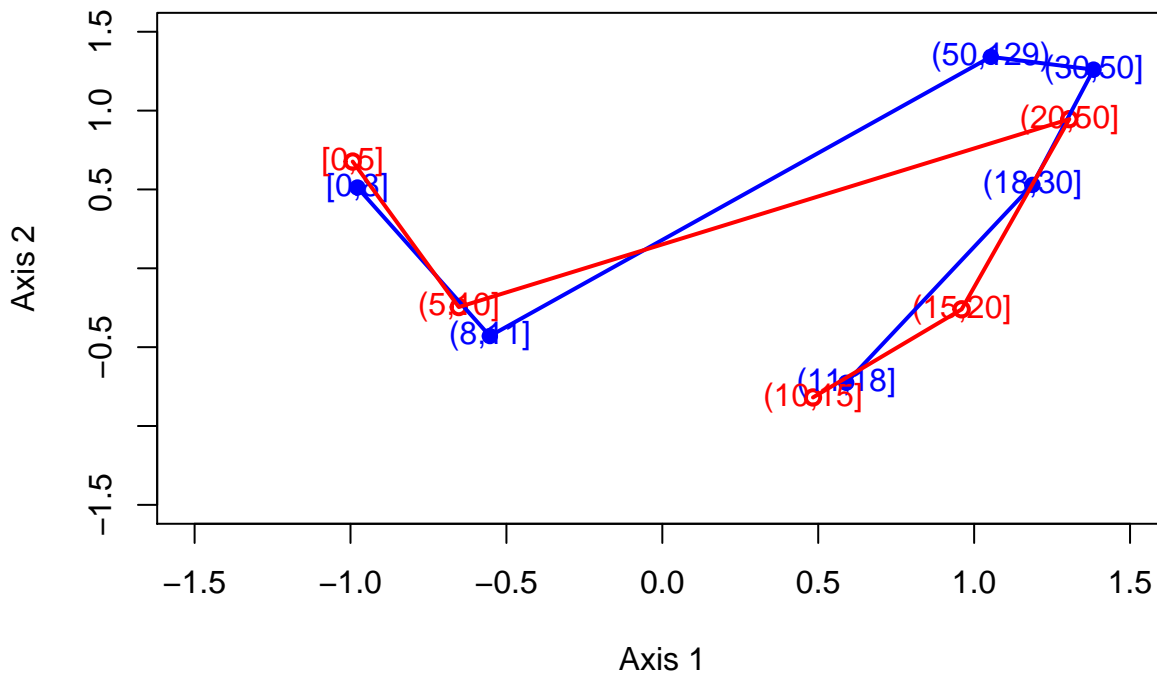
We are now going to take a look to the simple correspondences.

```
res.ca <- CA(tt)
```



```
plot(res.ca$row$coord[,1],res.ca$row$coord[,2],pch=19,col="blue",xlim=c(-1.5,1.5),ylim=c(-1.5,1.5),xlab=
points(res.ca$col$coord[,1],res.ca$col$coord[,2],lwd=2,col="red")
text(res.ca$row$coord[,1],res.ca$row$coord[,2],lwd=2,col="blue",labels=levels(df$f.cost))
text(res.ca$col$coord[,1],res.ca$col$coord[,2],lwd=2,col="red",labels=levels(df$f.tt))
lines(res.ca$row$coord[,1],res.ca$row$coord[,2],lwd=2,col="blue")
lines(res.ca$col$coord[,1],res.ca$col$coord[,2],lwd=2,col="red")
```

## CA f.cost vs f.tt



We

can see in the plot, clearly that there are some categories that occur simultaneously in the sample, for instant the trips up to 5 minutes with the cost up to 8, the trips between 5-10 minutes and the costs between 8-11, the same happen with the trips between 10-15 minutes and the costs between 11-18. There is a clear relation between the f.cost and f.tt categories, even though we can not see a Guttman's effect from manual the relation is there.

```
summary(res.ca)
```

```
##
## Call:
## CA(X = tt)
##
## The chi square of independence between the two variables is equal to 6099.333 (p-value = 0 ).
##
## Eigenvalues
##               Dim.1   Dim.2   Dim.3   Dim.4
## Variance       0.751   0.388   0.189   0.009
## % of var.      56.176  29.038  14.129   0.656
## Cumulative % of var. 56.176  85.215  99.344 100.000
##
## Rows
##               Iner*1000   Dim.1   ctr   cos2   Dim.2   ctr   cos2
## (11,18] | 266.105 | 0.590 11.967 0.338 | -0.726 35.079 0.512 |
## (18,30] | 269.624 | 1.187 29.477 0.821 | 0.529 11.324 0.163 |
## (30,50] | 175.119 | 1.383 11.441 0.491 | 1.260 18.373 0.407 |
## (50,129) | 31.782 | 1.054 1.425 0.337 | 1.341 4.467 0.546 |
## (8,11] | 221.698 | -0.553 10.223 0.346 | -0.429 11.924 0.209 |
## [0,8] | 372.951 | -0.978 35.466 0.714 | 0.512 18.833 0.196 |
##
##               Dim.3   ctr   cos2
## (11,18] 0.391 20.884 0.148 |
## (18,30] -0.063 0.333 0.002 |
```

```
## (30,50]    -0.582    8.062    0.087 |
## (50,129)   -0.419    0.895    0.053 |
## (8,11]     -0.627   52.158    0.445 |
## [0,8]      0.346   17.668    0.090 |
##
## Columns
##           Iner*1000    Dim.1    ctr    cos2    Dim.2    ctr    cos2
## (10,15] |    200.286 |    0.483    6.218    0.233 |   -0.819   34.577    0.670 |
## (15,20] |    143.488 |    0.960   14.763    0.773 |   -0.260    2.095    0.057 |
## (20,50] |    415.261 |    1.305   34.509    0.624 |    0.946   35.059    0.328 |
## (5,10]  |    236.860 |   -0.653   18.786    0.596 |   -0.246    5.145    0.084 |
## [0,5]   |    341.385 |   -0.993   25.724    0.566 |    0.677   23.123    0.263 |
##
##           Dim.3    ctr    cos2
## (10,15]    0.288    8.805    0.083 |
## (15,20]    0.398   10.107    0.133 |
## (20,50]   -0.357   10.289    0.047 |
## (5,10]    -0.477   39.954    0.319 |
## [0,5]      0.545   30.844    0.171 |
```

The first thing we can see from the summary is that we have a chi square statistic of 6099.333, great enough to reject the  $H_0$ , which means the intensity of the relation is high. If we take a look at the variances from the different dimensions, we can see that all together sum more than 1.

## 5.2 Eigenvalues and dominant axes analysis. How many axes we have to consider?

```
mean(res.ca$eig[,1])
```

```
## [1] 0.3343199
```

Following the kaiser kriteria and the value got in the output, we should retain dimensions with a variance greater than 0.3343199. In this case, the first dimension fulfills this because its variance is 0.751, but it is not enough to work with data so, we would choose 2 o 3 dimensions for this case.

## 6 MCA analysis

The Multiple correspondence analysis (MCA) is an extension of the simple correspondence analysis for summarizing and visualizing a data table containing more than two categorical variables.

MCA is generally used to analyse a data set from survey. The goal is to identify:

- A group of individuals with similar profile in their answers to the questions
- The associations between variable categories

First, we load the libraries we'll use:

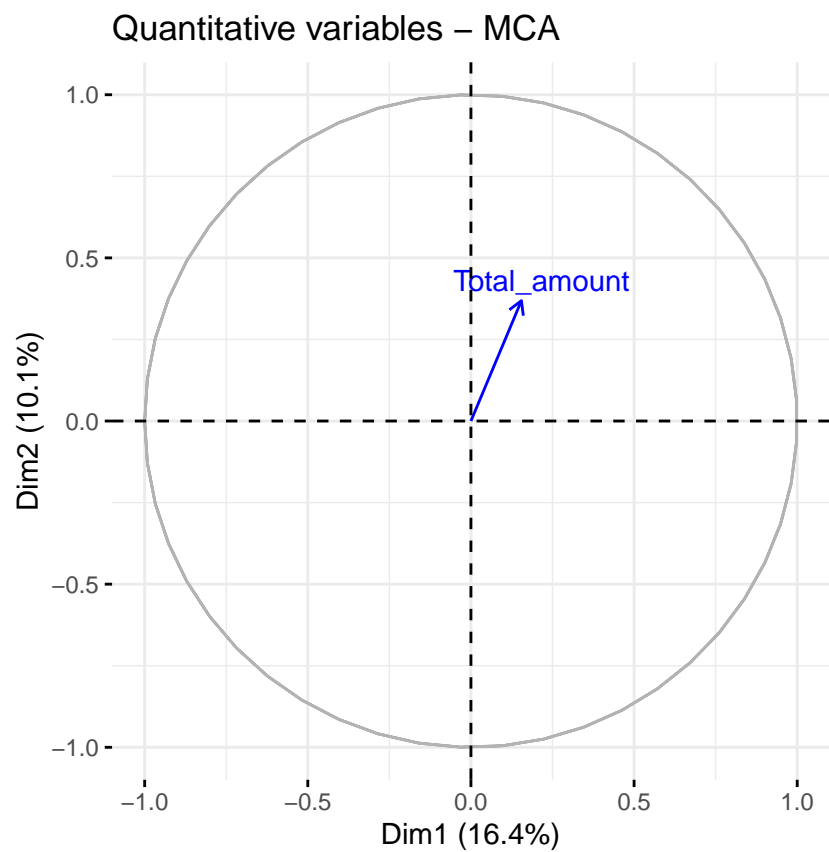
```
library(FactoMineR)
library(factoextra)
```

Now, we can start computing the MCA for our categorical variables:

```
res.mca <- MCA(
  df[,c(1:2,15:17,19,25,27:28,31)],
  quanti.sup=c(3),
  quali.sup=c(8,10),
  graph=FALSE
)
```

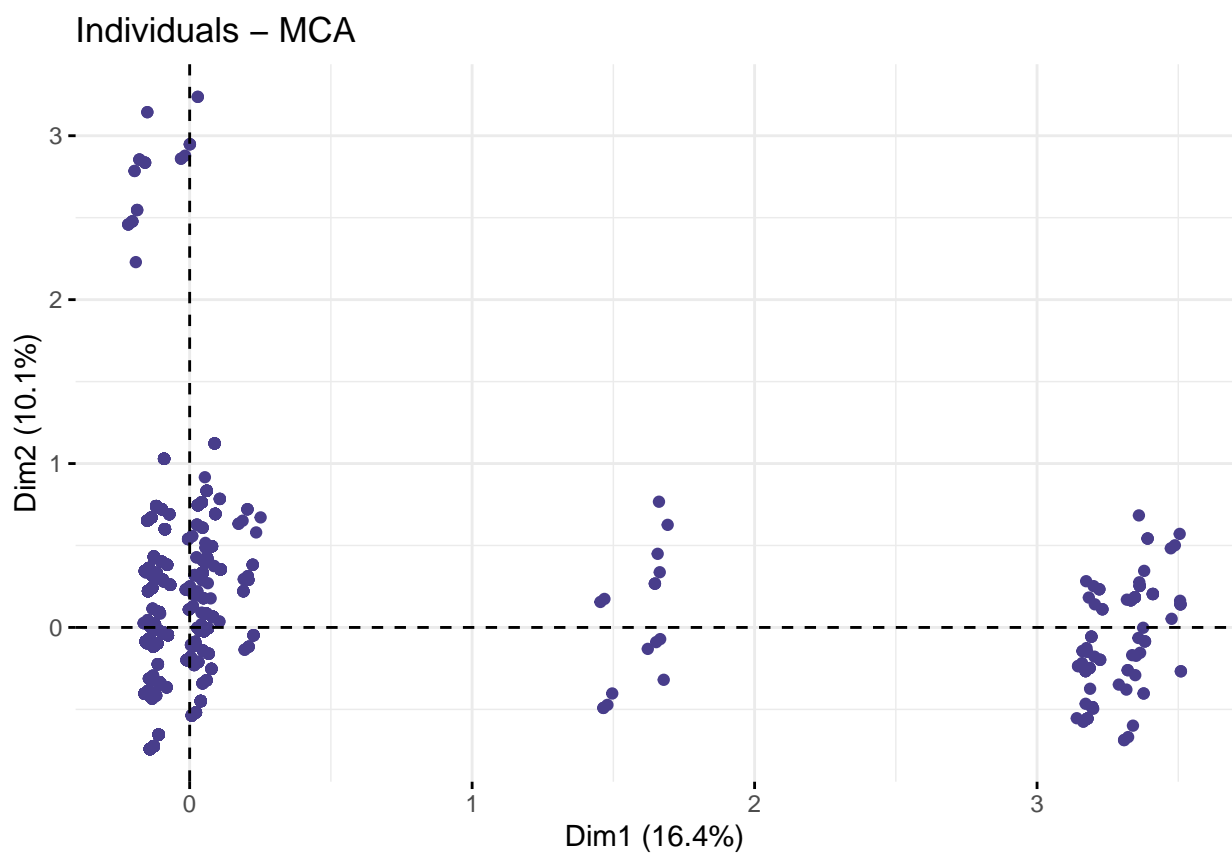
Let's look at the supplementary quantitative variable Total\_amount. We can see that it is closer to the Dim2 than to the Dim1.

```
fviz_mca_var(res.mca, choice="quanti.sup", repel=TRUE, ggtheme=theme_minimal())
```



