

TIME-SERIES ANALYSIS  
OF  
FOOD DONATION DATA  
FOR  
FOOD BANK OF CENTRAL AND EASTERN NORTH CAROLINA

*PREPARED BY*  
ANJALI DONERIA (adoneri)

*UNDER SUPERVISION OF*  
DR. MIN CHI,  
Associate Professor, Department of Computer Science,  
North Carolina State University, NC

*FOR THE CREDITS OF*  
CSC 630  
([GITHUB](#))



DEPARTMENT OF COMPUTER SCIENCE,  
NORTH CAROLINA STATE UNIVERSITY, RALEIGH, NC

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## **BACKGROUND**

Food Banks are non-profit hunger relief organizations that attempt to meet the need of the people with inconsistent access to nutritious food. So, these organizations try to meet these needs by recovering surplus food from different sources and distributing the food to charitable agencies that can serve the people in need. This task of collecting, storing and distributing food is non-trivial as Food Banks operate in complex environment. There is a high degree of uncertainty on the supply and demand side of the food, thus, making it difficult to understand the available food need. Therefore, food banks need a smart system that can make decisions in a way that (a) efficiently maximizes the supply of food and reduces wastage, (b) provides food equitably to those in need, and (c) efficient distribution of food. But these come with the challenge for a number of reasons, primarily because of the limited shelf life of the food products. Food quality and safety have to be considered while selecting the transportation ways and routes. Therefore, it becomes essential to build a smart system that can address the challenges that are connected with working of these non-profit organizations.

## **INTRODUCTION**

The ability for a decision maker to make strategic and tactical decisions affecting food aid while simultaneously meeting the objectives of equity, efficiency, and effectiveness is challenging. There is no system that allows food banks to learn the real-time inventory of the agencies that may be affected by factors like the amount of food they have distributed and the amount of donations they have received from other sources. These organizations generate a large amount of unstructured and complex data on food collection, inventory management, and distribution activities. For example, the Food Bank of Central and Eastern North Carolina (FBCENC) generates approximately 0.5 million rows in one fiscal year, from their six branch warehouse logistics network. Existing information systems lack the infrastructure to interpret this large-scale data to provide real-time recommendations to support operational and strategic decision making. Therefore, a smart service system is proposed by a team of researchers, that will enable the user to synthesize data from various sources to provide a real-time perspective of the food distribution environment and learn from the actions of the decision maker. In a nutshell, this system will automatically predict, visualize, and recommend decisions that will advance operational effectiveness of the food collection, distribution, and resource management in a way that will lead to ***flexible, equitable, efficient and effective distribution (FEEED)***. So, this project report aims to analyse the food donation data for FBCENC by agents and donors to assist in building a prediction model that would help in the decision making of the FEEED system.

## **DATA DESCRIPTION AND DATA PROCESSING**

The data has been recorded for the Food Bank of Central and Eastern North Carolina (FBCENC) from the fiscal years of 2006-2017 with around 1,329,550 records. There are around *105 attributes in total with 53 attributes holding meaningful values*. The following table describes the important attributes that have been used for data analysis in this report:

<b>Attribute Name</b>	<b>Attribute Type</b>	<b>Attribute Details</b>
Posting Date	ratio	Date item was entered
Entry Type	ordinal	Classifies entry as either distribution, negative adj., positive adj., purchase or transfer
Source No	nominal	The agency id for a distribution record; Donor ID for donation
Inventory Group	Posting	Source of items received (Donated, Purchased, Gov.)
Source Group	Posting	Categorizes the inventory posting group (donor, food bank, or agency)
Quantity	ratio	Positive or negative value pertaining to food received. (negative<distribution>, positive<donation>)
Department	ordinal	Used by different departments within food bank that completes a transaction
Source Type	ordinal	Customer or Vendor. This refers to internal orders (customer) and external orders (vendor)
Branch Code	nominal	Letter assigned to define each branch
UNC Donor ID code	nominal	Unique code assigned to each donor
UNC Donor class of trade code	nominal	Code classifying the UNC donor code
FBC Donor Class of Trade	ordinal	Categorizes donor by type of business

Vendor Type              ordinal              An external supplier of goods or services

The data can be broadly broken down into ***purchase\_data, distribution\_data, transfer\_data, positive\_adjustment\_data, and negative\_adjustment\_data*** on the basis of Entry\_Type attribute. So, I broke down the given data for all the fiscal years into different SQL views for these categories. After creating views for these, I processed the Posting\_Date attribute to extract the posting\_year and posting\_month for further analysis of the time-series data for months, years and weeks.

## **RESULTS AND DISCUSSION**

The actions for the data recorded for FBCENC can be broadly categorized into the following parts:

1. Food donations from donors including government donations
2. Food purchase from vendors
3. Food transfer from food bank to other branches and locations
4. Food distribution to the people in need or agents and customers

### **I. FOOD DONATION DATA ANALYSIS**

As first part, the food donation data from donors has been analysed in the form of graphs as listed below. The parameters that are used for querying the data for ***Entry\_Type = 'Purchase'*** from the financial year tables are as follows:

- Quantity > 0 for donations
- Data is recorded for year 2006 - 2010 but no quantities are specified for donations
- Fbc\_donor\_class = 'donor'

The general trend for food donation by donors is shown below which is plotted as data available over the span of 2011-2017 based on months. (**All the graphs are plotted for quantities of food in the given unit**). It can be seen that the highest donation has been made in 2016. Also, the data for 2017 is only present from January - May, which does not give us the overall picture of the donation trend in 2017. But it can be safely pointed out that the amount of donation has increased with each year from 2011.

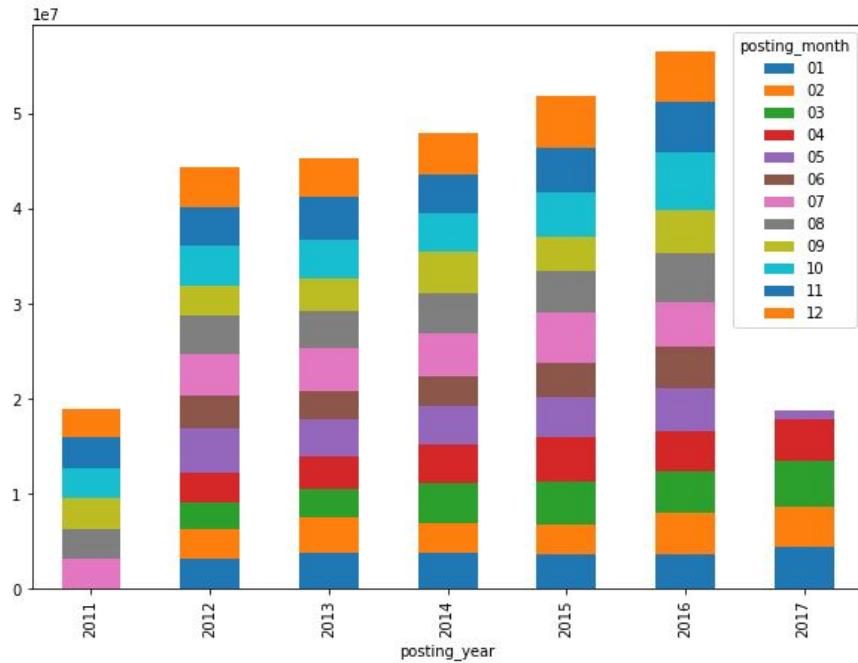


Fig 1. Trend from 2011-2017 over the months for food quantity donated

The above food donation trend can be further analyzed by breaking down into month-wise data for all the years from 2011-2017.

#### A. January (01)

Unrecorded Donations = 5,656,592 over the span of 2012-2017, that is unc\_donor\_class is 'null' for these records. The legend represents the donor codes

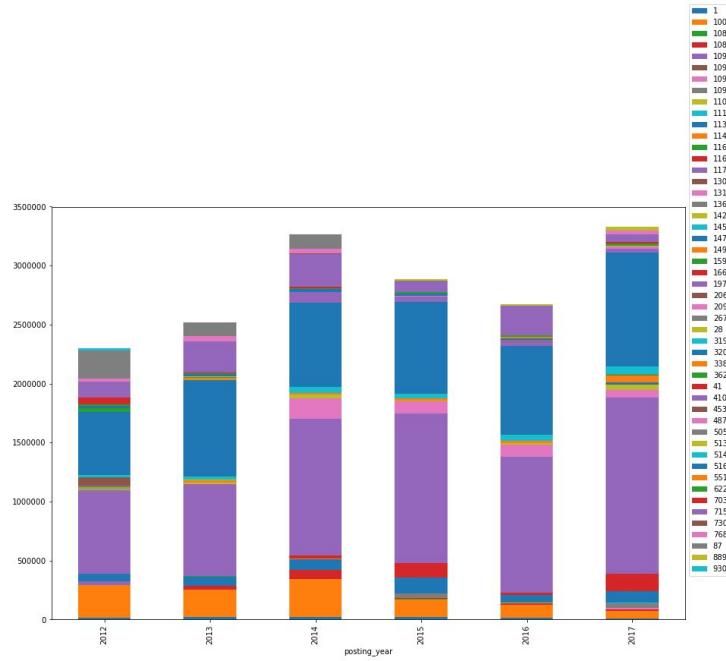


Fig 2. Donation trend by donor codes from 2012-2017 for the month of January

We can have a closer look at the donation trend for the month of January from 2011-2017  
**January, 2012**

Unrecorded Donations = 879,995. The graph is plotted for days in Jan vs. food donated.

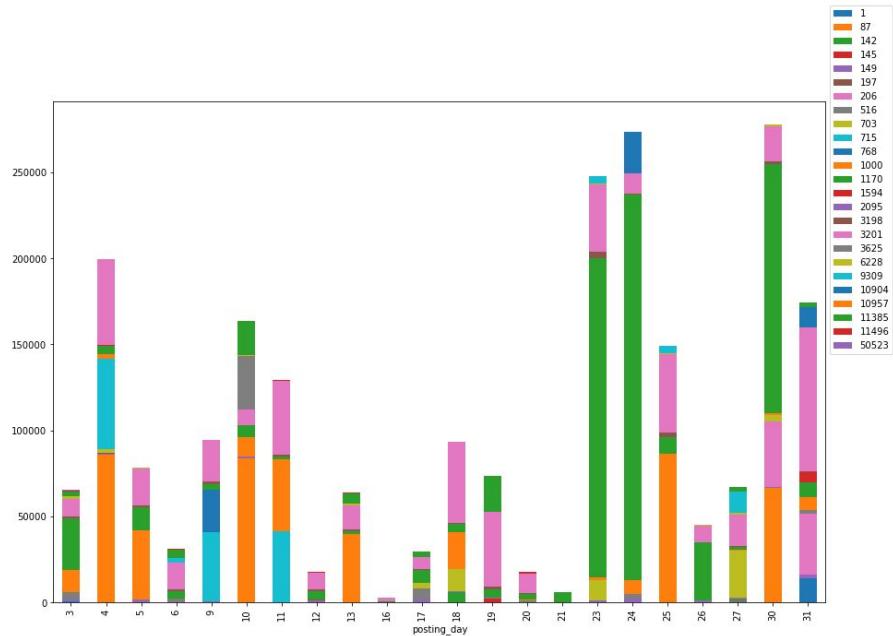


Fig 3. Donation trend in the month of January, 2012

### **January, 2013**

Unrecorded Donations = 1,352,287. Maximum donation is recorded on Jan 29.

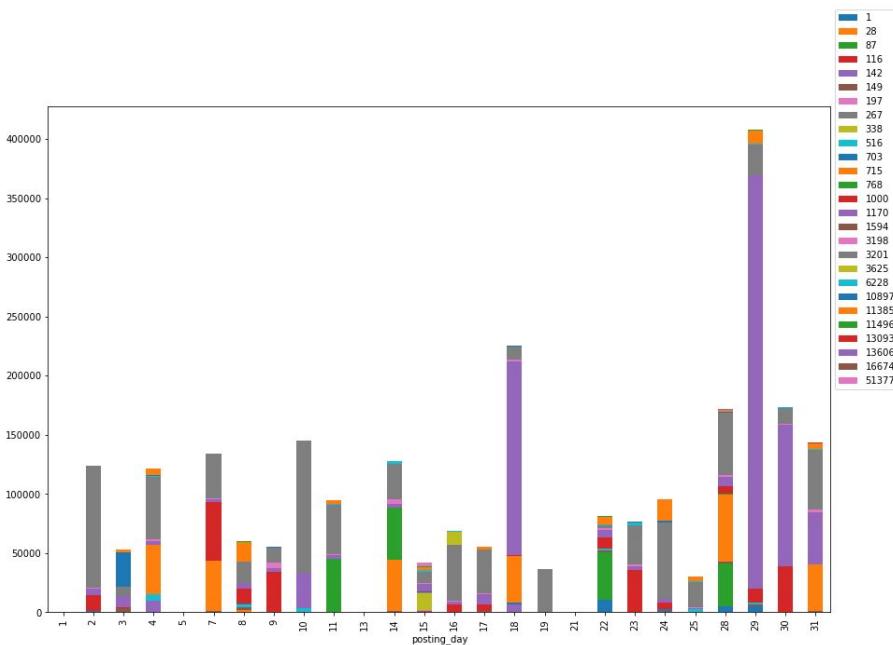


Fig 4. Donation trend in the month of January, 2013

## January, 2014

Unrecorded Donations = 473,826. Maximum donation is recorded on Jan 27.

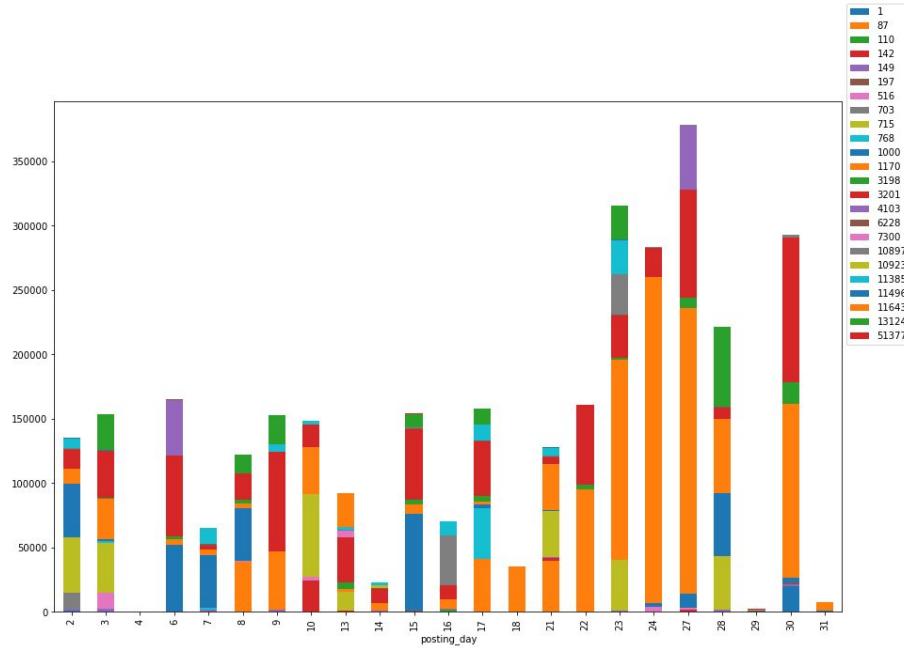


Fig 5. Donation trend in the month of January, 2014

## January, 2015

Unrecorded Donations = 808,614. Maximum donation is recorded on Jan 29.

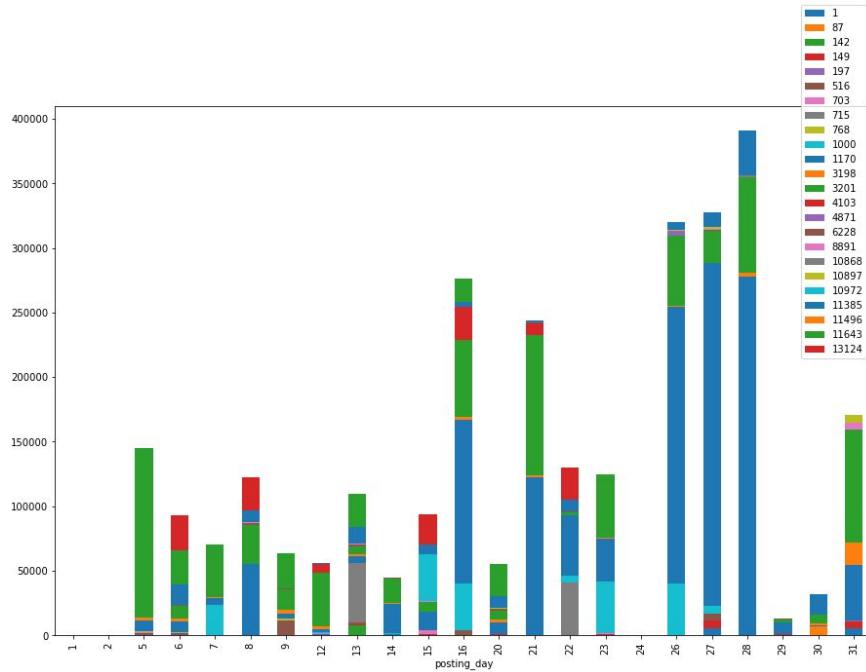


Fig 6. Donation trend in the month of January, 2015

## January, 2016

Unrecorded Donations = 1,017,726 with maximum donation on Jan 26.

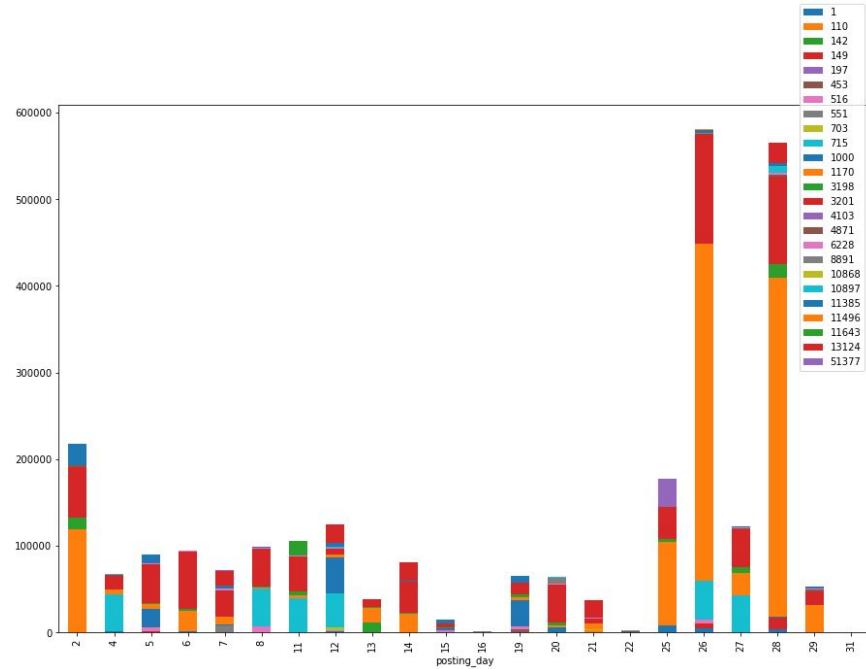


Fig 7. Donation trend in the month of January, 2016

## January, 2017

Unrecorded Donations = 1,124,504 with maximum donation recorded on Jan 31.

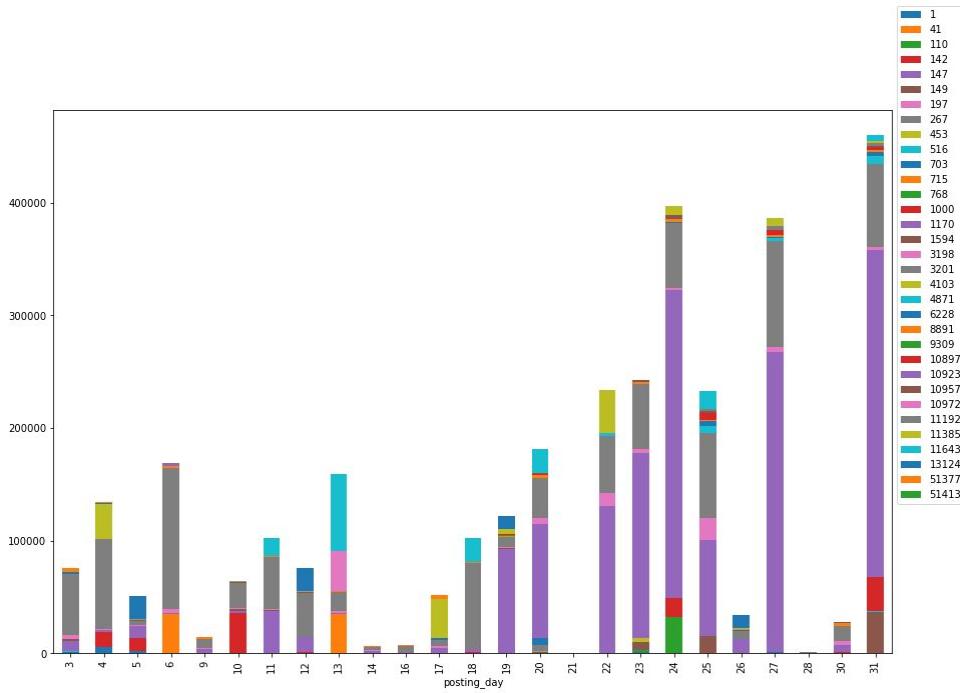
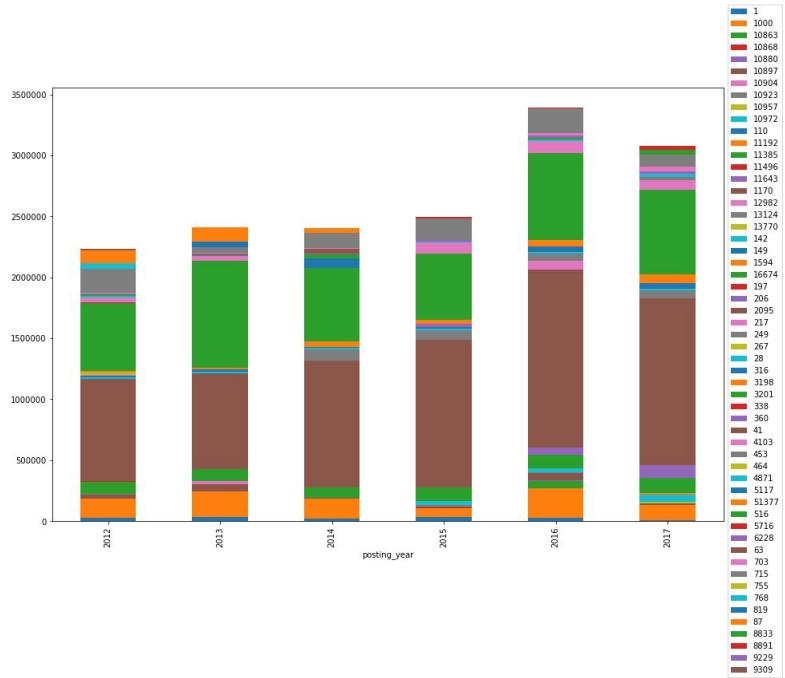


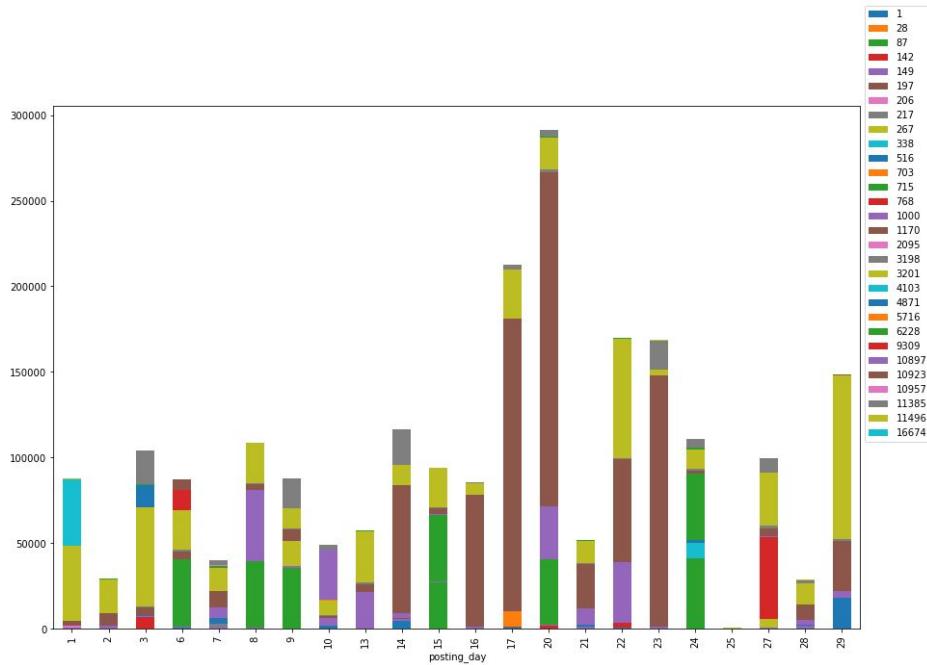
Fig 8. Donation trend in the month of January, 2017