Cloud of individuals:

```
fviz_mca_ind(  
  res.mca,  
  geom=c("point"),  
  col.ind="darkslateblue"  
)
```



## 6.1 Eigenvalues and dominant axes analysis

How many axes we have to consider for next Hierarchical Classification stage? We consider, according to the generalized Kaiser theorem, all those dimensions such that their eigenvalue is greater than the mean. We see that the average gives us 0.1428571. Therefore, we will take up to dimension 6, which represents the 62.07% of the sample.

```
mean(res.mca$eig[,1])
```

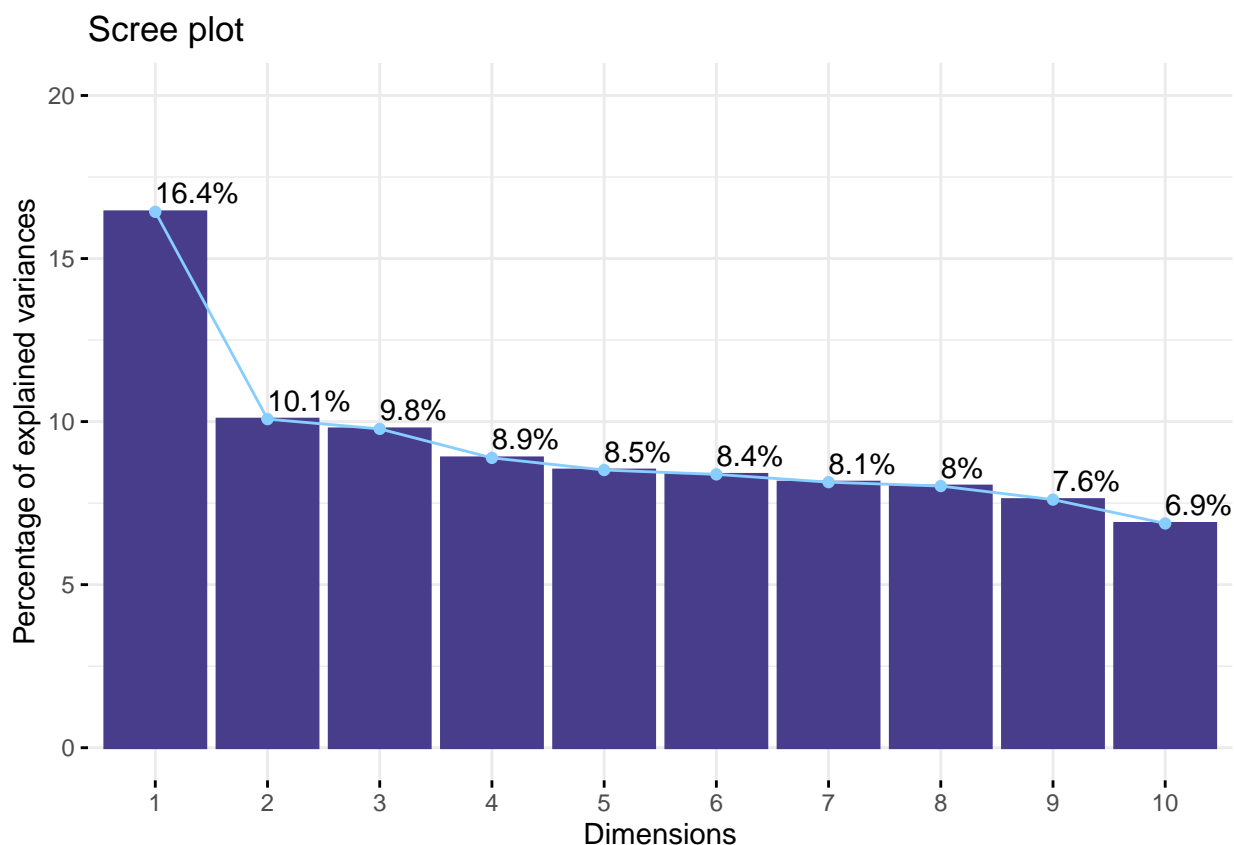
```
## [1] 0.1428571
```

```
head(get_eigenvalue(res.mca), 10)
```

```
##      eigenvalue variance.percent cumulative.variance.percent
## Dim.1  0.2817102      16.433095      16.43310
## Dim.2  0.1727341      10.076157      26.50925
## Dim.3  0.1676074       9.777097      36.28635
## Dim.4  0.1523716       8.888343      45.17469
## Dim.5  0.1459733       8.515108      53.68980
## Dim.6  0.1436861       8.381688      62.07149
## Dim.7  0.1396003       8.143350      70.21484
## Dim.8  0.1375543       8.024001      78.23884
## Dim.9  0.1304320       7.608536      85.84738
## Dim.10 0.1179063       6.877867      92.72524
```

We can also visualize the percentages of inertia explained by each MCA dimensions:

```
fviz_screplot(
  res.mca,
  addlabels=TRUE,
  ylim=c(0,20),
  barfill="darkslateblue",
  barcolor="darkslateblue",
  linecolor="skyblue1"
)
```

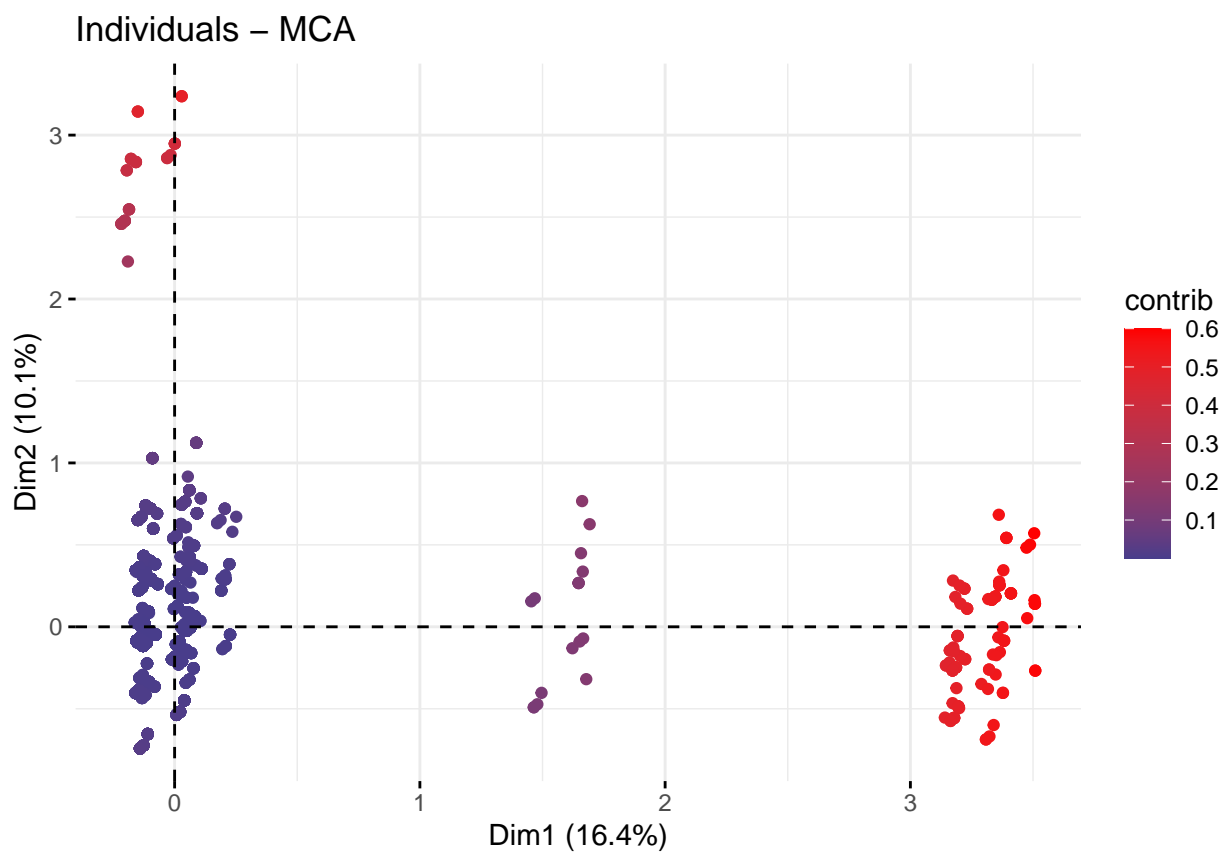


## 6.2 Individuals point of view

Are there any individuals “too contributive”?

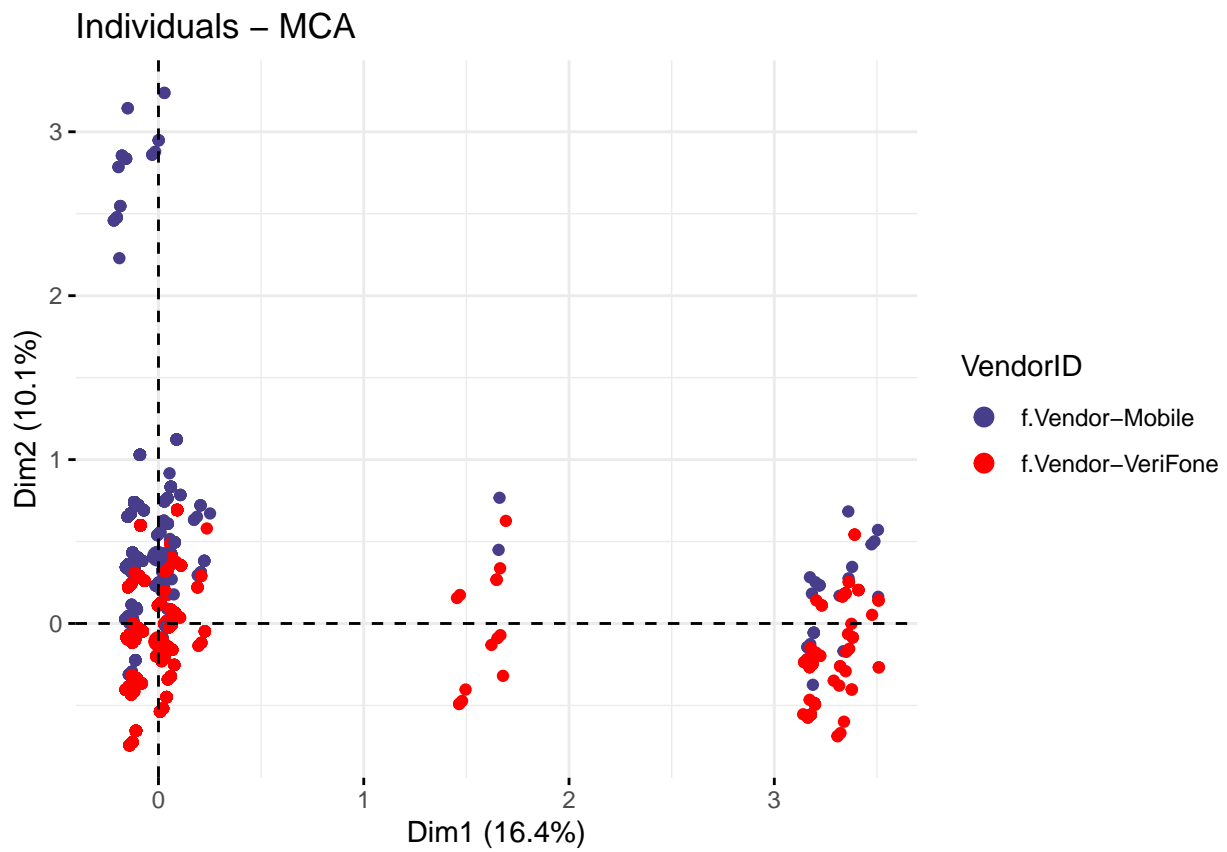


```
fviz_mca_ind(
  res.mca,
  geom=c("point"),
  col.ind="contrib",
  gradient.cols=c("darkslateblue", "red")
)
```

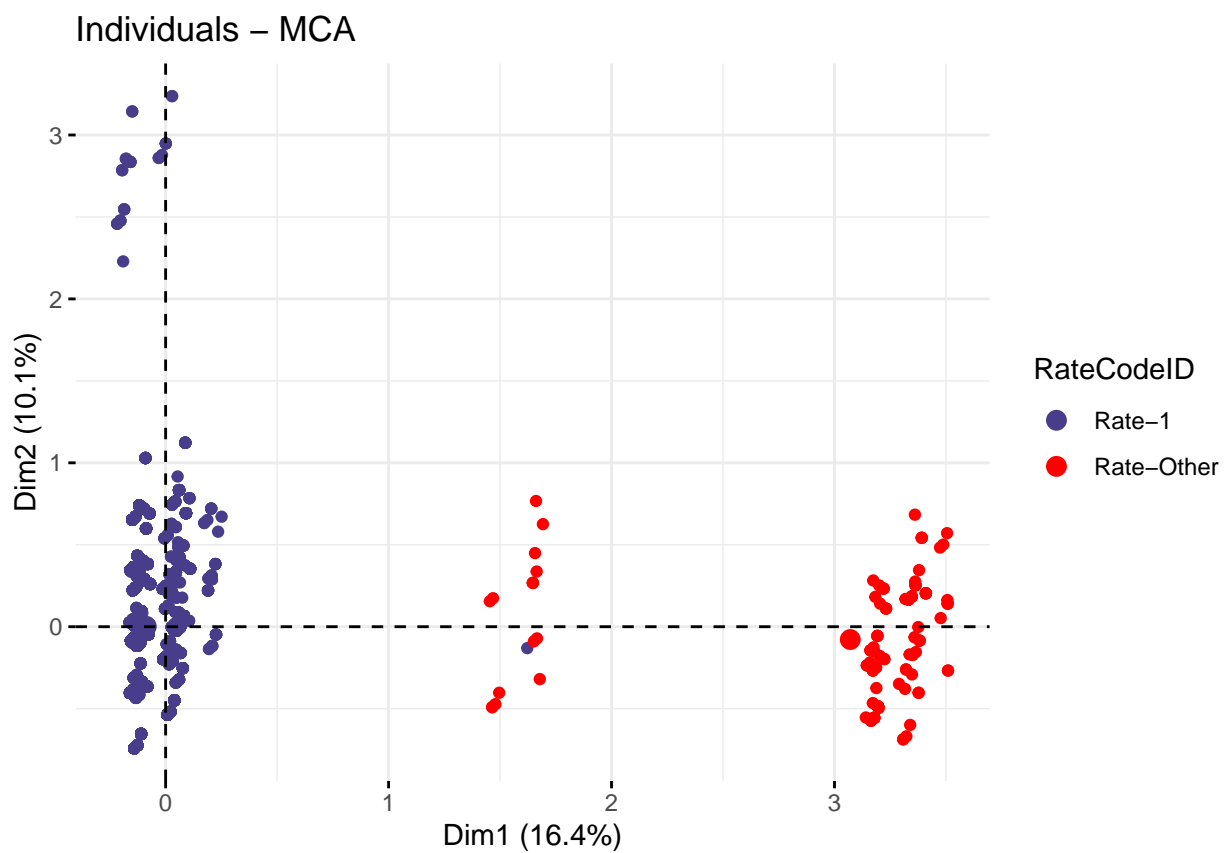


Are there any groups?

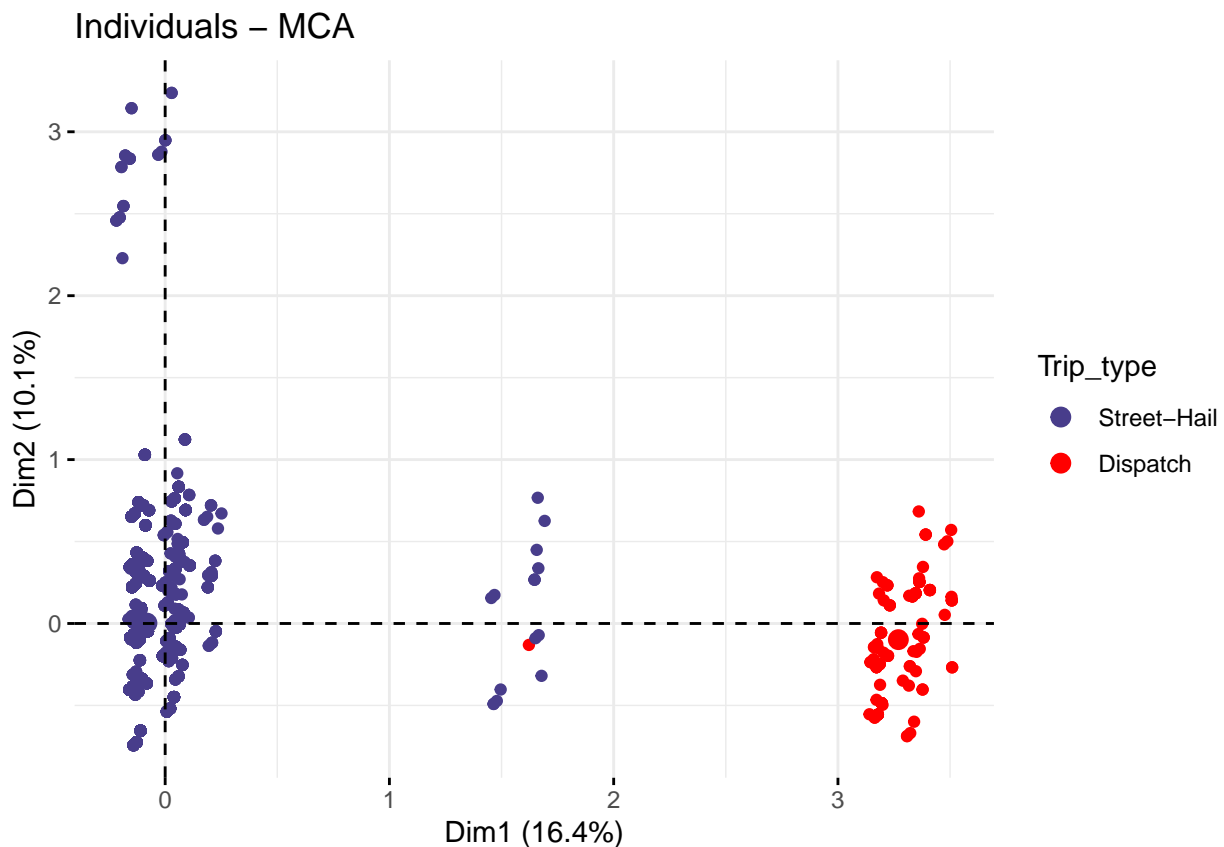
```
fviz_mca_ind(res.mca, label="none", habillage="VendorID", palette=c("darkslateblue", "red"))
```



```
fviz_mca_ind(res.mca, label="none", habillage="RateCodeID", palette=c("darkslateblue", "red"))
```



```
fviz_mca_ind(res.mca, label="none", habillage="Trip_type", palette=c("darkslateblue", "red"))
```



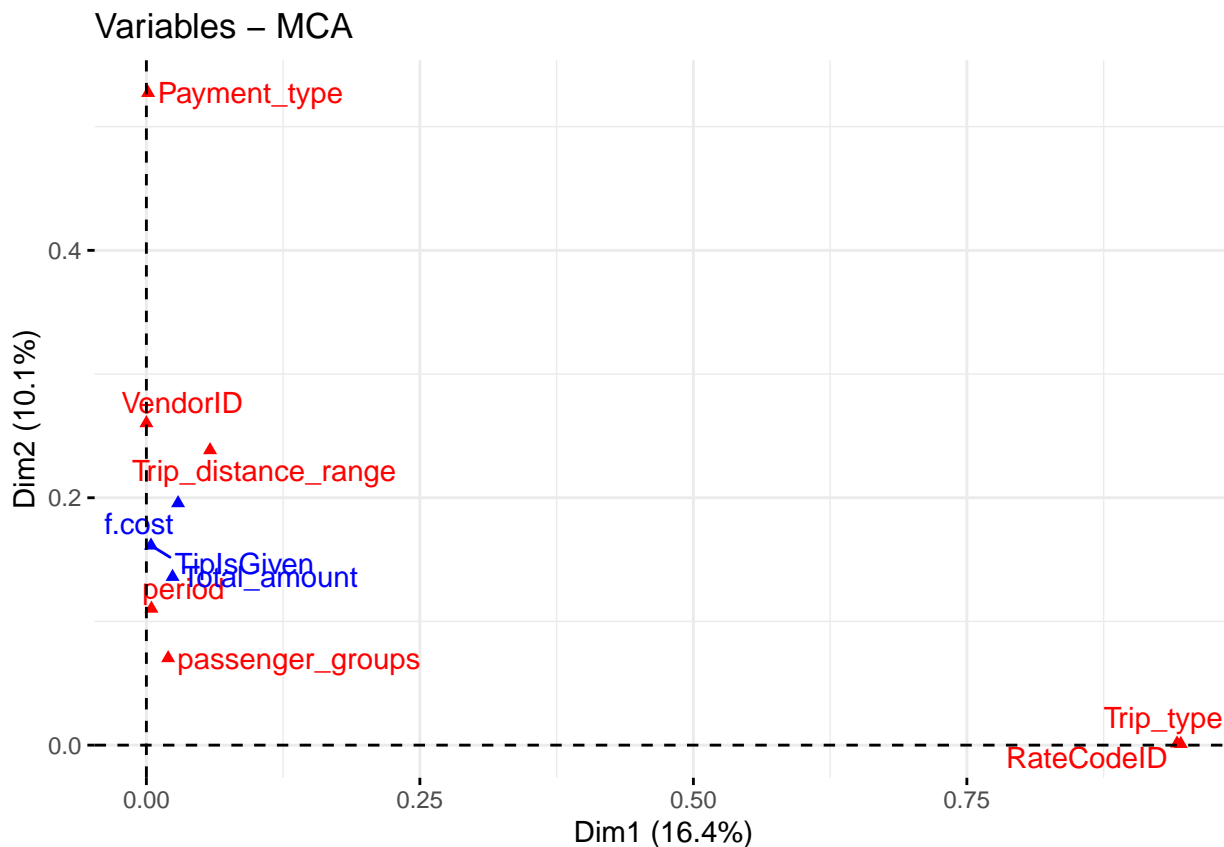
We can see that individuals are more grouped according to some variables than others. For example, the `f.VendorID-Mobile` is along the entire dimension 1 but also in the center of gravity. In contrast, the `Rate-Other` is only in the first dimension and does not touch the second at all.