## **B. February(02)**



**Fig 9. Donation trend by donor codes from 2012-2017 for the month of February**

## **February,2012**



**Fig 10. Donation trend for the month of February 2012**

## February, 2013

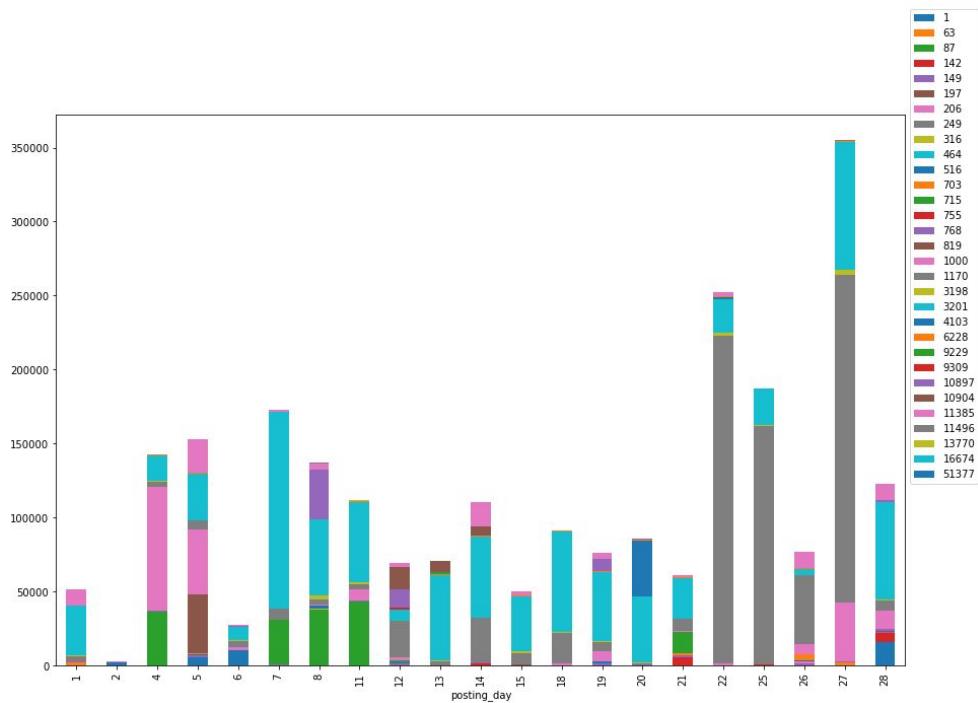


Fig 11. Donation trend for the month of February 2013

## February, 2014

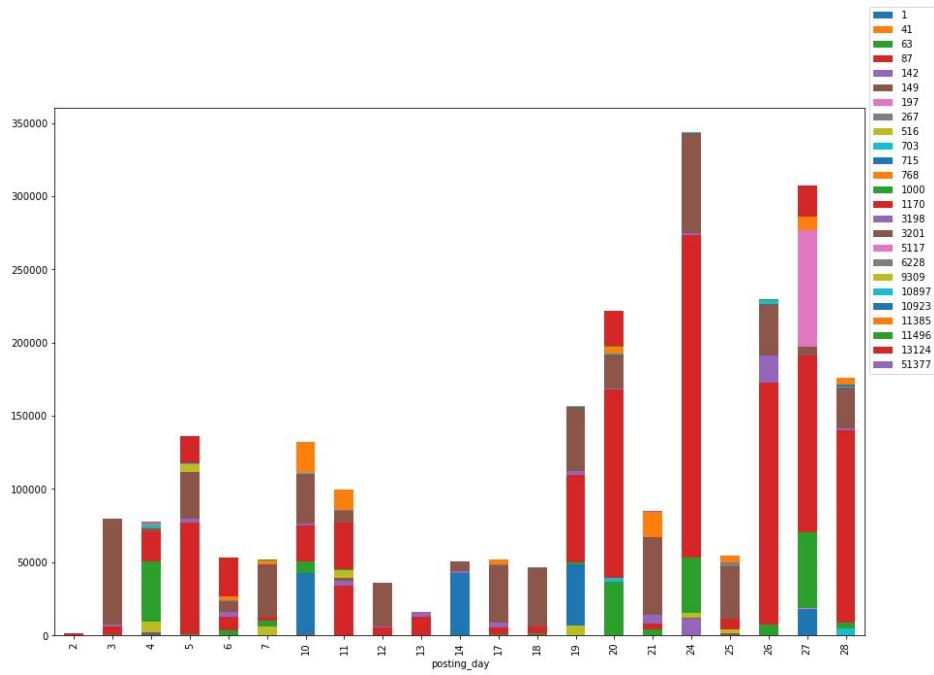


Fig 12. Donation trend for the month of February 2014

February, 2015

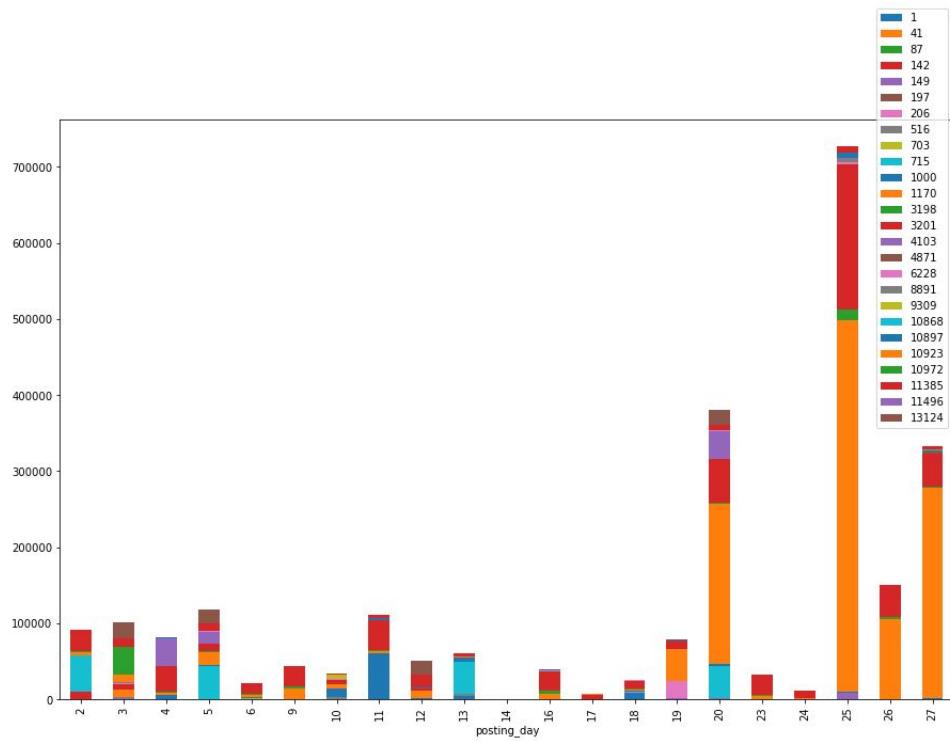


Fig 13. Donation trend for the month of February 2015

**February, 2016**

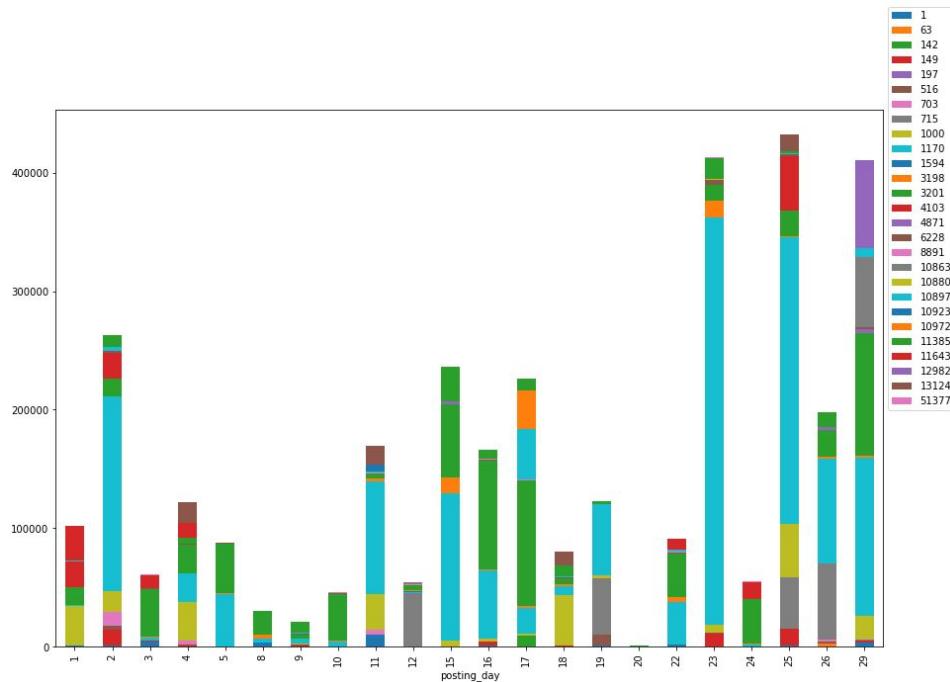


Fig 14. Donation trend for the month of February 2016

## February, 2017

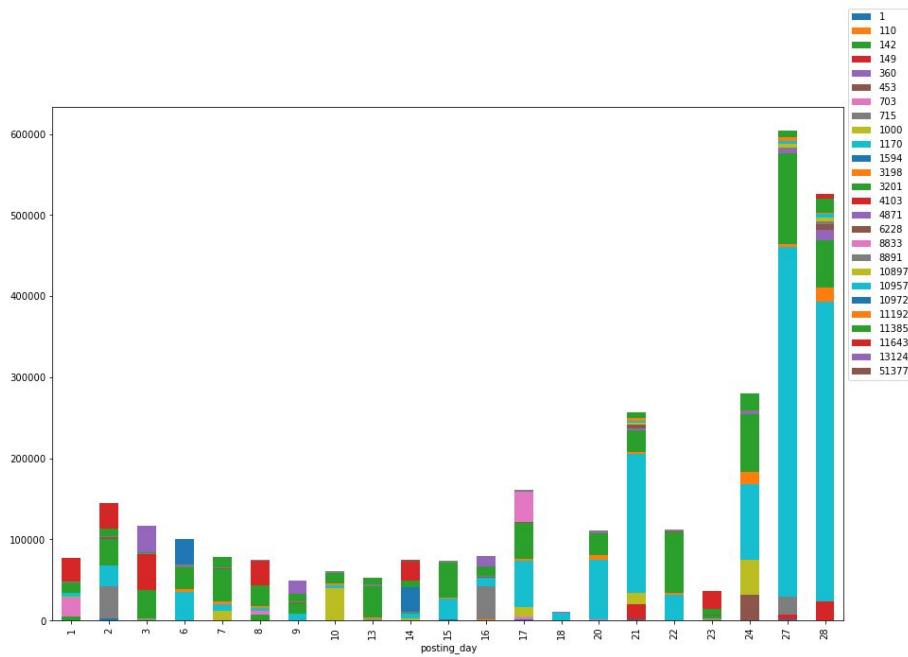


Fig 15. Donation trend for the month of February 2017

## C. March (03)

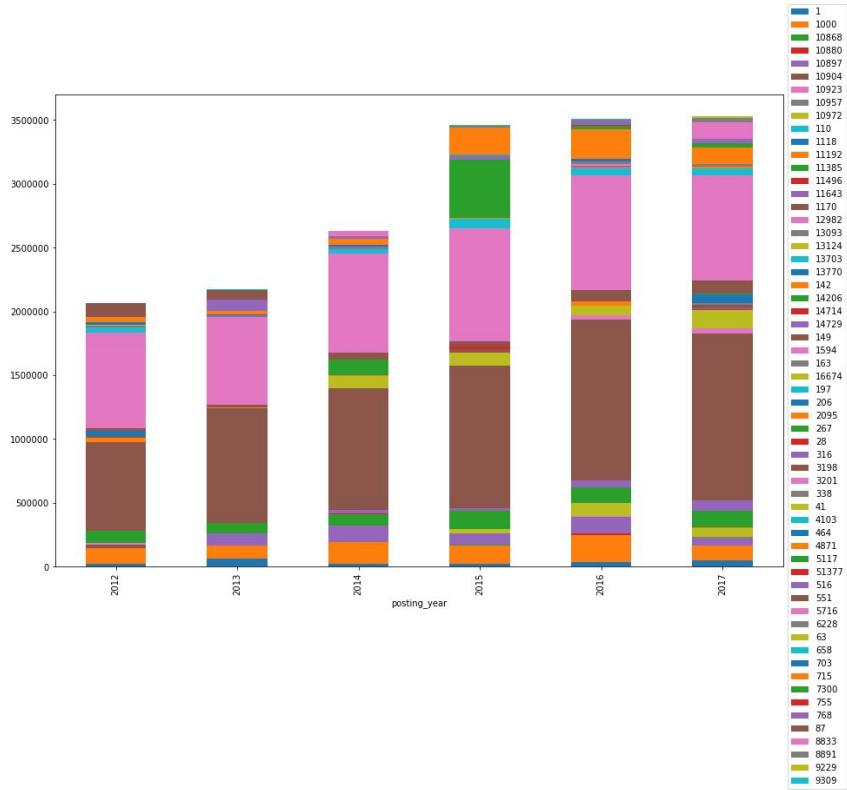


Fig 16. Donation trend by donor codes from 2012-2017 for the month of March

## March, 2012

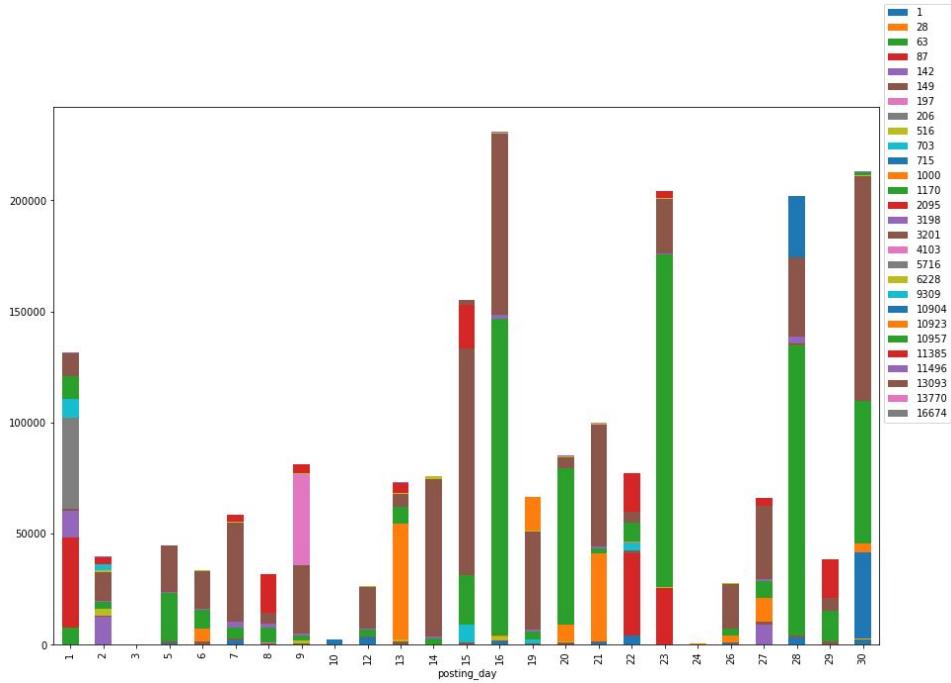


Fig 17. Donation trend for the month of March 2012

## March, 2013

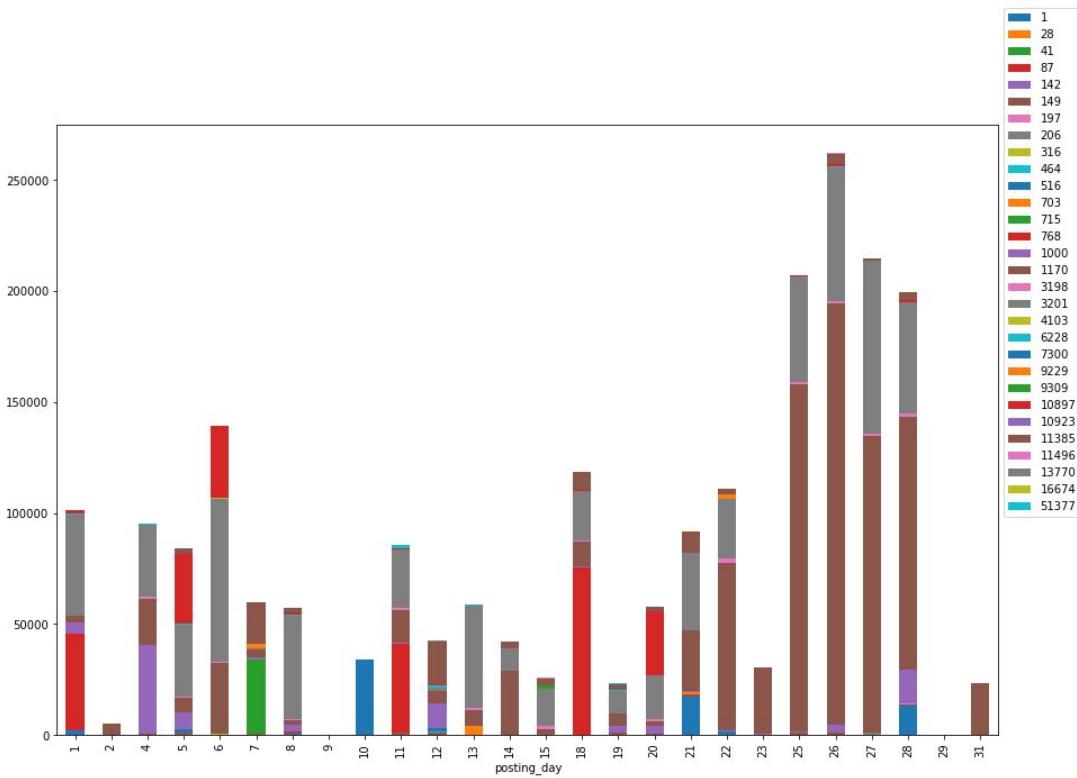


Fig 18. Donation trend for the month of March 2013