### 6.3 Interpreting map of categories: average profile versus extreme profiles (rare categories)

Before looking at the categories, let's look at its variables:

As we can see in the plot "Variables representation", the correlation between the `Payment_type` factor taking into account the `eta2` and the second factorial axis is a value greater than 0.5. On the other hand, we can see that something similar happens with the `Trip_type` factor and `RateCodeID` in dimension 1.

```
fviz_mca_var(res.mca, choice="mca.cor", repel=TRUE)
```



Now, let's analyze the categories.

As we can see, the “No paid” category (“Payment\_type” variable) is the one farthest from the center of the plot (in dimension 2). The farther from the center of gravity, the more rarely this feature value appears in the sample represented by the dimension. In addition, we see that in dimension 1 we also have two extremes, the “Rate-Other” category (“RateCodeID” variable) and the “Dispatch” category (“Trip\_type” variable). As we have said, this means that these categories are rarely represented in this dimension.

Regarding the center of mass, we can say that we find the categories most represented by the dimensions.

To give an example, let's suppose we look at the first dimension. An observation that we could find with high probability would be the following:

- RateCodeID = Rate-1
- Trip\_type = Street-Hail

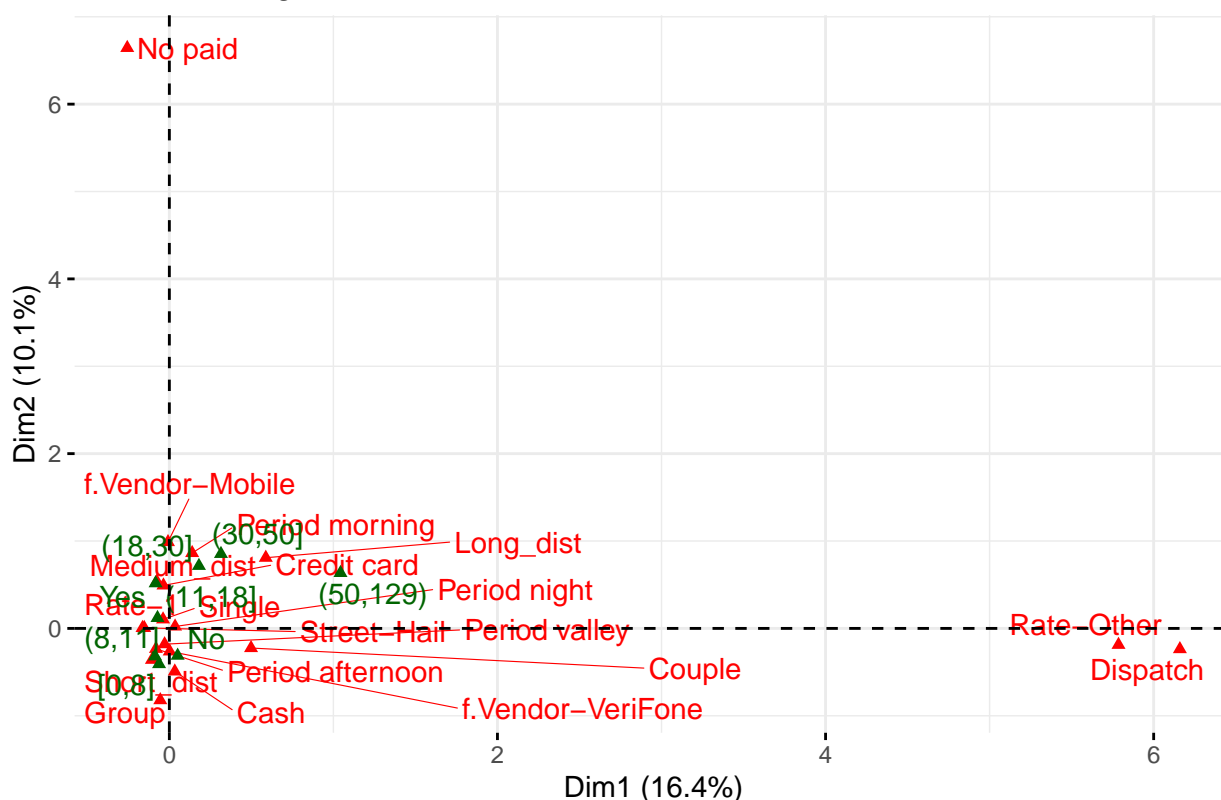
On the other hand, an observation that we could rarely find there would be...

- RateCodeID = Rate-Other
- Trip\_type = Street-Dispatch

We would follow the same logic for dimension 2 considering the Payment\_type variable.

```
fviz_mca_var(res.mca, repel=TRUE)
```

## Variable categories – MCA



## 6.4 Interpreting the axes association to factor map

```
res.desc <- dimdesc(res.mca, axes = c(1,2))
```

### 6.4.1 Description of dimension 1

```
res.desc[[1]]
```

```
## $quanti
##               correlation      p.value
## Total_amount    0.1547222 3.65431e-26
##
## $quali
##               R2      p.value
## RateCodeID      0.945537593 0.000000e+00
## Trip_type        0.942072409 0.000000e+00
## Trip_distance_range 0.058205469 6.898258e-61
## f.cost           0.028972784 1.405425e-27
## passenger_groups 0.019901125 6.814707e-21
## TipIsGiven       0.004240936 9.364240e-06
## period           0.004628593 8.564400e-05
## Payment_type     0.001608040 2.429314e-02
##
## $category
##               Estimate      p.value
## Trip_type=Dispatch 1.67529735 0.000000e+00
## RateCodeID=Rate-Other 1.57877258 0.000000e+00
## Trip_distance_range=Long_dist 0.24028354 4.637674e-62
## passenger_groups=Couple 0.19279452 5.856637e-22
## f.cost=(50,129) 0.43727781 5.906344e-17
## f.cost=(30,50] 0.05054341 1.602061e-06
## TipIsGiven=No 0.03566808 9.364240e-06
## period=Period morning 0.06536718 5.700992e-04
## Payment_type=Cash 0.06349408 1.434472e-02
## Payment_type=Credit card 0.02679756 2.616189e-02
```

```
## f.cost=[0,8] -0.14970203 8.537458e-03
## Trip_distance_range=Medium_dist -0.11215628 6.996595e-03
## f.cost=(11,18] -0.15476359 3.894367e-03
## period=Period afternoon -0.05178612 1.144725e-03
## f.cost=(8,11] -0.16266832 6.499724e-04
## TipIsGiven=Yes -0.03566808 9.364240e-06
## f.cost=(18,30] -0.02068728 1.202545e-07
## passenger_groups=Single -0.09190735 2.059738e-09
## Trip_distance_range=Short_dist -0.12812726 2.015102e-22
## Trip_type=Street-Hail -1.67529735 0.000000e+00
## RateCodeID=Rate-1 -1.57877258 0.000000e+00
##
## attr(,"class")
## [1] "condes" "list"
```

There is no info for the **quantitative** variables here.

In the first dimension we see that for the **qualitative** variables the most positively related, from more to less, are:

- RateCodeID (0.95)
- Trip\_type (0.94)

If we look at the **categories**, we see that the most related are,

- for Trip\_type:
  - Dispatch (1.68)
  - Long\_dist (0.24)
- and for RateCodeID:
  - Rate-Other (1.58)

## 6.4.2 Description of dimension 2

```
res.desc[[2]]
```

```
## $quanti
##           correlation      p.value
## Total_amount  0.3688482 5.757656e-149
##
## $quali
##           R2      p.value
## Payment_type  0.5272544813 0.000000e+00
## VendorID      0.2602830667 6.879178e-305
## Trip_distance_range 0.2384878813 4.714678e-274
## f.cost        0.1956079989 4.287815e-215
## TipIsGiven    0.1613968295 6.956769e-179
## period        0.1103532182 9.429917e-117
## passenger_groups 0.0703669803 6.304633e-74
## Trip_type     0.0013941924 1.111798e-02
## RateCodeID    0.0009990214 3.163284e-02
##
## $category
##           Estimate      p.value
## Payment_type=No paid 1.84096016 0.000000e+00
## VendorID=f.Vendor-Mobile 0.26007767 6.879178e-305
## TipIsGiven=Yes 0.17229953 6.956769e-179
## Trip_distance_range=Long_dist 0.19939818 5.880829e-119
## period=Period morning 0.30980763 1.193381e-106
## f.cost=(18,30] 0.18702736 1.831882e-102
## Trip_distance_range=Medium_dist 0.08653538 8.235254e-84
## passenger_groups=Single 0.17356325 4.157410e-60
## f.cost=(30,50] 0.24385380 3.076322e-39
## f.cost=(50,129) 0.15326671 3.834075e-07
## passenger_groups=Couple 0.03719691 1.495679e-05
## Trip_type=Street-Hail 0.05046600 1.111798e-02
## RateCodeID=Rate-1 0.04018420 3.163284e-02
## RateCodeID=Rate-Other -0.04018420 3.163284e-02
```

```
## Trip_type=Dispatch -0.05046600 1.111798e-02
## f.cost=(11,18] -0.06069884 1.647278e-06
## period=Period valley -0.12396133 4.566127e-14
## period=Period afternoon -0.14612741 8.436539e-21
## f.cost=(8,11] -0.24322507 1.869439e-36
## passenger_groups=Group -0.21076016 2.204053e-67
## f.cost=[0,8] -0.28022396 5.282753e-68
## TipIsGiven=No -0.17229953 6.956769e-179
## Payment_type=Credit card -0.71587782 4.558246e-227
## Trip_distance_range=Short_dist -0.28593356 2.059524e-267
## VendorID=f.Vendor-VeriFone -0.26007767 6.879178e-305
## Payment_type=Cash -1.12508234 0.000000e+00
##
## attr(,"class")
## [1] "condes" "list"
```

There is no info for the **quantitative** variables here.

For the second dimension we see that for the **qualitative** variables the most positively related, from more to less, are:

- Payment\_type (0.53)
- VendorID (0.26)

We see that they are not very large numbers, however.

If we look at the **categories**, we see that the most related are,

- for Payment\_type:
  - No paid (1.84)
- and for VendorID:
  - f.Vendor-Mobile (0.26)

## 6.5 Perform a MCA taking into account also supplementary variables (use all numeric variables) quantitative and/or categorical. How supplementary variables enhance the axis interpretation?

```
res.mca_all <- MCA(
  df[,c(1:32)],
  quanti.sup=c(3:10, 12:13, 15, 18, 20:22),
  quali.sup=c(27,31),
  graph=FALSE
)
```

### 6.5.1 Description of dimensions

```
res.desc <- dimdesc(res.mca_all, axes = c(1,2))
```

```
res.desc[[1]]
```

#### 6.5.1.1 Description of dimension 1

```
## $quanti
## correlation p.value
## Fare_amount 0.34704329 5.687723e-131
## Trip_distance 0.31264071 2.305988e-105
## Total_amount 0.28704716 2.116125e-88
## tlenkm 0.28360598 2.991362e-86
## traveltime 0.23128431 3.455149e-57
## espeed 0.18449624 1.122581e-36
## Tolls_amount 0.11567250 3.040161e-15
## Tip_amount 0.10081884 6.393352e-12
## Pickup_latitude 0.09471249 1.100053e-10
## Dropoff_latitude 0.08750941 2.525109e-09
## Pickup_longitude 0.04599144 1.760667e-03
```

```

## Passenger_count -0.06437422 1.184978e-05
## hour -0.20861841 1.253392e-46
## Extra -0.46952211 3.175111e-252
##
## $quali
## R2 p.value
## RateCodeID 0.693923341 0.000000e+00
## MTA_tax 0.711903229 0.000000e+00
## improvement_surcharge 0.698232732 0.000000e+00
## Trip_type 0.708486163 0.000000e+00
## hcpck 0.297939266 0.000000e+00
## dropoff 0.209345234 3.392119e-214
## pickup 0.207487287 6.821630e-212
## period 0.164815275 5.012350e-180
## claKM 0.163714821 1.972284e-177
## Trip_distance_range 0.136491381 5.970680e-148
## f.cost 0.102309739 1.704572e-105
## f.tt 0.076192183 6.211428e-77
## paidTolls 0.019509924 1.713157e-20
## passenger_groups 0.006558016 2.507248e-07
##
## $category
## Estimate p.value
## Trip_type=Dispatch 1.43031511 0.000000e+00
## improvement_surcharge=improvement_surcharge_No 1.38427751 0.000000e+00
## MTA_tax=MTA_tax_No 1.39203218 0.000000e+00
## RateCodeID=Rate-Other 1.33153381 0.000000e+00
## Trip_distance_range=Long_dist 0.32675153 8.100939e-136
## hcpck=kHP-2 0.07977521 1.681574e-104
## period=Period morning 0.37766782 8.601718e-102
## hcpck=kHP-4 0.20181507 3.099380e-90
## f.tt=(20,50] 0.18168927 6.096325e-53
## dropoff=dropoff_09 0.47527824 1.556093e-45
## pickup=pickup_09 0.43741728 3.021897e-39
## claKM=kKM-2 0.17416148 2.127247e-38
## f.cost=(18,30] 0.04742755 7.002029e-37
## f.cost=(30,50] 0.21181762 3.678115e-30
## pickup=pickup_10 0.35502449 2.166357e-28
## dropoff=dropoff_10 0.35598916 5.081215e-28
## pickup=pickup_08 0.37525538 4.215535e-27
## f.cost=(50,129) 0.51778721 1.154869e-26
## claKM=kKM-4 0.40726332 3.051827e-26
## period=Period valley 0.06316429 4.676156e-24
## dropoff=dropoff_08 0.31036705 1.118775e-18
## claKM=kKM-1 0.02088140 1.810760e-16
## dropoff=dropoff_11 0.24202770 2.191530e-15
## hcpck=kHP-5 0.51040471 4.740775e-15
## dropoff=dropoff_13 0.23740406 2.794296e-14
## paidTolls=paidTolls_Yes 0.01649022 1.300670e-13
## pickup=pickup_12 0.20658375 1.248113e-11
## pickup=pickup_13 0.20900204 1.839034e-11
## f.tt=f.tt.NA 0.32116637 2.544896e-10
## paidTolls=paidTolls.NA 0.58172801 2.637481e-09
## pickup=pickup_11 0.18243315 3.201149e-09
## dropoff=dropoff_12 0.17393741 1.042928e-08
## dropoff=dropoff_06 0.34833432 4.281223e-07
## pickup=pickup_06 0.29293154 5.357562e-07
## dropoff=dropoff_15 0.10947712 2.502414e-06
## pickup=pickup_14 0.08865893 3.225767e-05
## dropoff=dropoff_14 0.06535148 6.420665e-04
## pickup=pickup_07 0.10272201 9.978763e-04
## pickup=pickup_05 0.18403737 1.347096e-03
## passenger_groups=Couple 0.09533822 1.673249e-03
## pickup=pickup_15 0.05360616 1.924293e-03

```



```

## dropoff=dropoff_05          0.11200689  2.399701e-02
## dropoff=dropoff_07          0.04844411  4.477600e-02
## Trip_distance_range=Medium_dist -0.09239324  3.587226e-02
## pickup=pickup_03           -0.17632814  8.861076e-03
## dropoff=dropoff_16         -0.13845127  4.312258e-03
## pickup=pickup_16           -0.14870023  1.210472e-03
## dropoff=dropoff_22         -0.16127609  9.445790e-04
## f.tt=(15,20]               -0.02276355  5.656303e-04
## pickup=pickup_22           -0.17078247  2.323145e-04
## f.tt=(10,15]               -0.15233505  2.086366e-04
## dropoff=dropoff_03         -0.23113265  1.435539e-04
## f.cost=[0,8]                -0.23016247  1.876733e-05
## f.cost=(11,18]             -0.23321044  1.639065e-05
## pickup=pickup_21           -0.20005018  6.903869e-06
## dropoff=dropoff_23         -0.21249012  2.617862e-06
## pickup=pickup_00           -0.21451652  1.857404e-06
## passenger_groups=Group     -0.11005910  1.742479e-06
## pickup=pickup_23           -0.22469398  9.767269e-07
## dropoff=dropoff_00         -0.22732617  2.822646e-07
## dropoff=dropoff_21         -0.22321151  3.701867e-08
## period=Period night        -0.12234903  1.052033e-08
## hcpck=kHP-3                -0.34574730  5.171016e-11
## dropoff=dropoff_17         -0.27675451  1.836772e-12
## pickup=pickup_19           -0.27361333  9.619675e-15
## dropoff=dropoff_19         -0.28797827  1.382374e-16
## pickup=pickup_17           -0.31883145  6.076516e-17
## dropoff=dropoff_20         -0.30303289  1.825453e-17
## pickup=pickup_20           -0.30264483  2.466439e-18
## paidTolls=paidTolls_No     -0.59821823  5.109733e-20
## pickup=pickup_18           -0.33381152  2.133837e-23
## dropoff=dropoff_18         -0.33632575  1.896016e-23
## f.cost=(8,11]              -0.31365948  7.123600e-25
## f.tt=(5,10]                -0.22721770  1.228615e-33
## Trip_distance_range=Short_dist -0.23435829  4.137407e-87
## period=Period afternoon    -0.31848308  1.175534e-87
## claKM=kKM-3                -0.49342136  5.050918e-128
## hcpck=kHP-1                -0.44624768  2.882408e-285
## Trip_type=Street-Hail      -1.43031511  0.000000e+00
## improvement_surcharge=improvement_surcharge_Yes -1.38427751  0.000000e+00
## MTA_tax=MTA_tax_Yes        -1.39203218  0.000000e+00
## RateCodeID=Rate-1          -1.33153381  0.000000e+00
##
## attr(,"class")
## [1] "condes" "list"

```

In this dimension, since we have taken into account all the variables, we now have information for the **quantitative** variables. We see that, more or less, the most positively related are:

- Fare\_amount (0.35)
- Trip\_distance (0.31)
- Total\_amount (0.29)

We also see that they do not contribute much given the numbers.

However, there is a little more inverse relationship with Extra, with a -0.47.

Regarding the **qualitative** variables, the new relationship is as follows:

- RateCodeID (0.69)
- MTA\_tax (0.71)
- improvement\_surcharge (0.70)
- Trip\_type (0.71)

If we look at the **categories**, we see that the most related are,

- for Trip\_type:
  - Dispatch (1.43) -> same as before but less related
- for improvement\_surcharge:

- improvement\_surcharge\_No (1.38)
- for MTA\_tax:
  - MTA\_tax\_No (1.39)
- for Trip\_distance\_range:
  - Long\_dist (0.24)
- and for RateCodeID:
  - Rate-Other (1.33) -> same as before but less related

```
res.desc[[2]]
```

### 6.5.1.2 Description of dimension 2

```
## $quanti
##               correlation      p.value
## Extra          0.59540871 0.000000e+00
## Passenger_count 0.18753711 7.367467e-38
## hour           0.14546401 2.768090e-23
## Dropoff_longitude 0.10780500 1.991105e-13
## espeed         0.10518904 7.497280e-13
## Pickup_longitude 0.08329485 1.413350e-08
## Total_amount    0.04423863 2.624881e-03
## Trip_distance    0.04404583 2.740527e-03
## Fare_amount     0.03440690 1.931080e-02
## tlenkm          0.03204240 2.936007e-02
## traveltime     -0.03531017 1.635340e-02
## Tolls_amount    -0.05868397 6.539683e-05
## Dropoff_latitude -0.08128077 3.127258e-08
## Pickup_latitude -0.08469170 8.059026e-09
##
## $quali
##               R2      p.value
## period          0.7193448269 0.000000e+00
## pickup          0.7762688275 0.000000e+00
## dropoff         0.7624477783 0.000000e+00
## hcpck           0.4545819701 0.000000e+00
## MTA_tax         0.1619886885 1.358849e-179
## Trip_type       0.1582247481 4.316437e-175
## improvement_surcharge 0.1533670876 2.604975e-169
## RateCodeID      0.1514542007 4.820984e-167
## claKM           0.1244134404 1.691964e-131
## passenger_groups 0.0437705123 1.254658e-45
## f.cost          0.0076558568 1.198591e-06
## Trip_distance_range 0.0055181933 2.809998e-06
## paidTolls       0.0044565106 3.304810e-05
## f.tt            0.0041361451 1.808199e-03
## VendorID        0.0009197986 3.920678e-02
## Payment_type     0.0012977242 4.980251e-02
##
## $category
##               Estimate      p.value
## hcpck=kHP-1        0.31938183 0.000000e+00
## period=Period night 0.40222038 3.365631e-247
## period=Period afternoon 0.45882535 5.397000e-213
## MTA_tax=MTA_tax_No 0.61577827 1.358849e-179
## Trip_type=Dispatch 0.62682523 4.316437e-175
## improvement_surcharge=improvement_surcharge_No 0.60163400 2.604975e-169
## RateCodeID=Rate-Other 0.57687316 4.820984e-167
## claKM=kKM-3        0.28367351 8.583686e-105
## dropoff=dropoff_19 0.38381622 1.832601e-46
## pickup=pickup_19    0.38522256 2.503341e-46
## dropoff=dropoff_18 0.38168754 6.015986e-46
## pickup=pickup_18    0.37954972 6.838557e-46
## pickup=pickup_20    0.37329421 3.371096e-43
```

## dropoff=dropoff_20	0.37801770	3.497189e-42
## dropoff=dropoff_22	0.38091527	1.100903e-34
## pickup=pickup_22	0.36184277	2.051986e-32
## passenger_groups=Group	0.13528200	1.069335e-31
## dropoff=dropoff_21	0.32784913	6.528817e-29
## dropoff=dropoff_01	0.40551849	1.201710e-27
## pickup=pickup_01	0.41106345	2.203563e-27
## pickup=pickup_17	0.32837866	2.379219e-27
## hcpck=kHP-3	0.32908692	2.832286e-27
## pickup=pickup_21	0.33383417	1.161176e-26
## pickup=pickup_00	0.33610624	2.614122e-25
## dropoff=dropoff_00	0.32779268	3.212179e-24
## pickup=pickup_02	0.40676906	3.883490e-22
## dropoff=dropoff_02	0.41364408	4.972724e-22
## dropoff=dropoff_23	0.30192512	1.126132e-20
## pickup=pickup_23	0.30110187	3.234219e-19
## dropoff=dropoff_04	0.42108454	4.954886e-19
## pickup=pickup_04	0.40921819	2.566232e-15
## pickup=pickup_03	0.35653630	2.723112e-15
## dropoff=dropoff_03	0.33499061	5.956436e-14
## dropoff=dropoff_17	0.22947689	6.600147e-14
## passenger_groups=Couple	0.04411718	7.518697e-13
## claKM=kKM-2	0.10747201	4.561136e-12
## pickup=pickup_05	0.35086823	4.782705e-07
## Trip_distance_range=Long_dist	0.06959039	4.957575e-07
## dropoff=dropoff_05	0.33403293	1.329113e-06
## f.cost=(8,11]	0.02021781	4.875813e-04
## f.tt=[0,5]	0.03435830	1.662342e-03
## hcpck=kHP-4	0.05473367	1.732551e-02
## paidTolls=paidTolls.NA	0.36969056	2.729367e-02
## VendorID=f.Vendor-VeriFone	0.01802595	3.920678e-02
## dropoff=dropoff_07	-0.08624471	4.263781e-02
## VendorID=f.Vendor-Mobile	-0.01802595	3.920678e-02
## Trip_distance_range=Short_dist	-0.03003534	2.057557e-02
## Payment_type=No paid	-0.13844249	1.957223e-02
## claKM=kKM-4	-0.15080413	1.234479e-02
## pickup=pickup_07	-0.10307362	1.055184e-02
## paidTolls=paidTolls_No	-0.03224391	4.893648e-03
## f.tt=(20,50]	-0.06025223	3.961329e-03
## claKM=kKM-1	-0.08122460	3.001909e-03
## paidTolls=paidTolls_Yes	-0.33744664	6.994691e-05
## hcpck=kHP-5	-0.30151068	3.827631e-05
## f.cost=[0,8]	-0.08481507	7.958326e-08
## pickup=pickup_16	-0.19161428	6.634026e-13
## dropoff=dropoff_16	-0.26024731	6.381674e-22
## dropoff=dropoff_08	-0.43184566	5.369589e-31
## passenger_groups=Single	-0.17939918	2.073015e-45
## pickup=pickup_08	-0.53102690	2.383861e-49
## pickup=pickup_11	-0.54835024	3.477338e-53
## dropoff=dropoff_12	-0.54861363	3.112894e-53
## dropoff=dropoff_13	-0.53735642	6.910645e-55
## pickup=pickup_12	-0.53762203	6.088027e-55
## pickup=pickup_13	-0.55875049	3.267704e-57
## dropoff=dropoff_09	-0.54245620	1.605053e-57
## pickup=pickup_09	-0.55813145	7.767141e-61
## dropoff=dropoff_11	-0.55595768	9.959401e-62
## dropoff=dropoff_10	-0.59076056	7.773922e-69
## pickup=pickup_10	-0.59157063	1.412063e-70
## claKM=kKM-5	-0.15911679	1.682905e-71
## pickup=pickup_15	-0.54732996	3.165865e-72
## dropoff=dropoff_15	-0.55708943	1.053768e-72
## pickup=pickup_14	-0.61682332	1.161024e-92
## dropoff=dropoff_14	-0.63592139	2.251034e-94
## RateCodeID=Rate-1	-0.57687316	4.820984e-167

```
## improvement_surcharge=improvement_surcharge_Yes -0.60163400 2.604975e-169
## Trip_type=Street-Hail -0.62682523 4.316437e-175
## MTA_tax=MTA_tax_Yes -0.61577827 1.358849e-179
## period=Period morning -0.47130282 8.452319e-206
## hcpck=kHP-2 -0.40169174 0.000000e+00
## period=Period valley -0.38974292 0.000000e+00
##
## attr(,"class")
## [1] "condes" "list "
```