## March, 2014

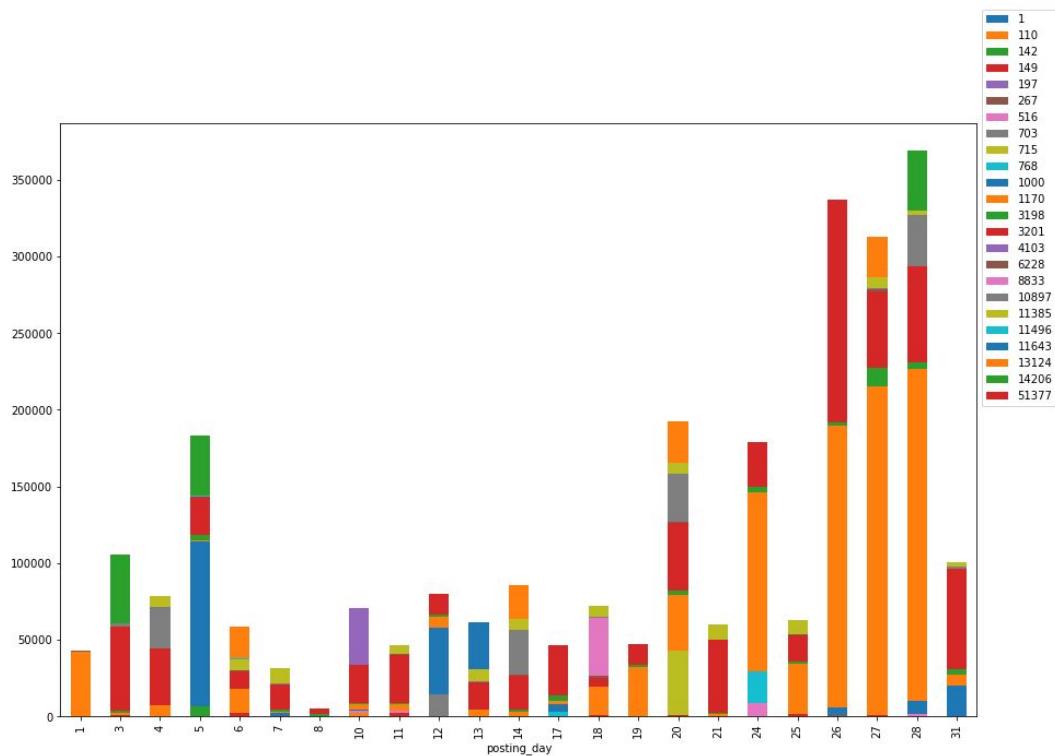


Fig 19. Donation trend for the month of March 2014

## March, 2015

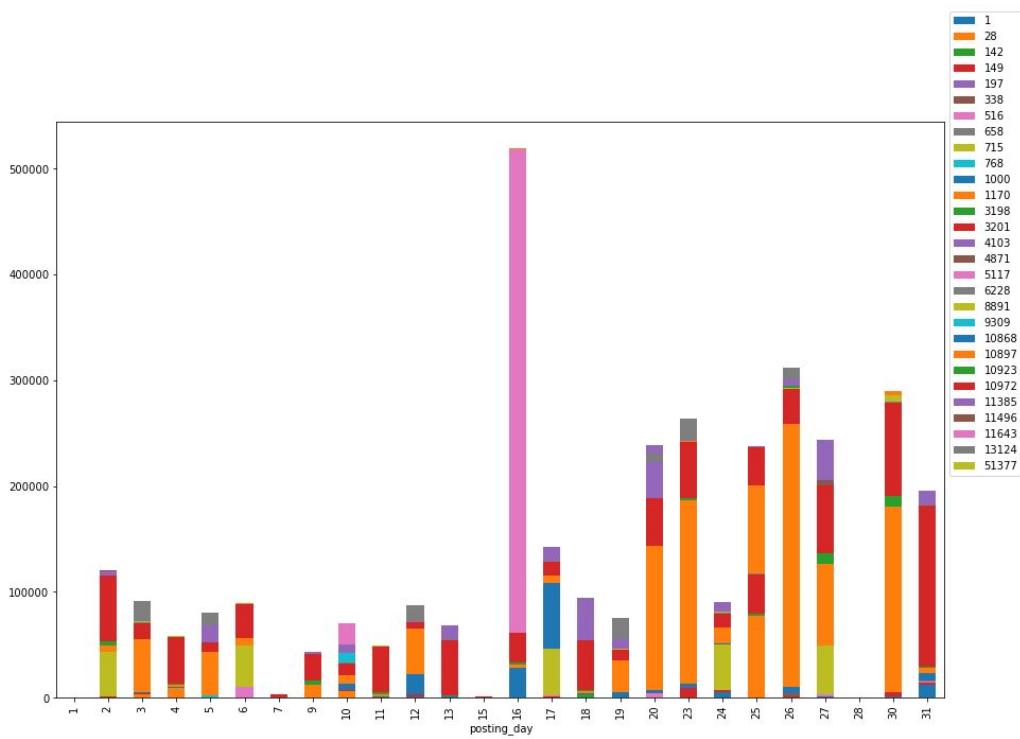


Fig 20. Donation trend for the month of March 2015

## March, 2016

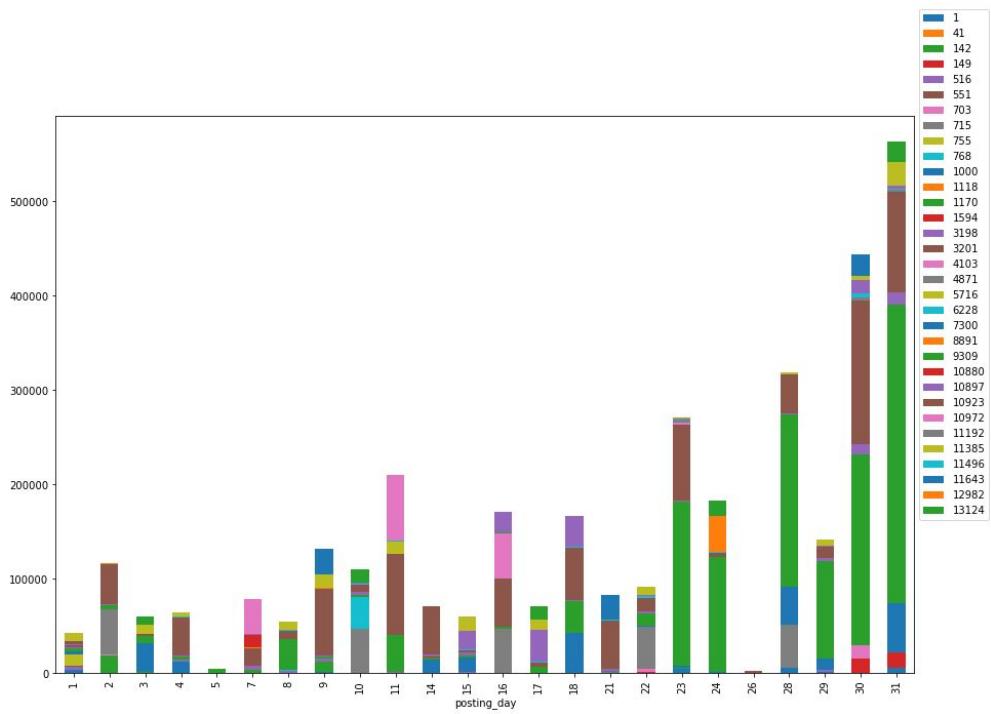


Fig 21. Donation trend for the month of March 2016

## March 2017

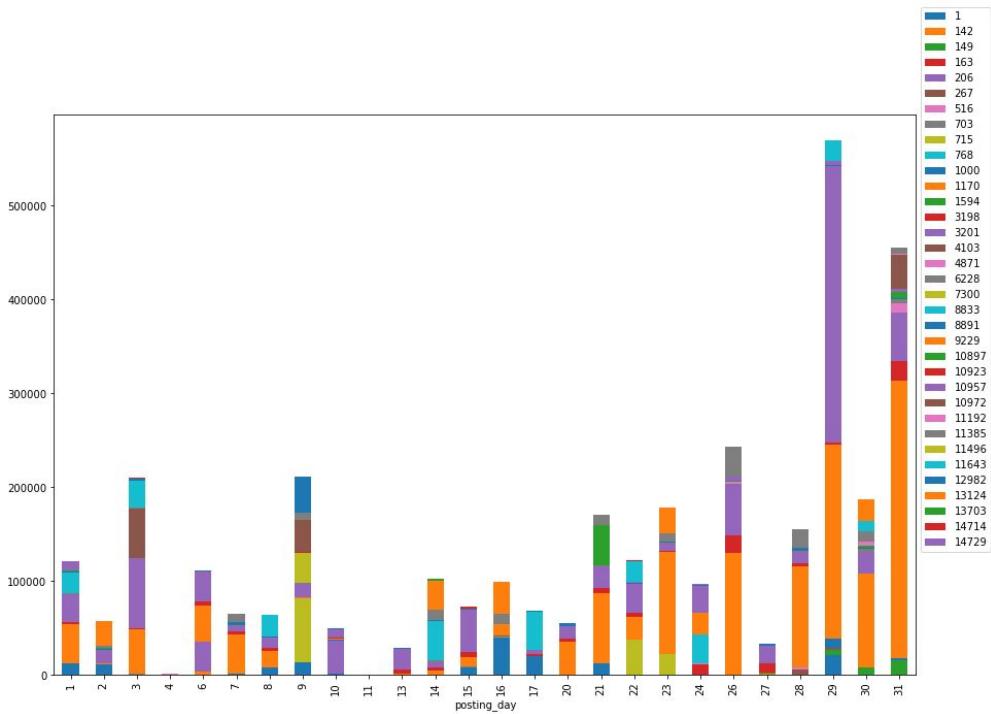


Fig 22. Donation trend for the month of March 2017

## D. April (04)

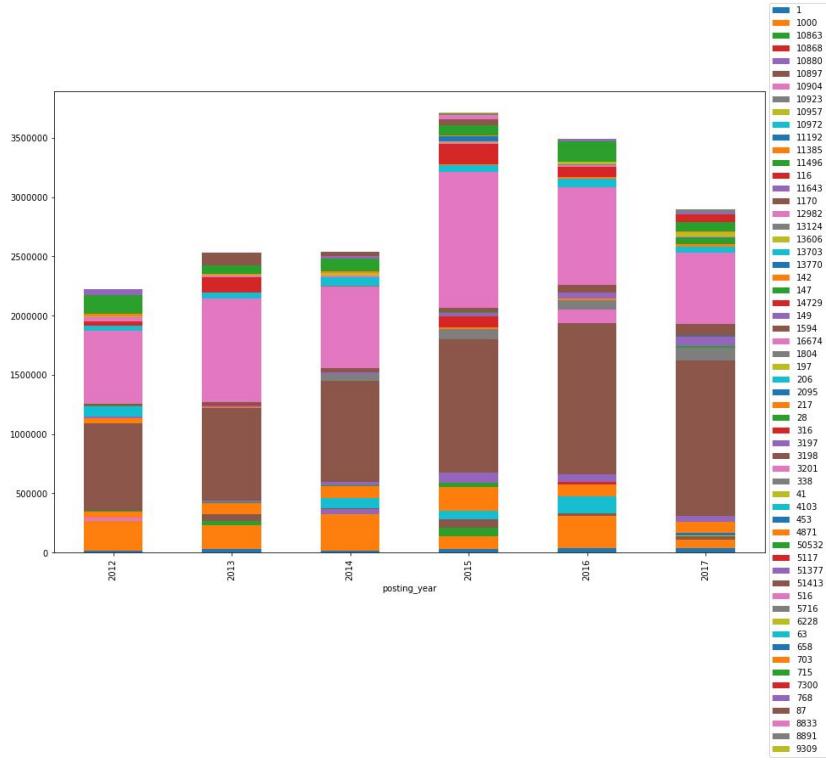


Fig 22. Donation trend by donor codes from 2012-2017 for the month of **April**

**April, 2012**

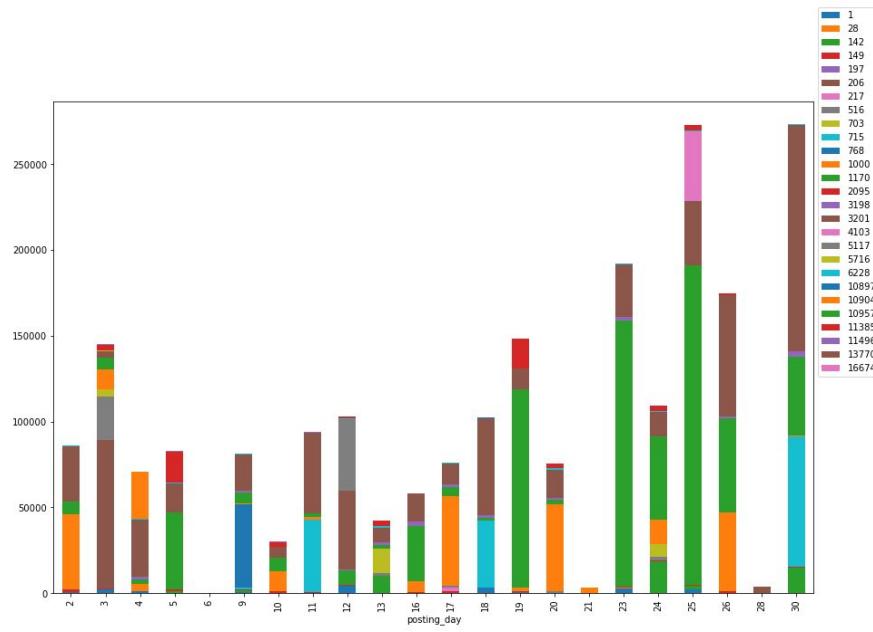


Fig 23. Donation trend for the month of **April 2012**

**April, 2013**

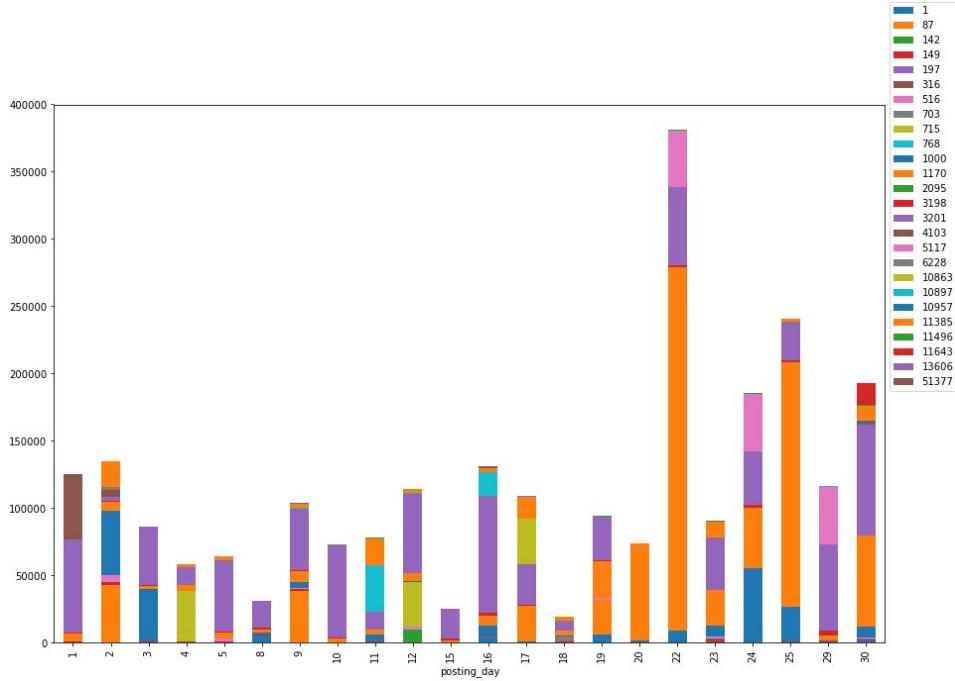


Fig 24. Donation trend for the month of April 2013

**April, 2014**

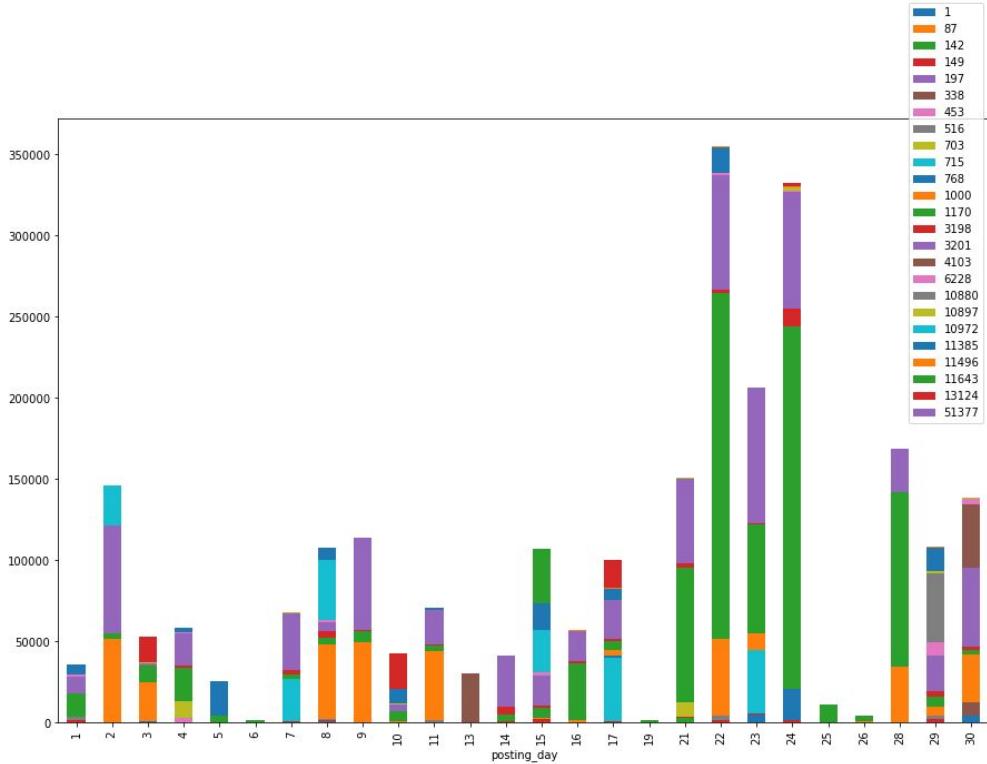


Fig 25. Donation trend for the month of April 2014

**April, 2015**

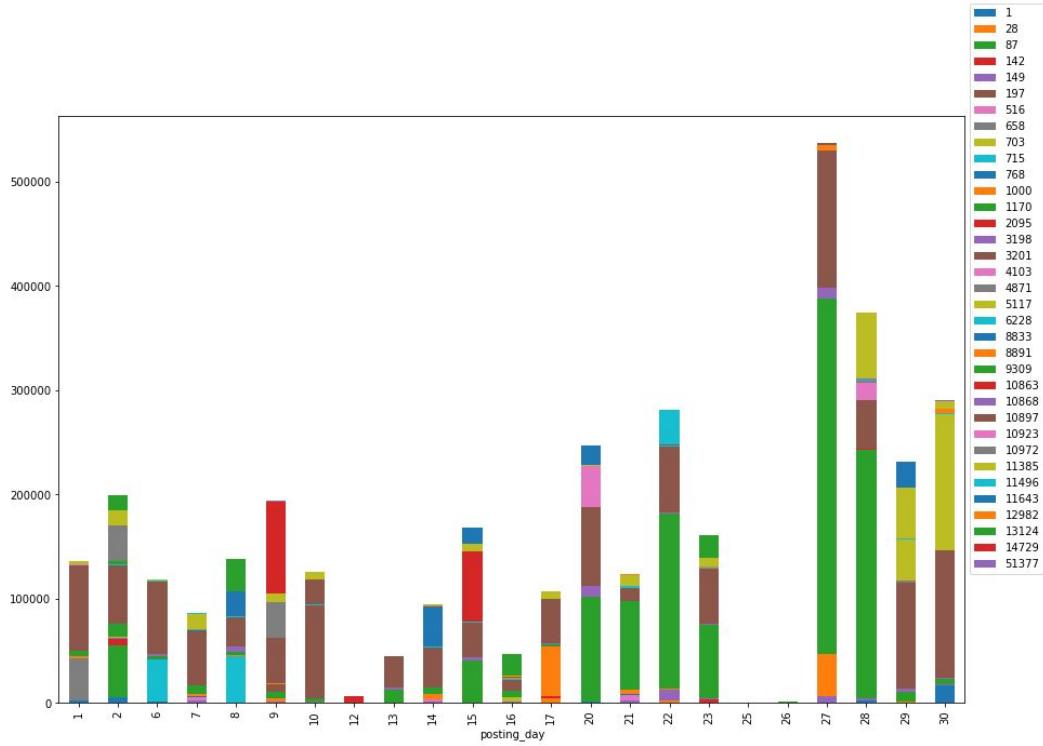


Fig 26. Donation trend for the month of April 2015

**April, 2016**

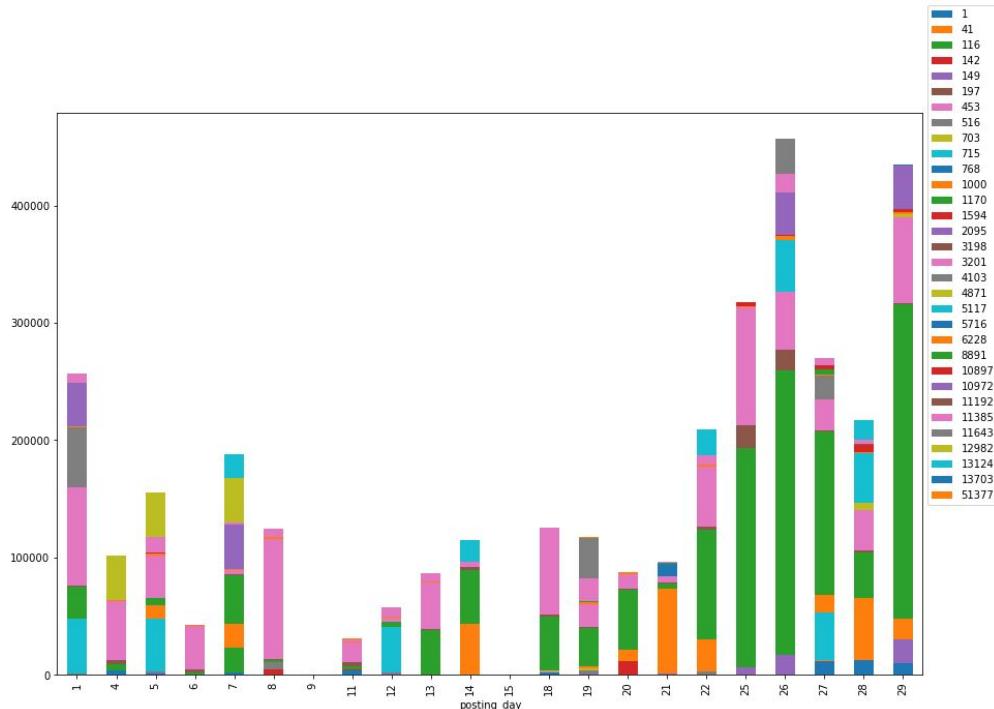
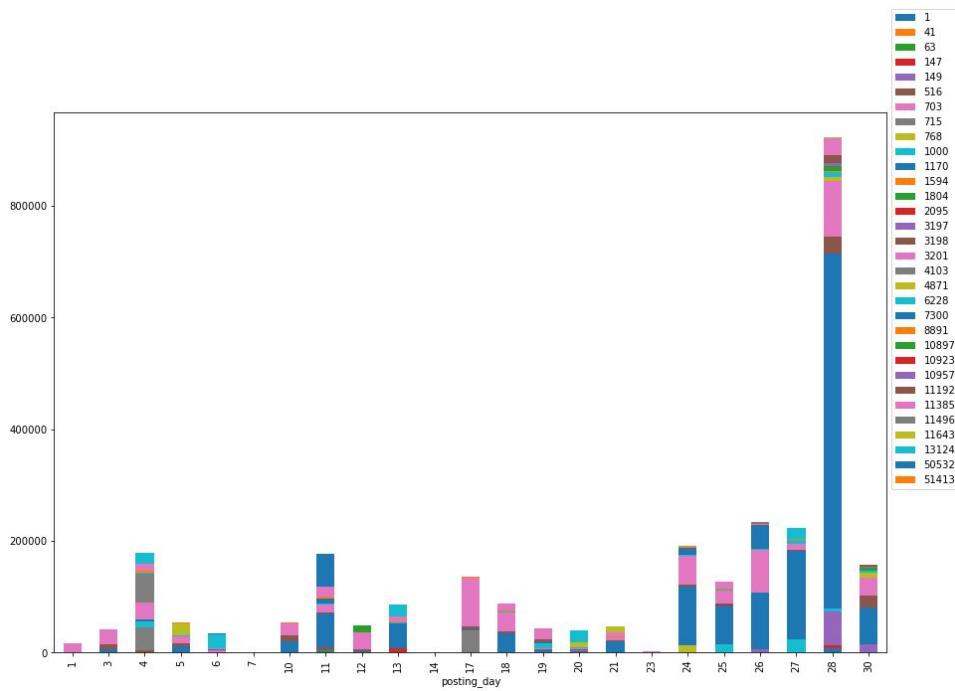