In this dimension, since we have taken into account all the variables, we now have information for the **quantitative** variables. We see that, more or less, the most positively related are:

- Extra (0.59540871)
- Passenger\_count (0.18753711)

For the second dimension we see that for the **qualitative** variables the most positively related, from more to less, are:

- period (0.72)
- pickup (0.78)
- dropoff (0.76)
- hcpck (0.45)
- MTA\_tax (0.16)
- ...
- Payment\_type (0.0013) -> we see that it has lowed down in front of the other variables
- VendorID -> it does not even appear We see that they are not very large numbers, however.

If we look at the **categories**, we see that the most related are,

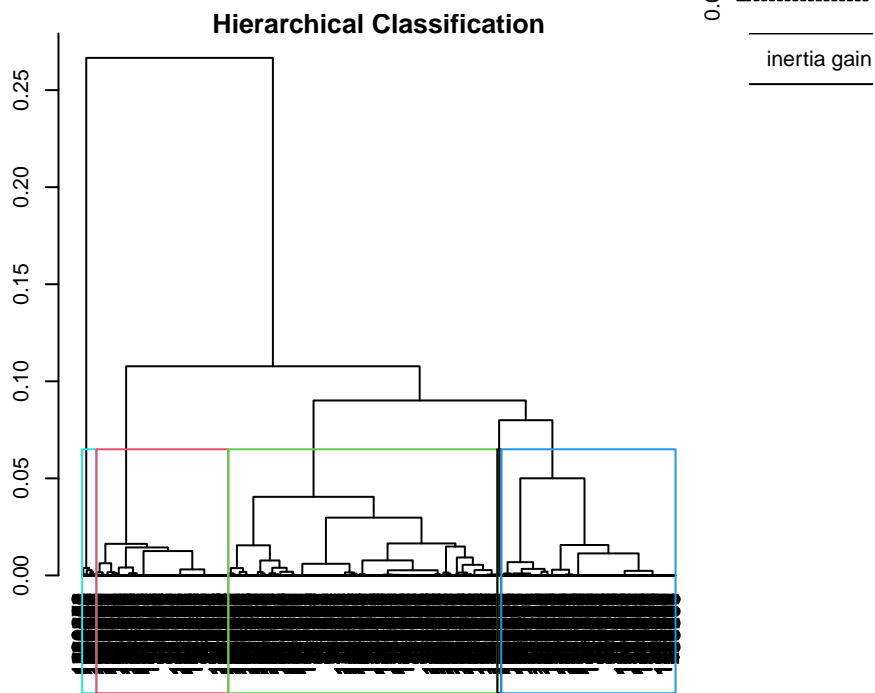
- for period:
  - Period night (0.40)
  - Period afternoon (0.46)
- ...
- for Payment\_type:
  - No paid (1.84) -> now it's inversed
- and for VendorID:
  - f.Vendor-Mobile -> it does not even appear

---

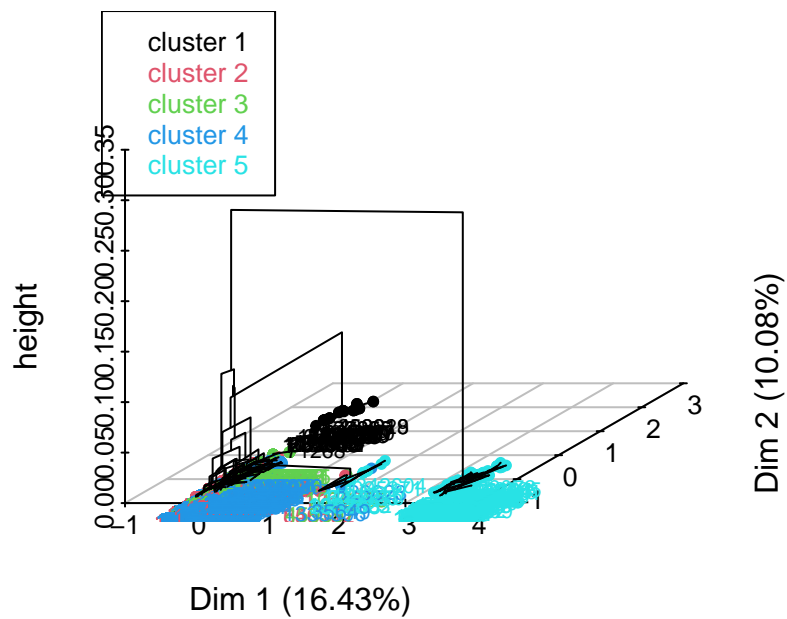
## 7 Hierarchical Clustering (from MCA)

```
res.hcpcMCA <- HCPC(res.mca,nb.clust = 5, order = TRUE)
```

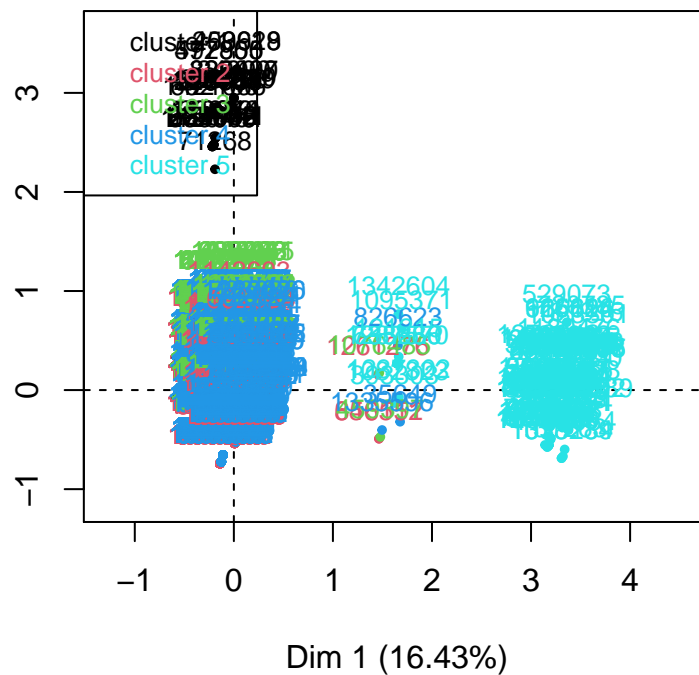
# Hierarchical Clustering



## Hierarchical clustering on the factor map



## Factor map



*Note:* If we chose the default number of cluster it would be 5, as we can guess from the inertia reduction plot, that follows the Elbow's rule (number of black lines plus 1). In our case, after trying with bigger number of clusters, we decided that the default number of cluster was fine for our case and data.

### 7.1 Description of clusters

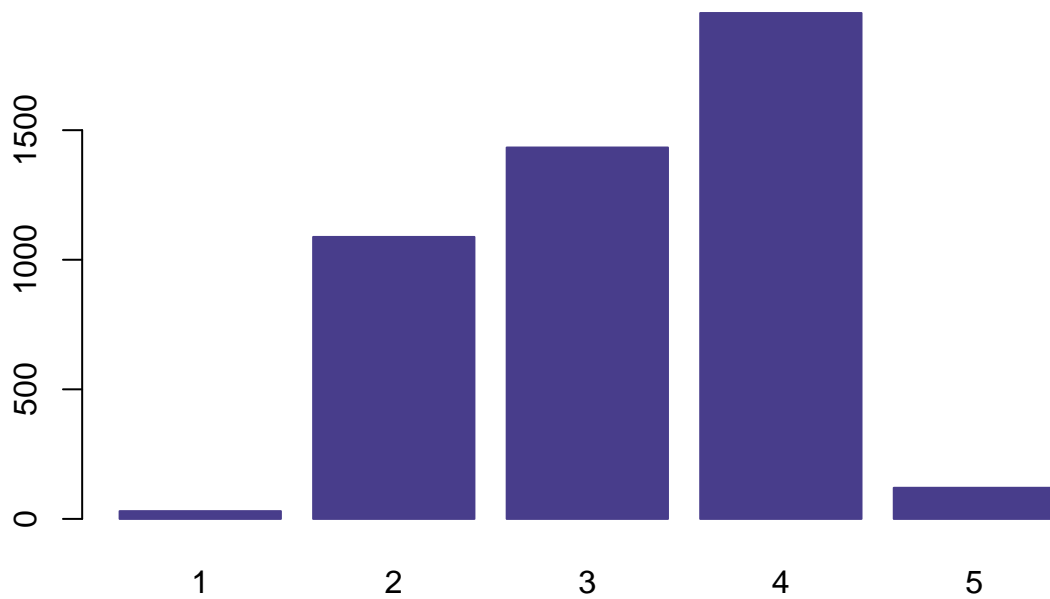
Number of observations in each cluster:

```
table(res.hcpcMCA$data.clust$clust)
```

```
##
##    1    2    3    4    5
##   30 1088 1433 1952 120
```

```
barplot(table(res.hcpcMCA$data.clust$clust), col="darkslateblue", border="darkslateblue", main="[hierarc
```

## [hierarchical] #observations/cluster



## 7.2 Interpret the results of the classification

### 7.2.1 The description of the clusters by the variables

```
names(res.hcpcMCA$desc.var)
```

```
## [1] "test.chi2" "category" "quanti.var" "quanti" "call"
```

```
res.hcpcMCA$desc.var$test.chi2 # categorical variables which characterizes the clusters
```

```
##                p.value df
## RateCodeID      0.000000e+00 4
## Payment_type    0.000000e+00 8
## Trip_type       0.000000e+00 4
## period          0.000000e+00 12
## passenger_groups 2.601045e-94 8
## Trip_distance_range 6.685645e-92 8
## f.cost          1.448630e-51 20
## VendorID        2.325462e-27 4
## TipIsGiven      2.455088e-11 4
```

We start with the description of the categorical variables that characterize the clusters, so in this output we do not have dimensions because it is the total association. We can see the intensity of the variables, in our case the variables that affect more to the clustering are **RateCodeID**, **Payment\_type**, **Trip\_type** and **period** because they are the ones with the smallest p.value. The variables associated to the clusters are the ones that appear on the output.

Next, we want to see for each cluster which are the categories that characterize them. The clusters that contain more individuals are the first, the second and the fourth one. Clusters number 1 and 5 are the ones that have less individuals. We proceed to analyze them.

```
res.hcpcMCA$desc.var$category # description of each cluster by the categories
```

```
## $`1`
##                Cla/Mod  Mod/Cla  Global  p.value
## Payment_type=No paid    100.000000 100.00000 0.6489293 3.287724e-78
## VendorID=f.Vendor-Mobile 3.0832477 100.00000 21.0469392 3.471103e-21
## TipIsGiven=No          1.0409438 100.00000 62.3404716 6.580800e-07
```

```

## period=Period morning      1.4760148  26.66667 11.7239888 2.482286e-02
## passenger_groups=Single    0.7464607  96.66667 84.0363400 4.121461e-02
## TipIsGiven=Yes             0.0000000   0.00000 37.6595284 6.580800e-07
## Payment_type=Credit card   0.0000000   0.00000 45.3385248 1.248361e-08
## Payment_type=Cash          0.0000000   0.00000 54.0125460 6.774205e-11
## VendorID=f.Vendor-VeriFone 0.0000000   0.00000 78.9530608 3.471103e-21
##
##                               v.test
## Payment_type=No paid      18.721812
## VendorID=f.Vendor-Mobile   9.447473
## TipIsGiven=No             4.973343
## period=Period morning      2.244148
## passenger_groups=Single     2.041364
## TipIsGiven=Yes            -4.973343
## Payment_type=Credit card  -5.692987
## Payment_type=Cash         -6.525573
## VendorID=f.Vendor-VeriFone -9.447473
##
## $`2`
##                               Cla/Mod      Mod/Cla      Global      p.value
## period=Period afternoon    88.379983    95.7720588    25.5029202    0.000000e+00
## Trip_distance_range=Short_dist 28.162853    76.9301471    64.2872594    2.073868e-24
## Trip_type=Street-Hail      24.118821    100.0000000    97.5773307    5.821121e-14
## RateCodeID=Rate-1          24.132562    99.7242647    97.2528661    1.150890e-11
## passenger_groups=Couple     37.900875    11.9485294    7.4194246    5.792479e-10
## f.cost=(11,18]             29.461279    32.1691176    25.6975990    3.920300e-08
## f.cost=(8,11]              28.844483    30.5147059    24.8972529    1.397923e-06
## VendorID=f.Vendor-Mobile    26.927030    24.0808824    21.0469392    5.477246e-03
## VendorID=f.Vendor-VeriFone  22.630137    75.9191176    78.9530608    5.477246e-03
## f.cost=(50,129)            9.523810     0.5514706     1.3627515     4.760384e-03
## Payment_type=No paid        0.000000     0.0000000     0.6489293     3.099747e-04
## passenger_groups=Single     22.265122    79.5036765    84.0363400    5.081032e-06
## RateCodeID=Rate-Other       2.362205     0.2757353     2.7471339     1.150890e-11
## f.cost=(18,30]             13.812155     9.1911765     15.6608263     1.988020e-12
## Trip_type=Dispatch          0.000000     0.0000000     2.4226693     5.821121e-14
## f.cost=(30,50]             4.072398     0.8272059     4.7804456     5.272518e-16
## period=Period morning       4.428044     2.2058824     11.7239888     1.528422e-37
## Trip_distance_range=Long_dist 1.654135     1.0110294     14.3845987     1.258712e-66
## period=Period valley        1.746032     2.0220588     27.2550292     6.479660e-137
## period=Period night         0.000000     0.0000000     35.5180619     1.204220e-246
##
##                               v.test
## period=Period afternoon      Inf
## Trip_distance_range=Short_dist 10.195634
## Trip_type=Street-Hail        7.512044
## RateCodeID=Rate-1            6.786246
## passenger_groups=Couple       6.195976
## f.cost=(11,18]               5.494405
## f.cost=(8,11]                4.825301
## VendorID=f.Vendor-Mobile      2.777538
## VendorID=f.Vendor-VeriFone    -2.777538
## f.cost=(50,129)              -2.822816
## Payment_type=No paid          -3.606818
## passenger_groups=Single       -4.561414
## RateCodeID=Rate-Other        -6.786246
## f.cost=(18,30]               -7.035322
## Trip_type=Dispatch            -7.512044
## f.cost=(30,50]               -8.105047
## period=Period morning        -12.805447
## Trip_distance_range=Long_dist -17.243201
## period=Period valley         -24.905542
## period=Period night          -33.541337
##
## $`3`
##                               Cla/Mod      Mod/Cla      Global      p.value
## period=Period valley         77.222222    67.8995115    27.2550292    0.000000e+00

```



```

## period=Period morning      84.870849  32.1004885 11.7239888 2.187992e-171
## passenger_groups=Single    36.885457 100.0000000 84.0363400 7.053895e-133
## Trip_type=Street-Hail      31.766792 100.0000000 97.5773307 4.847071e-19
## RateCodeID=Rate-1          31.828292  99.8604327 97.2528661 2.899525e-18
## f.cost=[0,8]                36.990596  32.9378925 27.6011248 7.127666e-08
## Trip_distance_range=Short_dist 33.411844  69.2951849 64.2872594 1.662139e-06
## Payment_type=Cash           33.520224  58.4089323 54.0125460 5.704677e-05
## TipIsGiven=No               32.616239  65.5966504 62.3404716 2.137595e-03
## TipIsGiven=Yes              28.317059  34.4033496 37.6595284 2.137595e-03
## f.cost=(18,30]              26.104972  13.1891137 15.6608263 1.731548e-03
## Payment_type=Credit card    28.435115  41.5910677 45.3385248 5.948993e-04
## f.cost=(30,50]              20.814480   3.2100488  4.7804456 5.532609e-04
## f.cost=(50,129)             11.111111   0.4884857  1.3627515 2.255397e-04
## Payment_type=No paid         0.000000   0.0000000  0.6489293 1.404592e-05
## Trip_distance_range=Long_dist 17.894737   8.3042568 14.3845987 1.903360e-16
## RateCodeID=Rate-Other       1.574803   0.1395673  2.7471339 2.899525e-18
## Trip_type=Dispatch           0.000000   0.0000000  2.4226693 4.847071e-19
## passenger_groups=Couple      0.000000   0.0000000  7.4194246 1.245354e-58
## passenger_groups=Group       0.000000   0.0000000  8.5442353 6.606223e-68
## period=Period afternoon      0.000000   0.0000000 25.5029202 4.668360e-228
## period=Period night          0.000000   0.0000000 35.5180619 0.000000e+00
##                               v.test
## period=Period valley         Inf
## period=Period morning        27.907100
## passenger_groups=Single       24.530099
## Trip_type=Street-Hail         8.915708
## RateCodeID=Rate-1            8.715315
## f.cost=[0,8]                  5.387923
## Trip_distance_range=Short_dist 4.790684
## Payment_type=Cash             4.024705
## TipIsGiven=No                 3.070418
## TipIsGiven=Yes               -3.070418
## f.cost=(18,30]               -3.132787
## Payment_type=Credit card     -3.433929
## f.cost=(30,50]               -3.453549
## f.cost=(50,129)              -3.688545
## Payment_type=No paid         -4.343142
## Trip_distance_range=Long_dist -8.228018
## RateCodeID=Rate-Other        -8.715315
## Trip_type=Dispatch           -8.915708
## passenger_groups=Couple      -16.144309
## passenger_groups=Group       -17.412726
## period=Period afternoon      -32.241234
## period=Period night          -Inf
##
## $`4`
##                               Cla/Mod      Mod/Cla      Global      p.value
## period=Period night          96.711328  81.3524590 35.5180619 0.000000e+00
## Trip_distance_range=Long_dist 71.578947  24.3852459 14.3845987 1.695159e-61
## passenger_groups=Group        74.430380  15.0614754  8.5442353 6.686185e-42
## Trip_type=Street-Hail         43.272002 100.0000000 97.5773307 7.579366e-28
## RateCodeID=Rate-1            43.349644  99.8463115 97.2528661 2.409545e-26
## f.cost=(30,50]                71.493213   8.0942623  4.7804456 2.347589e-19
## f.cost=(18,30]                56.215470  20.8504098 15.6608263 1.698775e-16
## passenger_groups=Couple       55.685131   9.7848361  7.4194246 1.982848e-07
## TipIsGiven=Yes                46.984492  41.9057377 37.6595284 3.681425e-07
## VendorID=f.Vendor-VeriFone   43.945205  82.1721311 78.9530608 3.937983e-06
## Payment_type=Credit card     45.753817  49.1290984 45.3385248 9.740537e-06
## f.cost=(50,129)              61.904762   1.9979508  1.3627515 1.700462e-03
## f.cost=(8,11]                39.530843  23.3094262 24.8972529 3.262945e-02
## Payment_type=Cash            39.767721  50.8709016 54.0125460 2.505066e-04
## f.cost=[0,8]                  36.912226  24.1290984 27.6011248 5.881095e-06
## VendorID=f.Vendor-Mobile     35.765673  17.8278689 21.0469392 3.937983e-06
## TipIsGiven=No                39.347675  58.0942623 62.3404716 3.681425e-07

```

```

## Payment_type=No paid          0.000000  0.0000000  0.6489293  6.644475e-08
## f.cost=(11,18]               35.521886  21.6188525  25.6975990  4.928571e-08
## RateCodeID=Rate-Other        2.362205  0.1536885  2.7471339  2.409545e-26
## Trip_type=Dispatch           0.000000  0.0000000  2.4226693  7.579366e-28
## Trip_distance_range=Short_dist 36.238223  55.1741803  64.2872594  2.788750e-28
## passenger_groups=Single       37.760618  75.1536885  84.0363400  1.056095e-44
## period=Period morning         5.350554  1.4856557  11.7239888  2.335274e-94
## period=Period valley          18.015873  11.6290984  27.2550292  2.460280e-99
## period=Period afternoon       9.160305  5.5327869  25.5029202  1.780977e-179
##                               v.test
## period=Period night           Inf
## Trip_distance_range=Long_dist 16.546560
## passenger_groups=Group        13.562453
## Trip_type=Street-Hail         10.938073
## RateCodeID=Rate-1            10.619847
## f.cost=(30,50]                8.995687
## f.cost=(18,30]                8.241632
## passenger_groups=Couple       5.200938
## TipIsGiven=Yes                5.084734
## VendorID=f.Vendor-VeriFone   4.614629
## Payment_type=Credit card      4.422854
## f.cost=(50,129)               3.138101
## f.cost=(8,11]                 -2.136613
## Payment_type=Cash             -3.661741
## f.cost=[0,8]                  -4.530620
## VendorID=f.Vendor-Mobile     -4.614629
## TipIsGiven=No                 -5.084734
## Payment_type=No paid          -5.400529
## f.cost=(11,18]                -5.453868
## RateCodeID=Rate-Other        -10.619847
## Trip_type=Dispatch            -10.938073
## Trip_distance_range=Short_dist -11.028370
## passenger_groups=Single       -14.027639
## period=Period morning         -20.607817
## period=Period valley          -21.155413
## period=Period afternoon       -28.565936
##
## $`5`
##                               Cla/Mod   Mod/Cla   Global   p.value
## RateCodeID=Rate-Other        93.70078740  99.1666667  2.747134  3.098738e-225
## Trip_type=Dispatch           100.00000000  93.3333333  2.422669  2.173170e-216
## Trip_distance_range=Long_dist  7.66917293  42.5000000  14.384599  3.518497e-14
## f.cost=(50,129)              15.87301587  8.3333333  1.362751  4.263359e-06
## TipIsGiven=No                 3.33102012  80.0000000  62.340472  2.655335e-05
## passenger_groups=Couple       6.41399417  18.3333333  7.419425  7.020893e-05
## passenger_groups=Single       2.34234234  75.8333333  84.036340  1.837786e-02
## TipIsGiven=Yes                1.37851809  20.0000000  37.659528  2.655335e-05
## Trip_distance_range=Short_dist 1.68236878  41.6666667  64.287259  3.637606e-07
## Trip_type=Street-Hail         0.17734427  6.6666667  97.577331  2.173170e-216
## RateCodeID=Rate-1            0.02224199  0.8333333  97.252866  3.098738e-225
##                               v.test
## RateCodeID=Rate-Other        32.039255
## Trip_type=Dispatch           31.397728
## Trip_distance_range=Long_dist  7.577658
## f.cost=(50,129)              4.598112
## TipIsGiven=No                 4.201175
## passenger_groups=Couple       3.975577
## passenger_groups=Single       -2.357916
## TipIsGiven=Yes                -4.201175
## Trip_distance_range=Short_dist -5.087006
## Trip_type=Street-Hail        -31.397728
## RateCodeID=Rate-1            -32.039255

```

**Cluster 1** The first thing we can notice from this cluster is that all observations are of **Payment\_type=No**

**paid**, even though this category only intervenes in the sample 0.65% this cluster contains all the individuals of this payment type and all of the observations in the cluster are of **VendorID=f.Vendor-Mobile**, a category that intervenes a 21.05% from the sample, but this cluster is that small that we only have a 3.08% of observations of this kind represented in the cluster. So, what is logical is that the other payment types represent a 0% in this cluster as well as the other vendor type. We can also see that all the observations in the did not left a tip, and again and because of the size of the cluster, even though the **TipIsGive=No** represents a 62.34% of the observations from sample, we only have a representation of the 1.04% of these individuals in this cluster. We can also notice that the majority of the trips are made by just one person (96.67%) and we have some morning trips (26.67%).