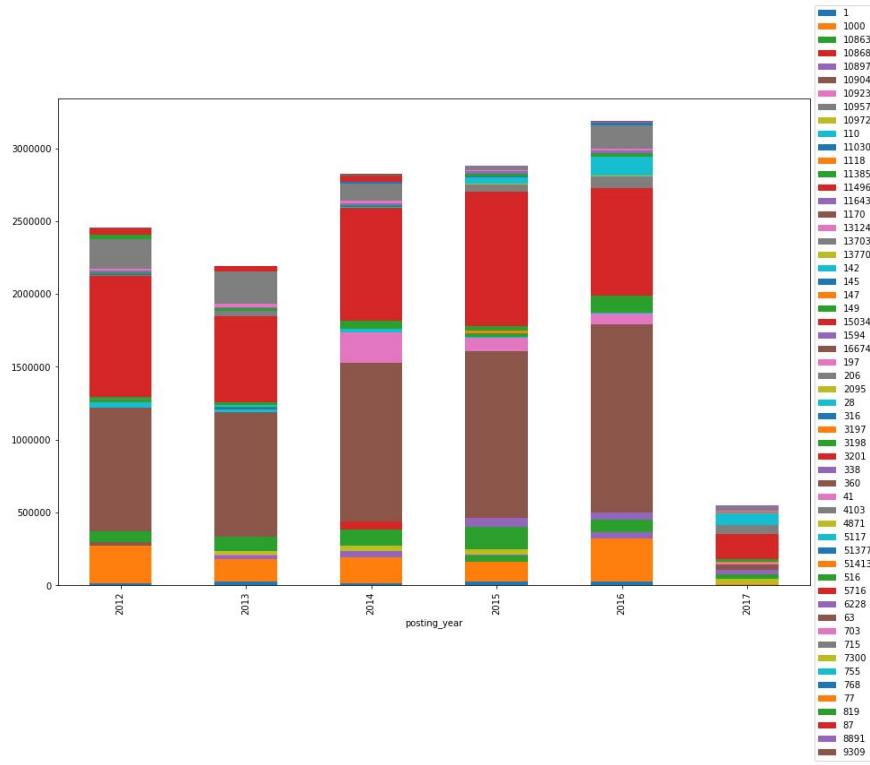
Fig 27. Donation trend for the month of April 2016

**April, 2017**



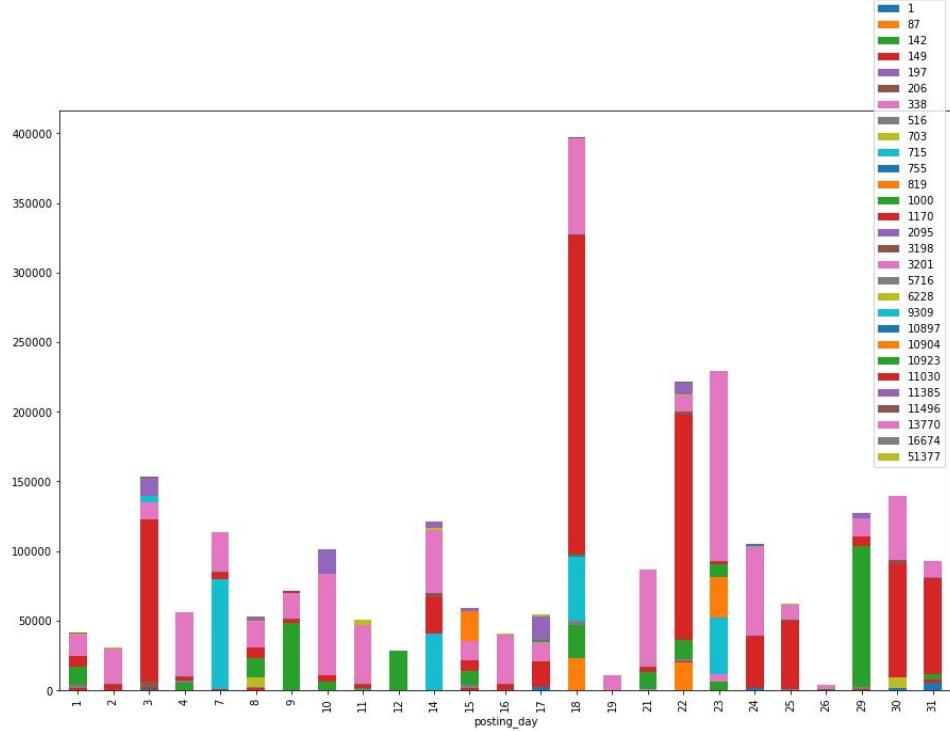
**Fig 28. Donation trend for the month of April 2017**

**E. May (05)**



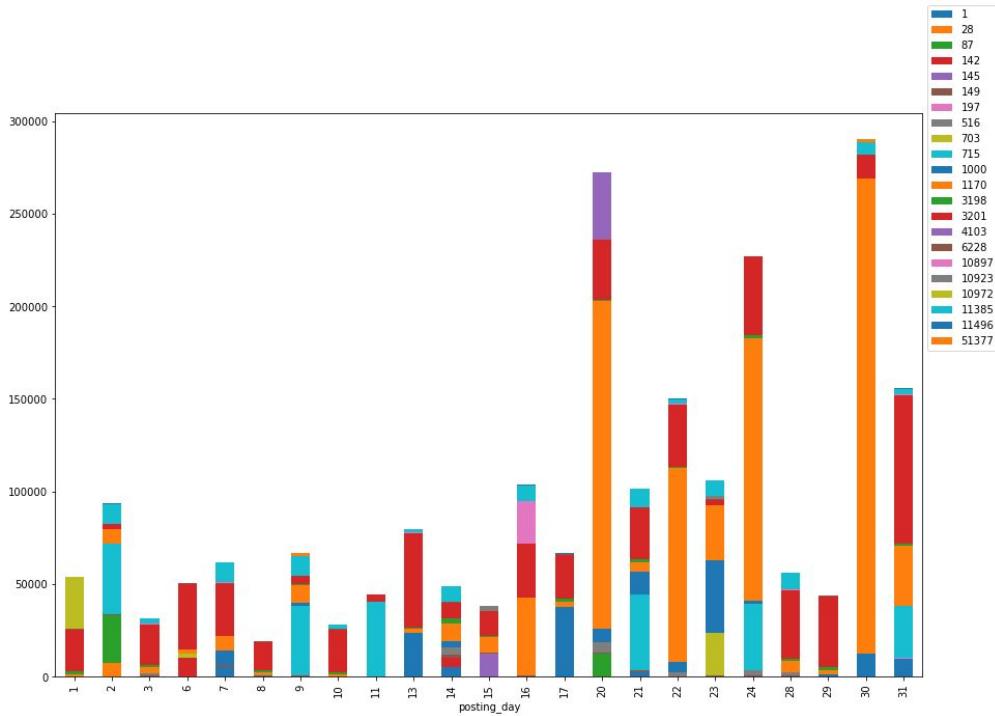
**Fig 29. Donation trend by donor codes from 2012-2017 for the month of May**

**May, 2012**



**Fig 30. Donation trend for the month of May 2012**

**May, 2013**



**Fig 31. Donation trend for the month of May 2013**

## May, 2014

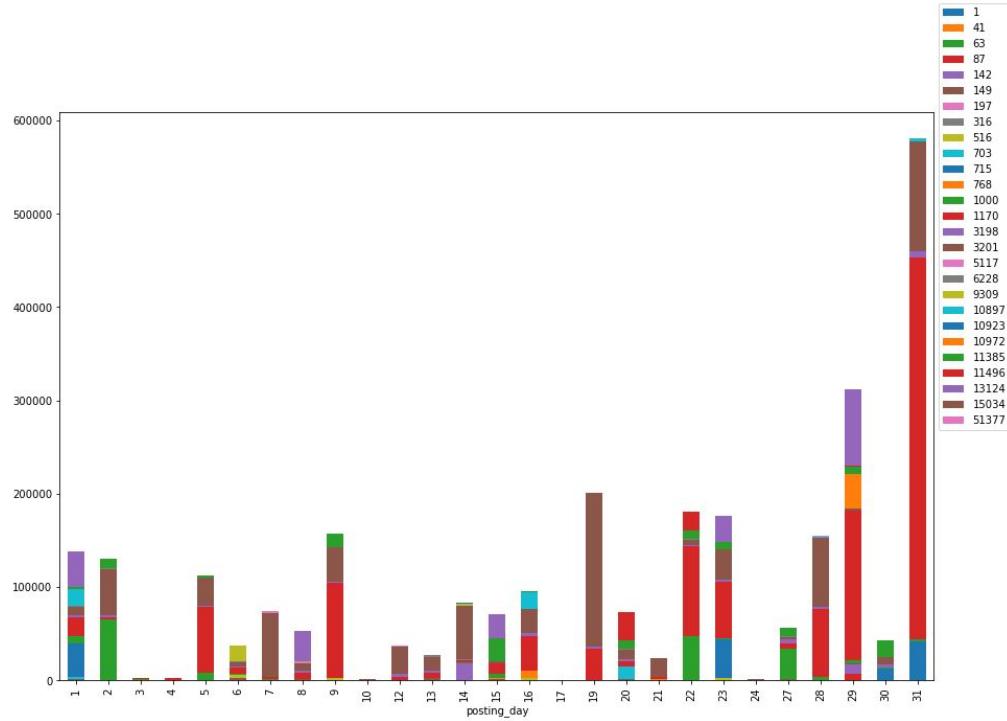


Fig 32. Donation trend for the month of May 2014

## May, 2015

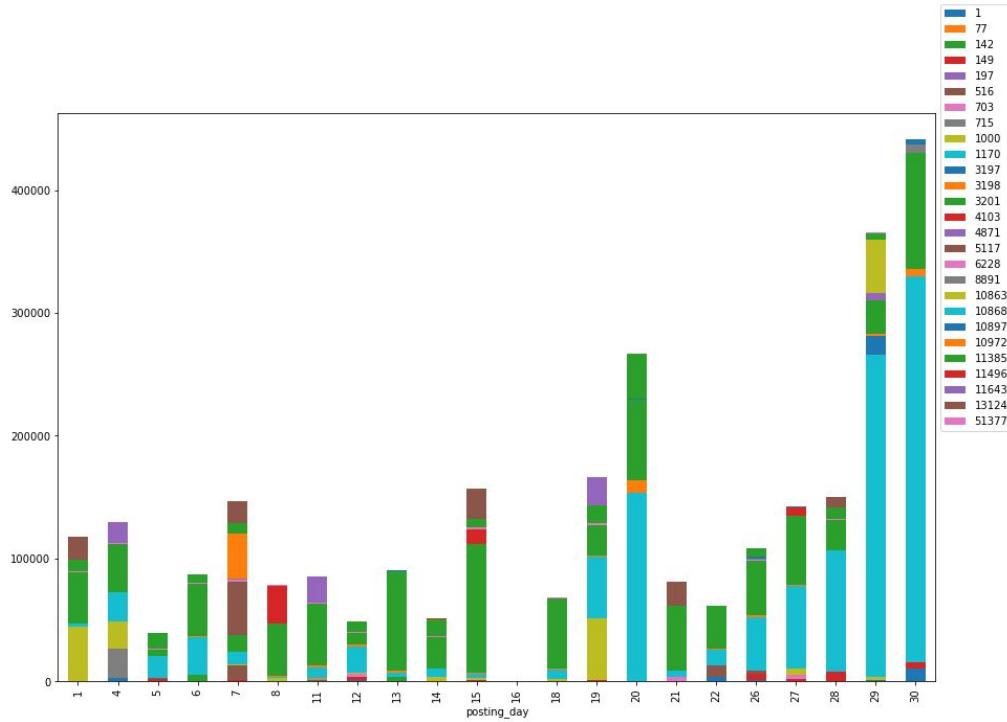


Fig 33. Donation trend for the month of May 2015

**May, 2016**

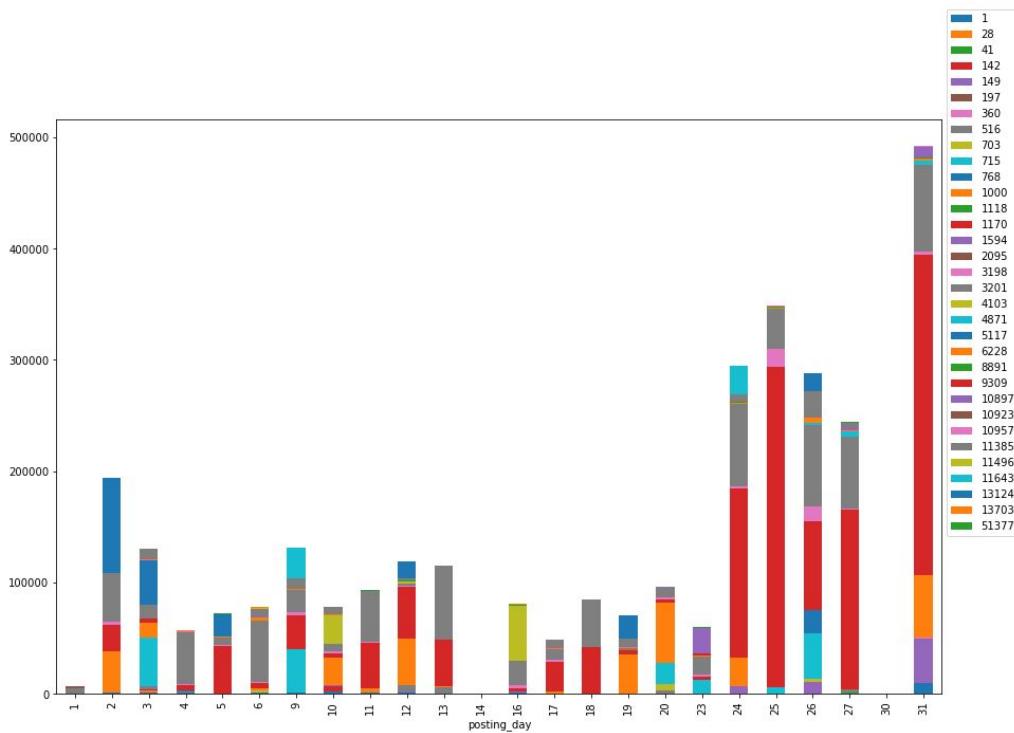


Fig 34. Donation trend for the month of May 2016

**May, 2017**

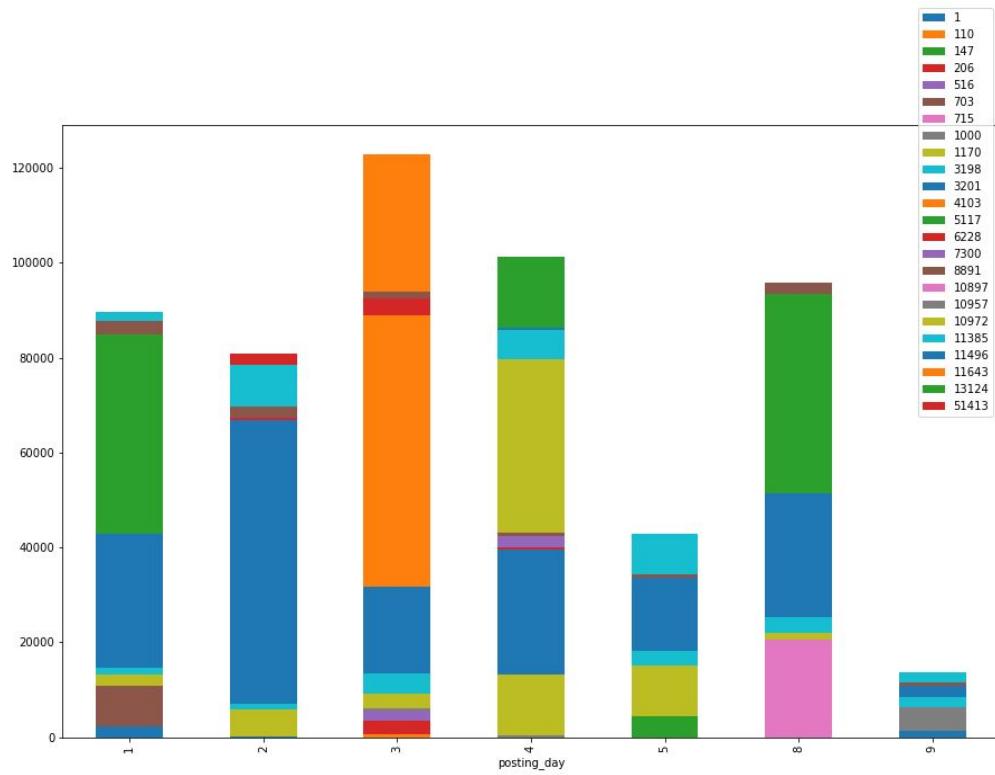


Fig 35. Donation trend for the month of May 2017

## **F. June (06)**

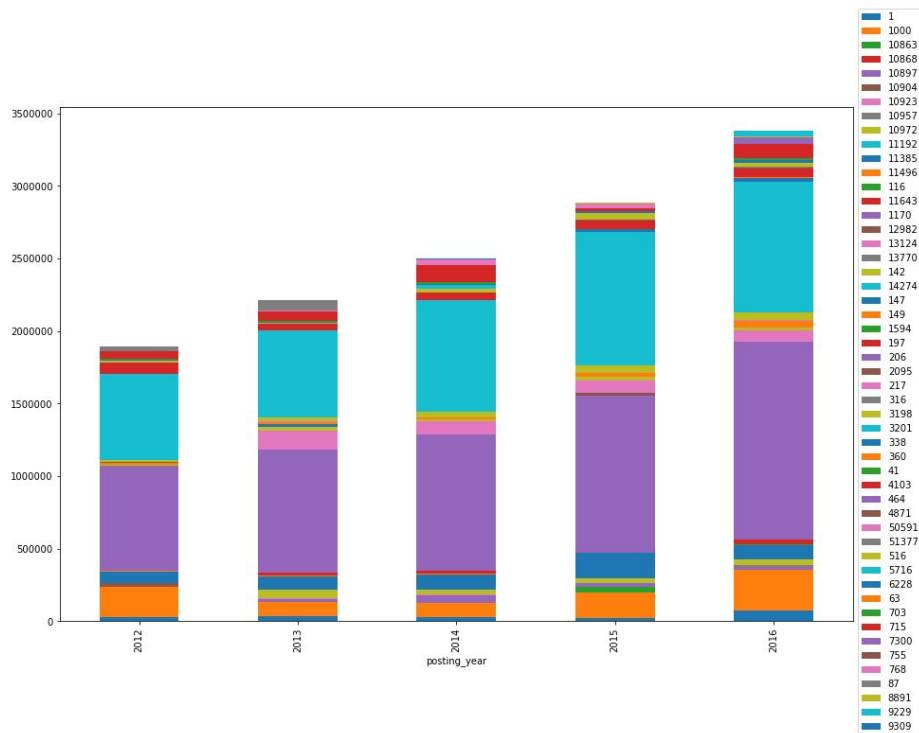


Fig 36. Donation trend by donor codes from 2012-2017 for the month of June

**June, 2012**

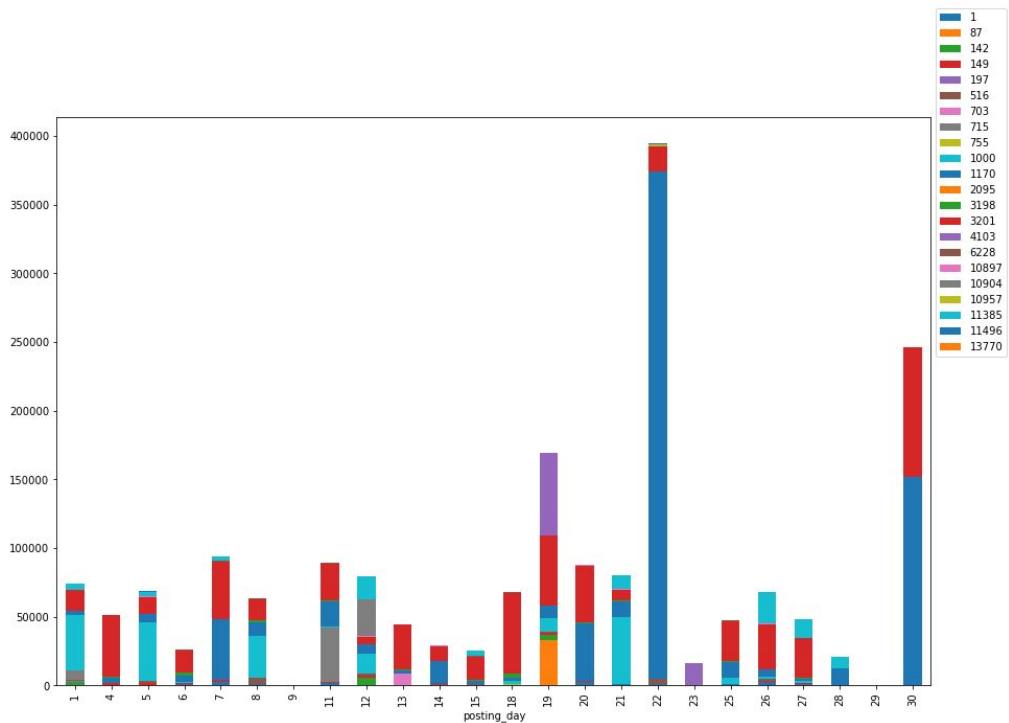


Fig 37. Donation trend for the month of June 2012

**June, 2013**

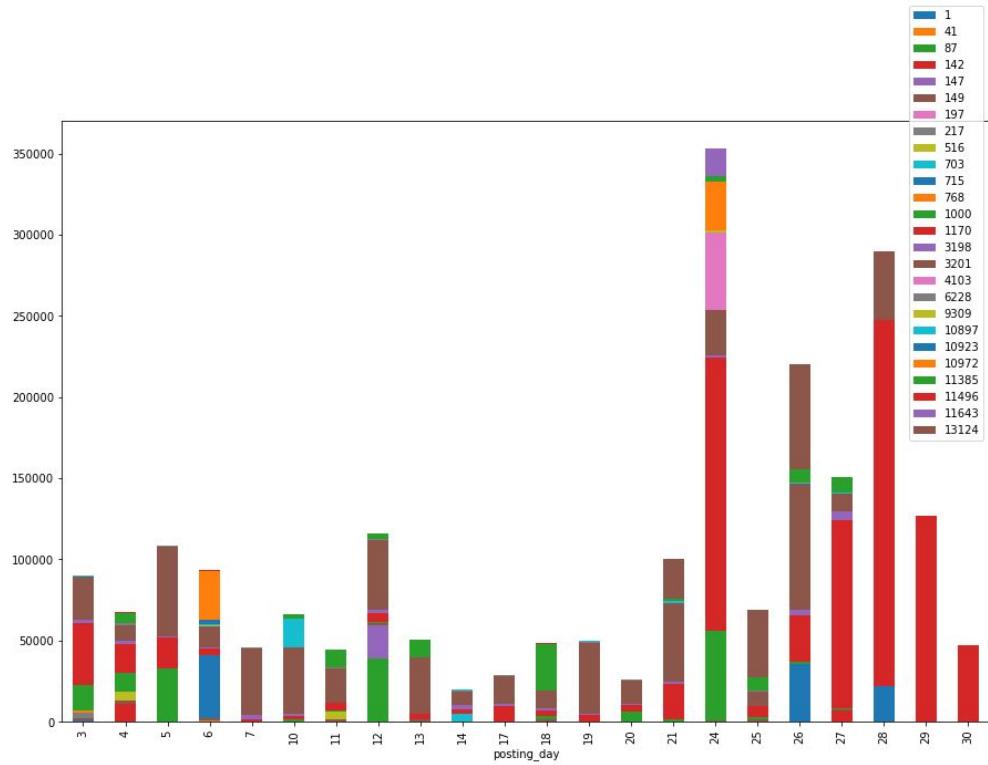


Fig 38. Donation trend for the month of June 2013

**June, 2014**

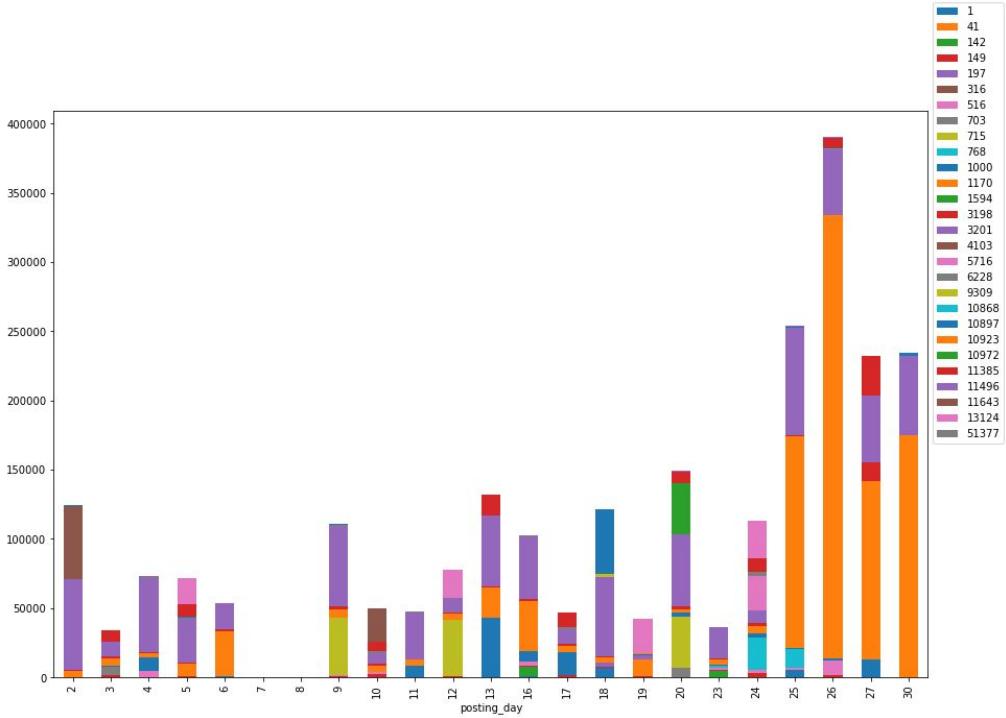


Fig 39. Donation trend for the month of June 2014