**Cluster 2** The first thing we can see from the cluster is that all of the observations present are of the category **Trip\_type=Street-Hail** and we have in this cluster a representation of the 24.12% of the observations of this category from sample. Something similar happens to the category **RateCodeID=Rate-1**. We can also see that we have the 88.38% of the observations from sample of the category **period=Period afternoon** represented in this cluster and they represent the 95.77% of the observations of the cluster. We can also notice that around the 80% of the observations in this cluster are single passengers and we have 22.27% of the observations of this category from the sample represented here.

!!!PENDENT EXPLICAR **Cluster 3 Cluster 4**

**Cluster 5** The first thing we can notice from this cluster is that we have represented in this cluster all the observations of **Trip\_type=Dispatch** from the sample here and they represent the 93.33% of the observations of this kind in the cluster, so the rest are **Trip\_type=Street-Hail** and we only have a representation of 0.18% of the observations from the sample in this cluster. We can also see that the 80% of the observations in the cluster did not left any tip and the other 20% left some tips, we have a very small representation of observations from the sample of these two categories in this cluster. We can also see that almost every observation in the cluster (99.17%) is of **RateCodeID=Rate-Ohter** and we have the 93.70% of the observations from the sample of this category represented in this cluster. We can see that in this cluster we have represented the 15.87% of the observations from the sample of the category **f.cost=(50,129)**.

We now proceed to see the quantitative variables that characterizes the clusters.

```
res.hcpcMCA$desc.var$quanti.var # quantitative variables which characterizes the clusters
```

```
##                               Eta2      P-value
## Total_amount 0.03950465 3.518655e-39
```

We can see in the output that the variable that appears is slightly over represented in the clusters. We can notice that **Total\_amount** is over represented with 0.04 units over the global mean. So it is practically the same as the global mean.

We want to know now which variables are associated with the quantitative variables.

```
res.hcpcMCA$desc.var$quanti # description of each cluster by the quantitative variables
```

```
## $`1`
## NULL
##
## $`2`
##               v.test Mean in category Overall mean sd in category Overall sd
## Total_amount -7.859152      11.83333      13.9264      7.170368      10.04487
##               p.value
## Total_amount 3.867431e-15
##
## $`3`
##               v.test Mean in category Overall mean sd in category Overall sd
## Total_amount -6.69081      12.45144      13.9264      7.604782      10.04487
##               p.value
## Total_amount 2.219385e-11
##
## $`4`
##               v.test Mean in category Overall mean sd in category Overall sd
## Total_amount 11.26398      15.87319      13.9264      11.44962      10.04487
##               p.value
## Total_amount 1.976246e-29
##
## $`5`
##               v.test Mean in category Overall mean sd in category Overall sd
```

```
## Total_amount 5.641927      19.03283      13.9264      19.88545      10.04487
##                p.value
## Total_amount 1.681571e-08
```

!!!!PENDENT EXPLICAR Cluster 1 Cluster 2 Cluster 3 Cluster 4 Cluster 5

## 7.2.2 Partition quality

We are going to evaluate the partition quality.

```
#res.hcpcMCA$call$t$within[1] = Total sum of squares
#(res.hcpcMCA$call$t$within[1]-res.hcpcMCA$call$t$within[5] = between sum of squares
((res.hcpcMCA$call$t$within[1]-res.hcpcMCA$call$t$within[5])/res.hcpcMCA$call$t$within[1])*100
```

### 7.2.2.1 Gain in inertia (in %)

```
## [1] 59.14975
```

The quality of this reduction is of 59.15%.

In case we wanted to achieve an 80% of the clustering representativity we would need 13 clusters.

```
((res.hcpcMCA$call$t$within[1]-res.hcpcMCA$call$t$within[13])/res.hcpcMCA$call$t$within[1])*100

## [1] 80.77602
```

## 7.3 Parangons and class-specific individuals.

### 7.3.1 The description of the clusters by the individuals

```
res.hcpcMCA$desc.ind$para # representative individuals of each cluster
```

```
## Cluster: 1
##      632100  1421036      64149   154087   437922
## 0.2538258 0.2538258 0.3519479 0.3519479 0.3519479
## -----
## Cluster: 2
##      48587   53670   55526   93463   96109
## 0.2668603 0.2668603 0.2668603 0.2668603 0.2668603
## -----
## Cluster: 3
##      43055   85690   135038   135275   139019
## 0.1708958 0.1708958 0.1708958 0.1708958 0.1708958
## -----
## Cluster: 4
##      1200   13382   14314   21607   22076
## 0.222467 0.222467 0.222467 0.222467 0.222467
## -----
## Cluster: 5
##      485688  1399808  1399419   747830   27974
## 0.2623554 0.2623554 0.2979732 0.3158258 0.4450544
```

What we obtain are the more representative individuals, parangons, for each cluster. We get the rownames of each paragon in every single cluster.

```
res.hcpcMCA$desc.ind$dist # individuals distant from each cluster
```

```
## Cluster: 1
##      881540  209928  453619   24990  329000
## 3.776488 3.763555 3.763555 3.753329 3.753329
## -----
## Cluster: 2
##      1261276  646551  856112  187123  226984
## 1.936593 1.817659 1.817659 1.553835 1.553835
## -----
## Cluster: 3
##      459397  1076485  128467  163845  168358
```

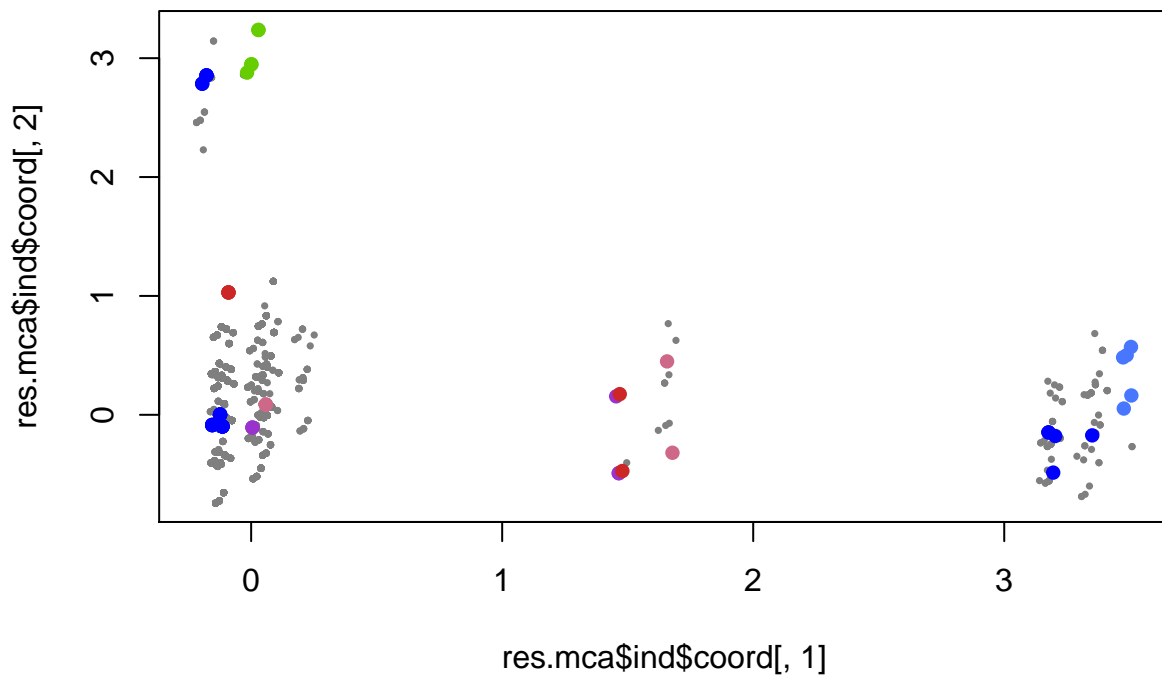
```
## 1.834493 1.735617 1.342113 1.342113 1.342113
## -----
## Cluster: 4
##      826623      35649      202294      245448      321262
## 2.123598 2.034772 1.818039 1.818039 1.818039
## -----
## Cluster: 5
##      1083301      173366      720785      131915      810930
## 3.739454 3.714631 3.708608 3.654759 3.652079
```

What we obtain are those individuals of each cluster that that far away in the same cluster from the rest of the individuals. We also obtain the rownames of each individual with the bigger distance respect the other ones in the cluster.

**7.3.1.1 Examine the values of individuals that characterize classes** We get the graphical representation for the individuals that characterize classes (para and dist).

```
# characteristic individuals
para1<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$para[[1]]))
dist1<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$dist[[1]]))
para2<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$para[[2]]))
dist2<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$dist[[2]]))
para3<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$para[[3]]))
dist3<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$dist[[3]]))
para4<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$para[[4]]))
dist4<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$dist[[4]]))
para5<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$para[[5]]))
dist5<-which(rownames(res.mca$ind$coord)%in%names(res.hcpcMCA$desc.ind$dist[[5]]))

plot(res.mca$ind$coord[,1],res.mca$ind$coord[,2],col="grey50",cex=0.5,pch=16)
points(res.mca$ind$coord[para1,1],res.mca$ind$coord[para1,2],col="blue",cex=1,pch=16)
points(res.mca$ind$coord[dist1,1],res.mca$ind$coord[dist1,2],col="chartreuse3",cex=1,pch=16)
points(res.mca$ind$coord[para2,1],res.mca$ind$coord[para2,2],col="blue",cex=1,pch=16)
points(res.mca$ind$coord[dist2,1],res.mca$ind$coord[dist2,2],col="darkorchid3",cex=1,pch=16)
points(res.mca$ind$coord[para3,1],res.mca$ind$coord[para3,2],col="blue",cex=1,pch=16)
points(res.mca$ind$coord[dist3,1],res.mca$ind$coord[dist3,2],col="firebrick3",cex=1,pch=16)
points(res.mca$ind$coord[para4,1],res.mca$ind$coord[para4,2],col="blue",cex=1,pch=16)
points(res.mca$ind$coord[dist4,1],res.mca$ind$coord[dist4,2],col="palevioletred3",cex=1,pch=16)
points(res.mca$ind$coord[para5,1],res.mca$ind$coord[para5,2],col="blue",cex=1,pch=16)
points(res.mca$ind$coord[dist5,1],res.mca$ind$coord[dist5,2],col="royalblue1",cex=1,pch=16)
```



- 7.4 Comparison of clusters obtained after K-Means (based on PCA) and/or Hierarchical Clustering (based on PCA) focusing on f.cost target.
- 7.5 Comparison of clusters obtained after K-Means (based on PCA) and/or Hierarchical Clustering (based on PCA) focusing on the binary target.