## June, 2015

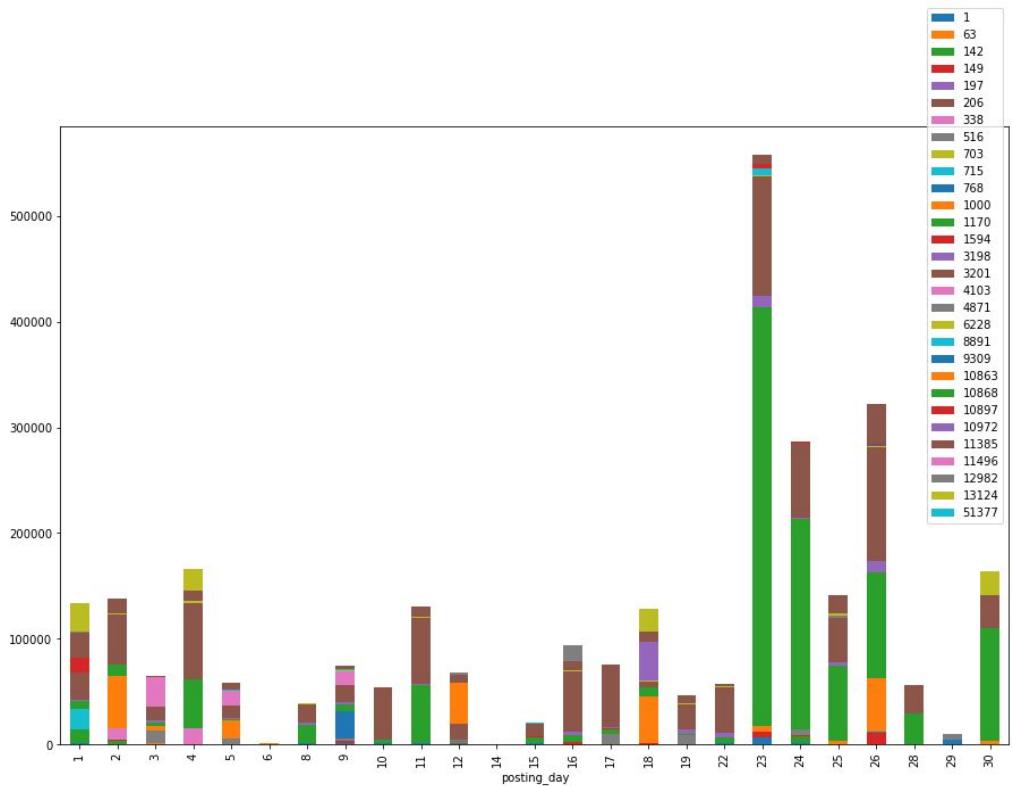


Fig 40. Donation trend for the month of June 2015

## June, 2016

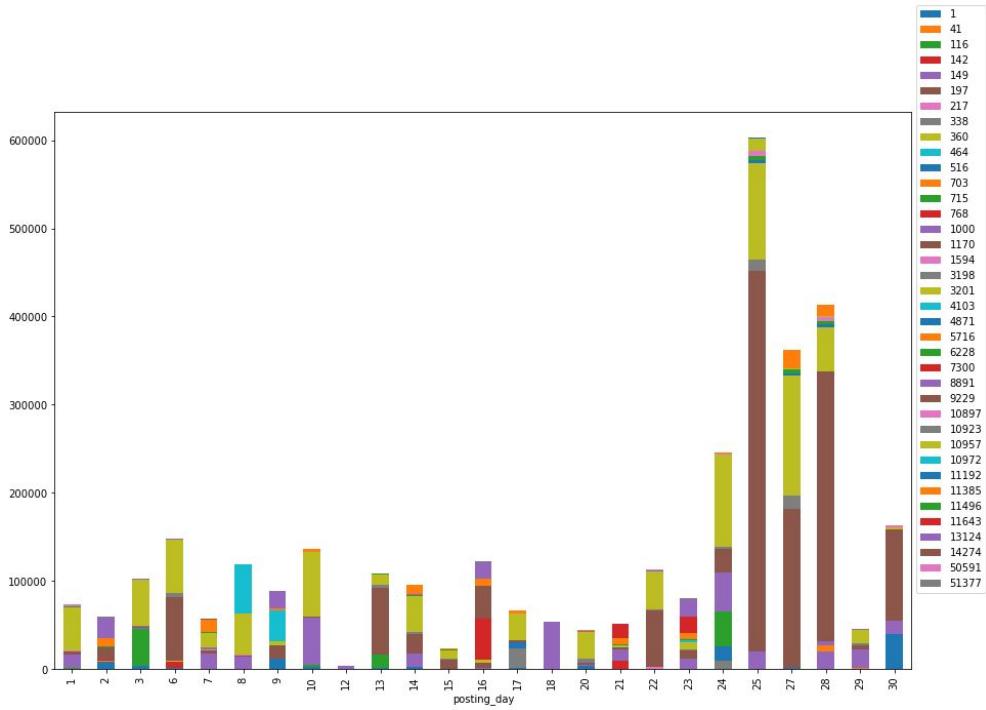


Fig 41. Donation trend for the month of June 2016

## G. July (07)

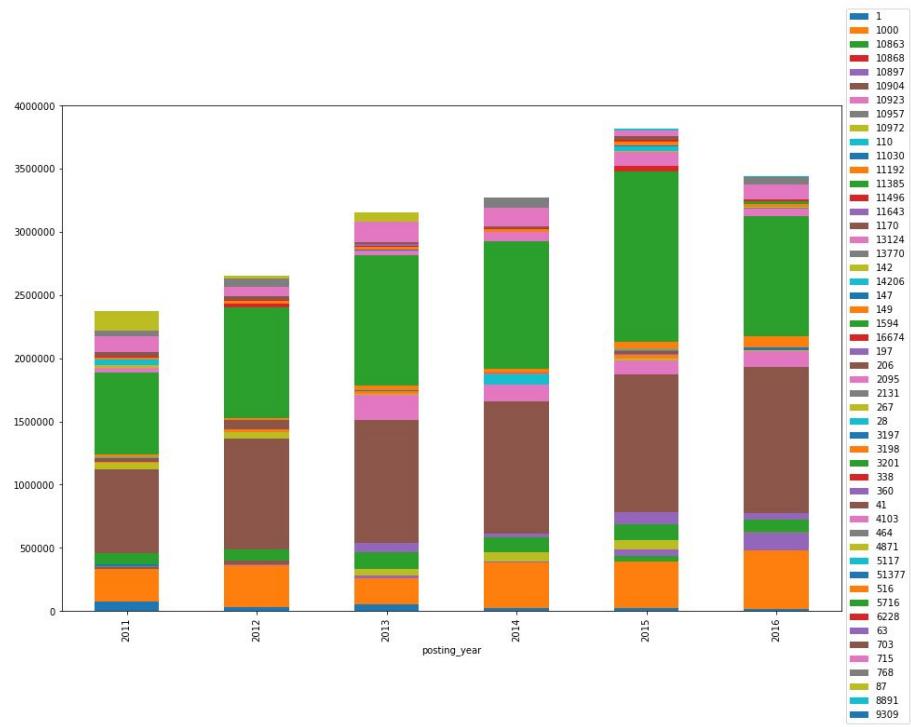


Fig 42. Donation trend by donor codes from 2012-2017 for the month of **July**

**July, 2011**

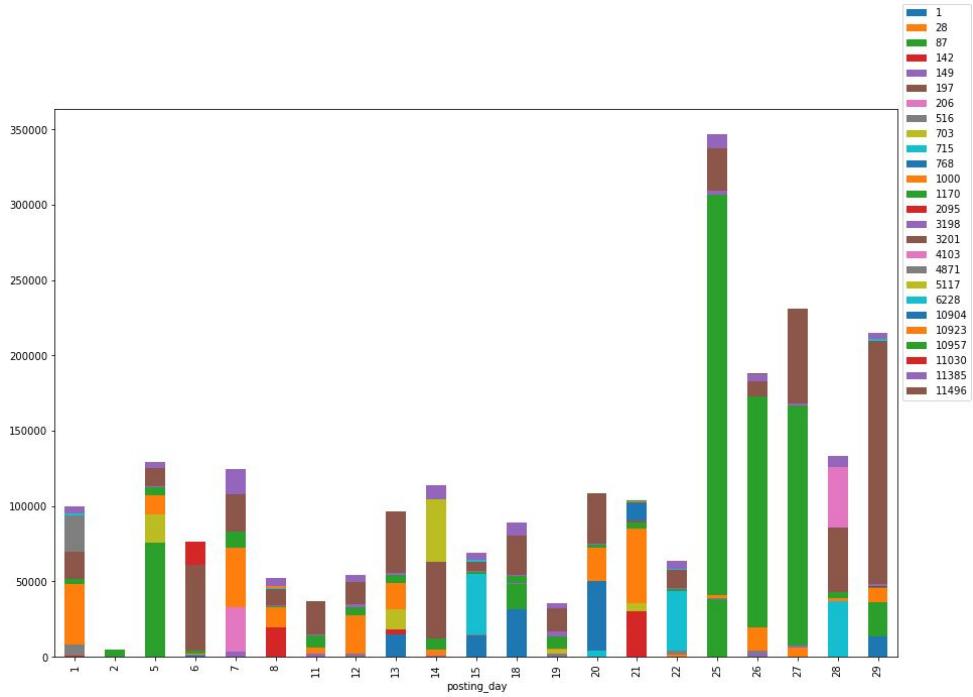


Fig 43. Donation trend for the month of **July 2011**

**July, 2012**

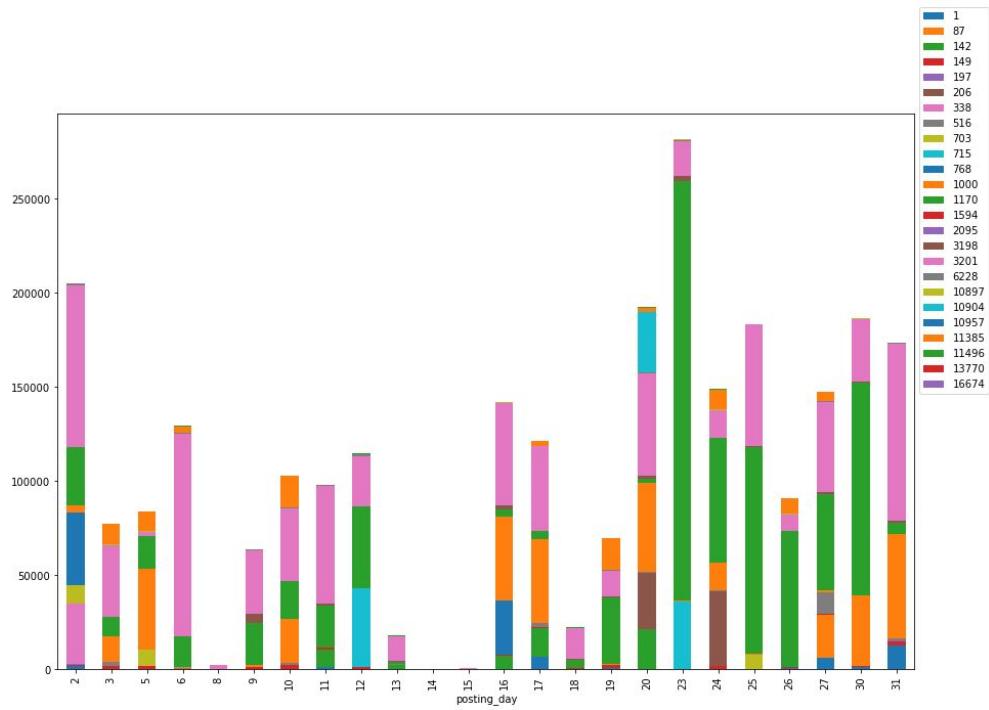


Fig 44. Donation trend for the month of July 2012

**July, 2013**

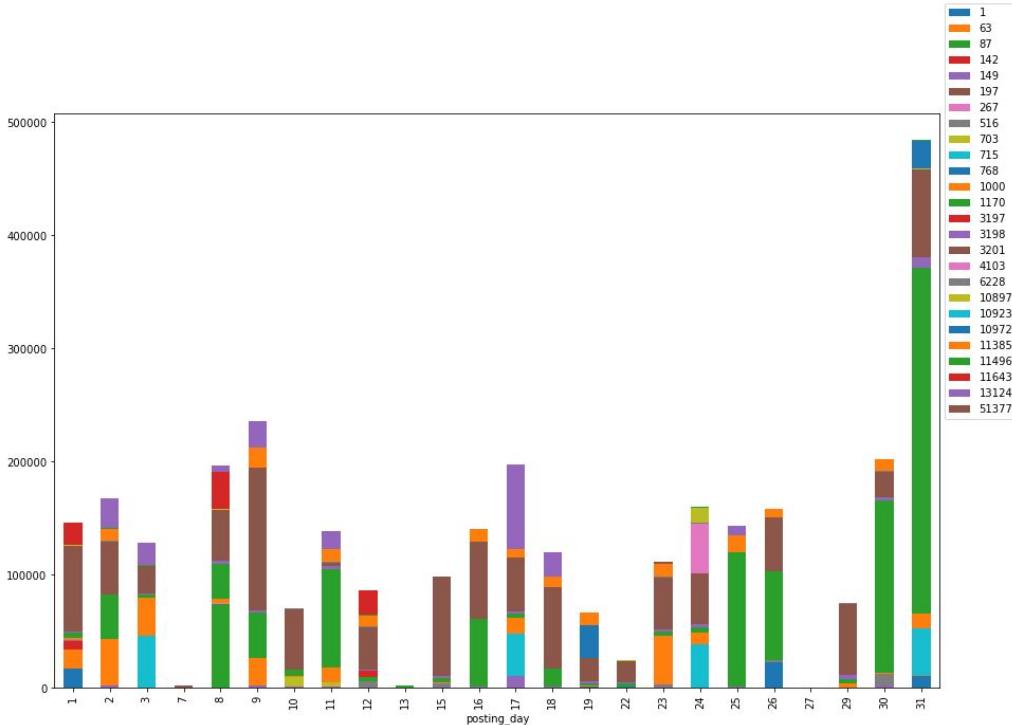


Fig 45. Donation trend for the month of July 2013

## July, 2014

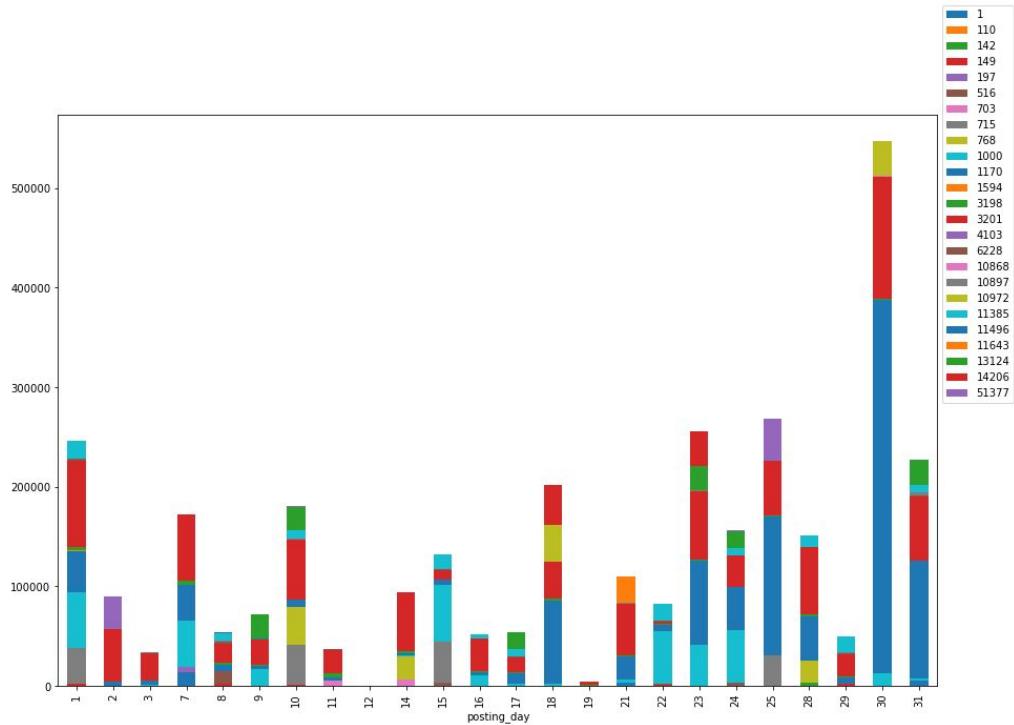


Fig 46. Donation trend for the month of July 2014

## July, 2015

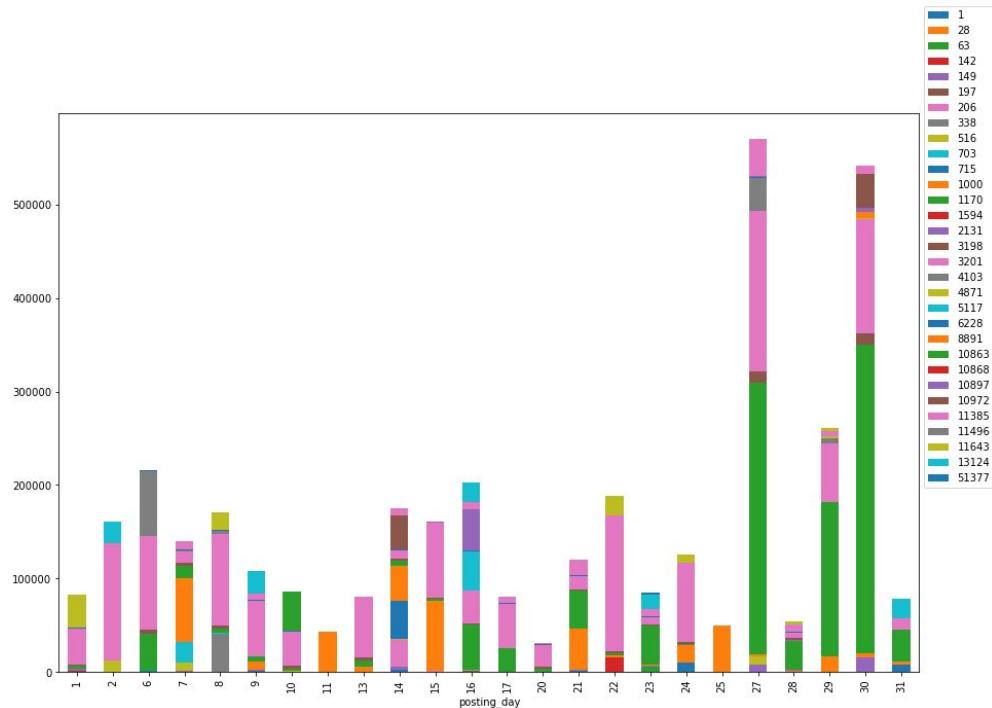
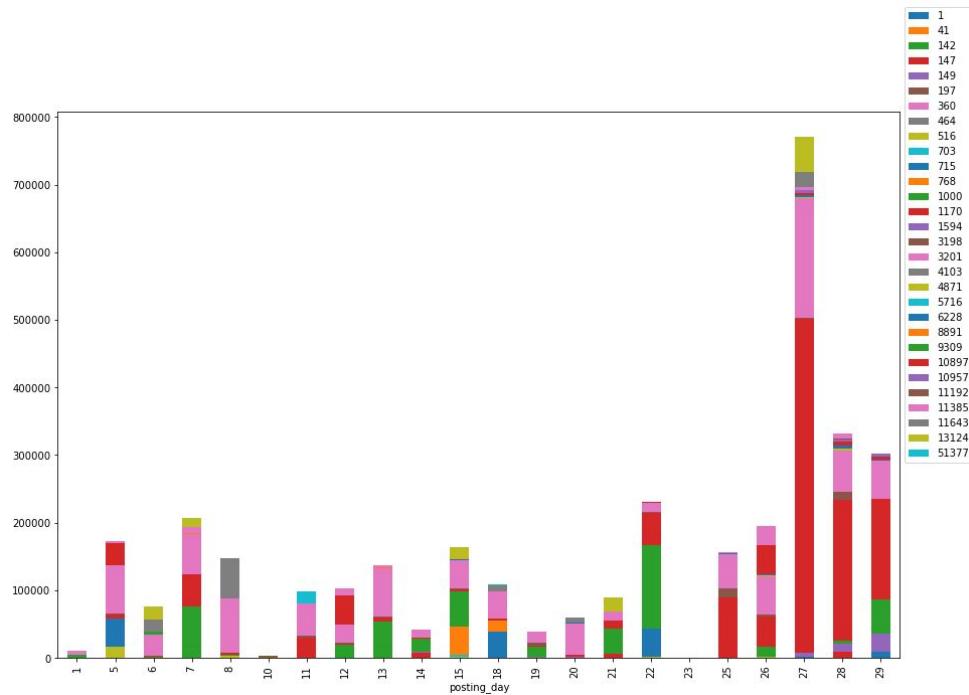


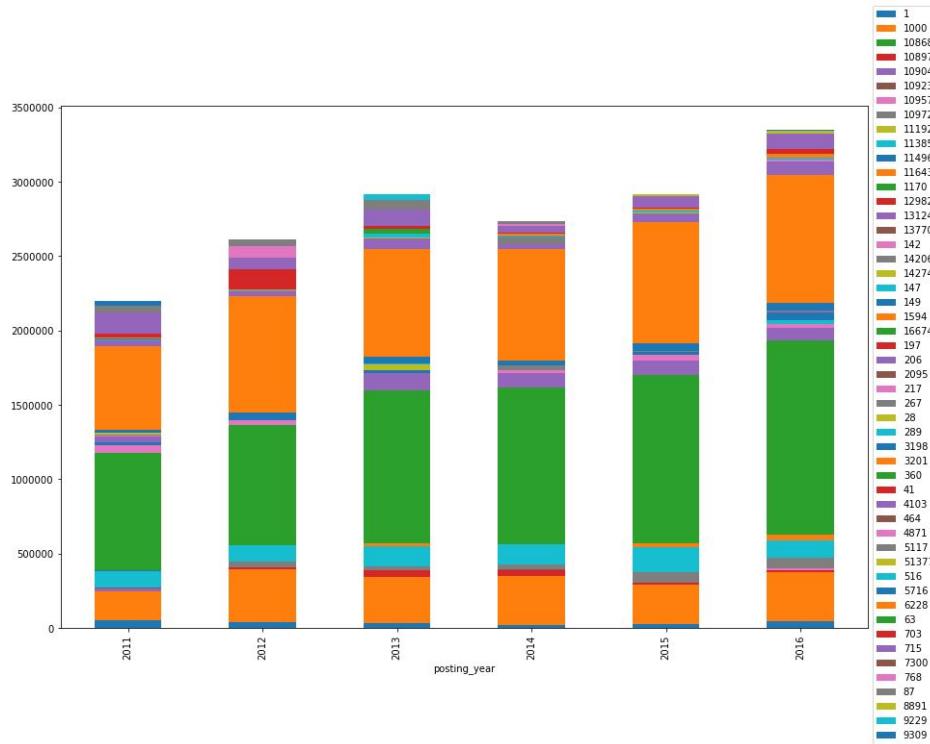
Fig 47. Donation trend for the month of July 2015

**July, 2016**



**Fig 48. Donation trend for the month of July 2016**

**H. August (08)**



**Fig 49. Donation trend by donor codes from 2012-2017 for the month of August**

## August, 2011

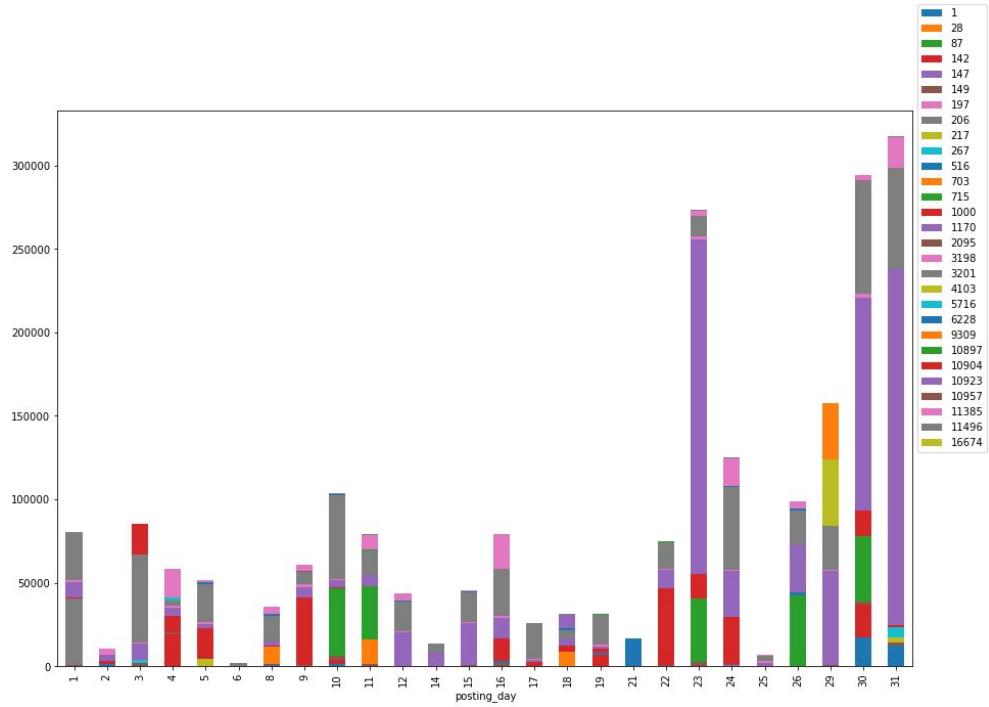


Fig 50. Donation trend for the month of **August 2011**

## August, 2012

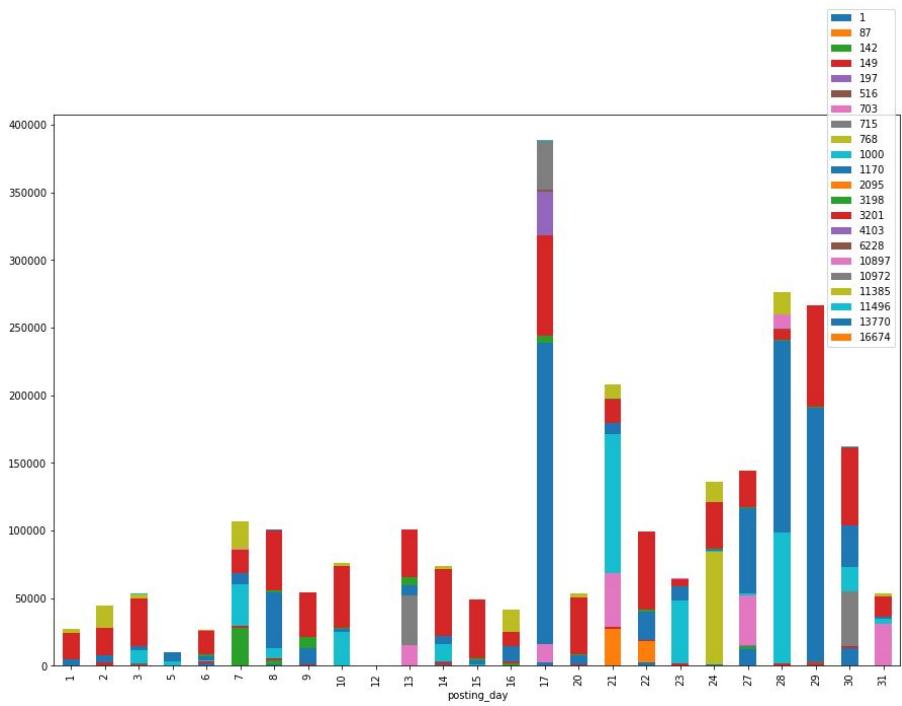
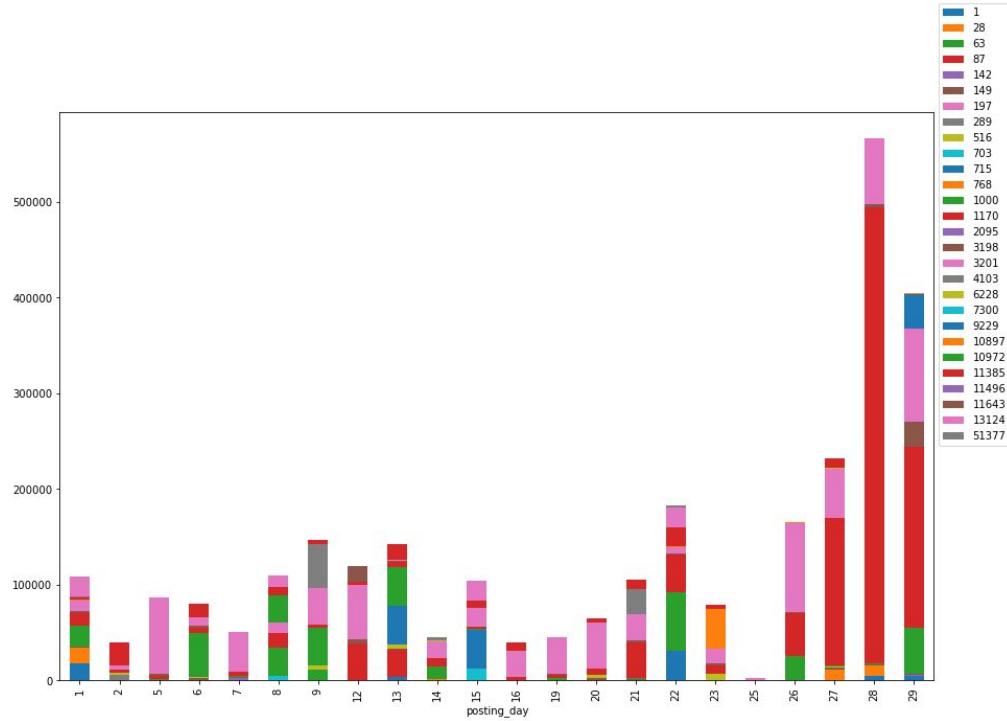


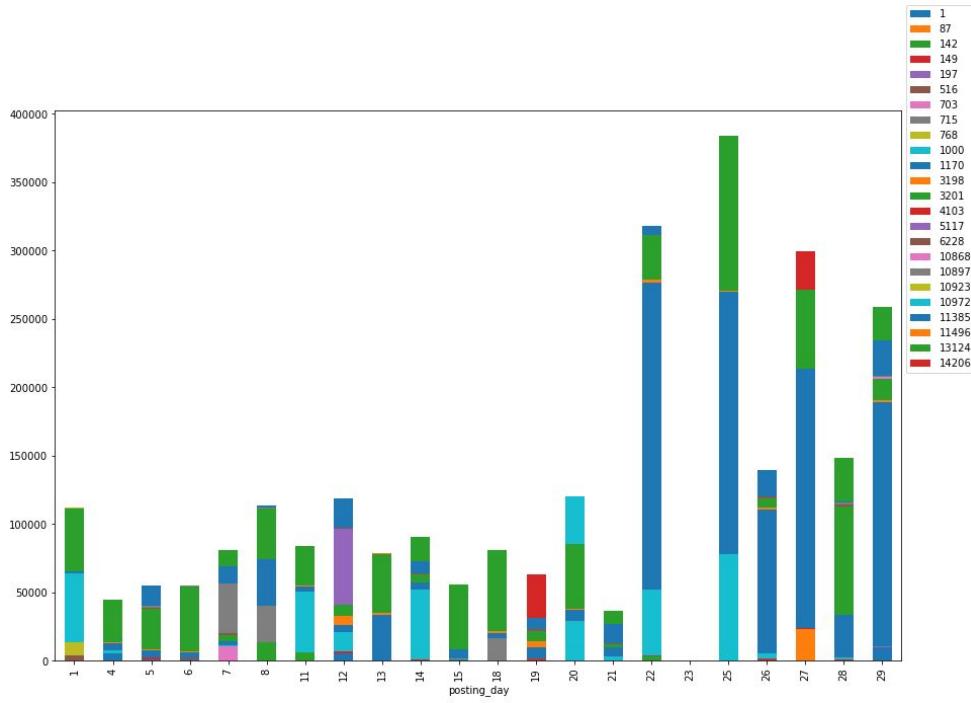
Fig 51. Donation trend for the month of **August 2012**

## August, 2013



**Fig 52. Donation trend for the month of August 2013**

## August, 2014



**Fig 53. Donation trend for the month of August 2014**

## August, 2015

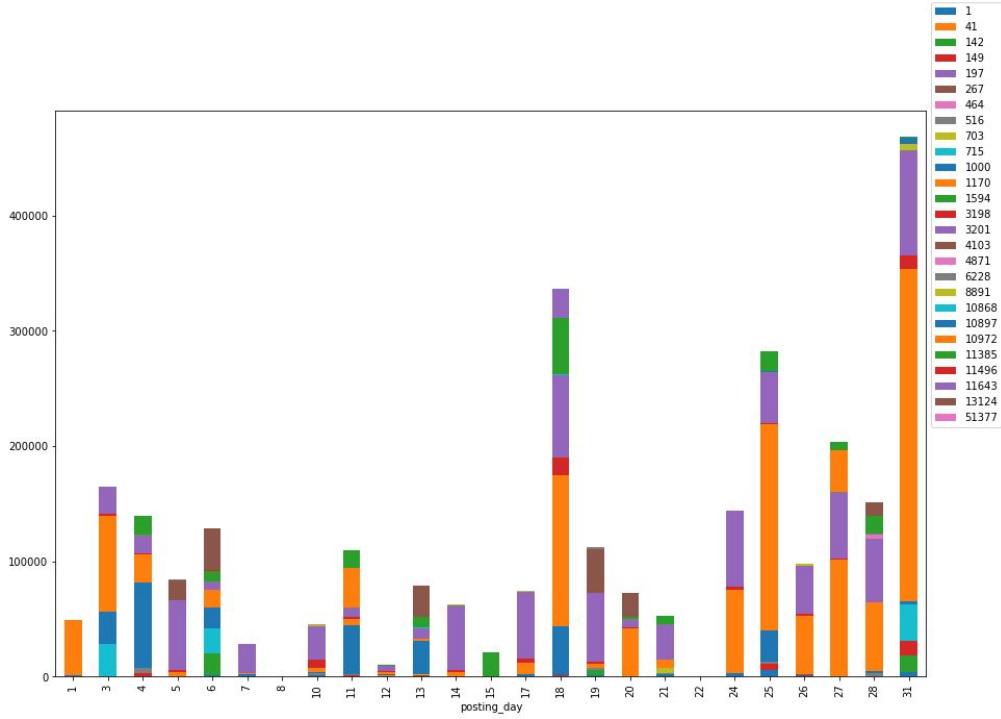


Fig 54. Donation trend for the month of August 2015

## August, 2016

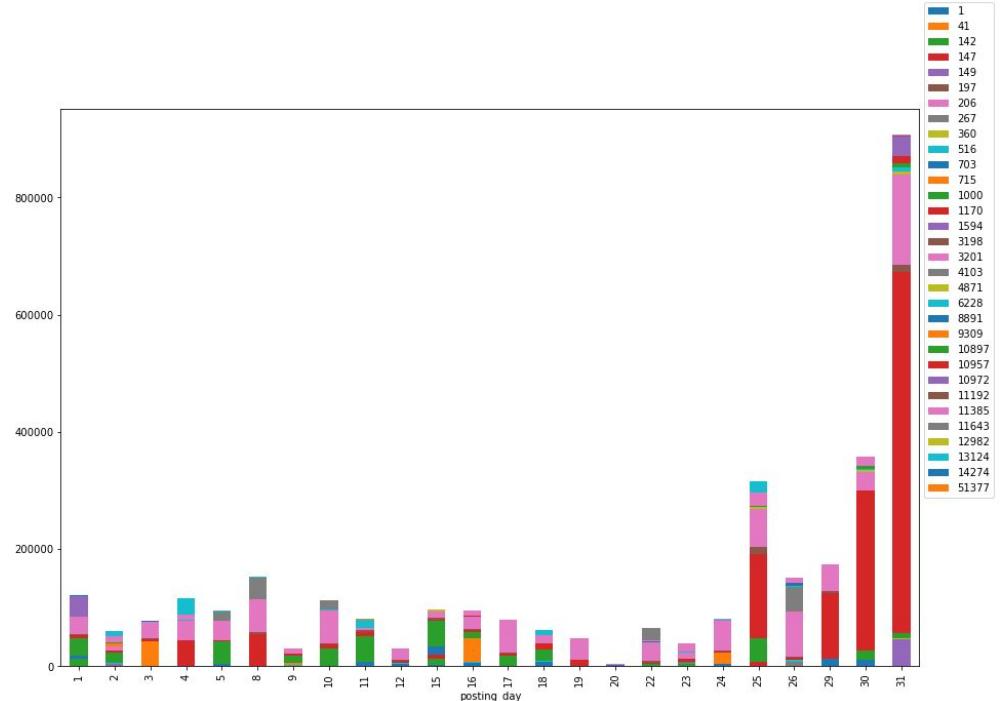
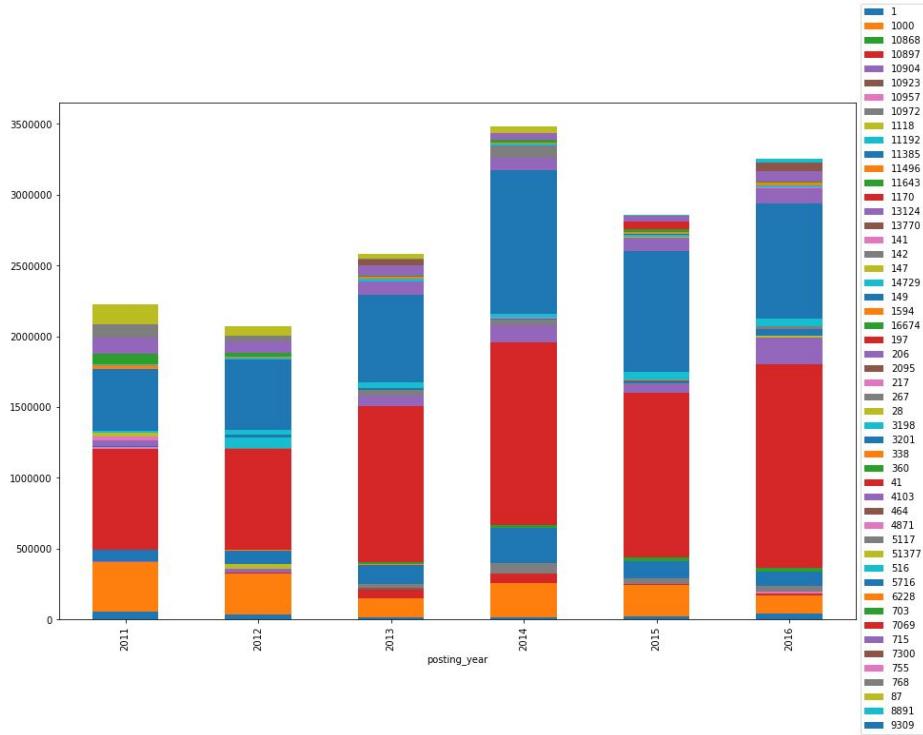


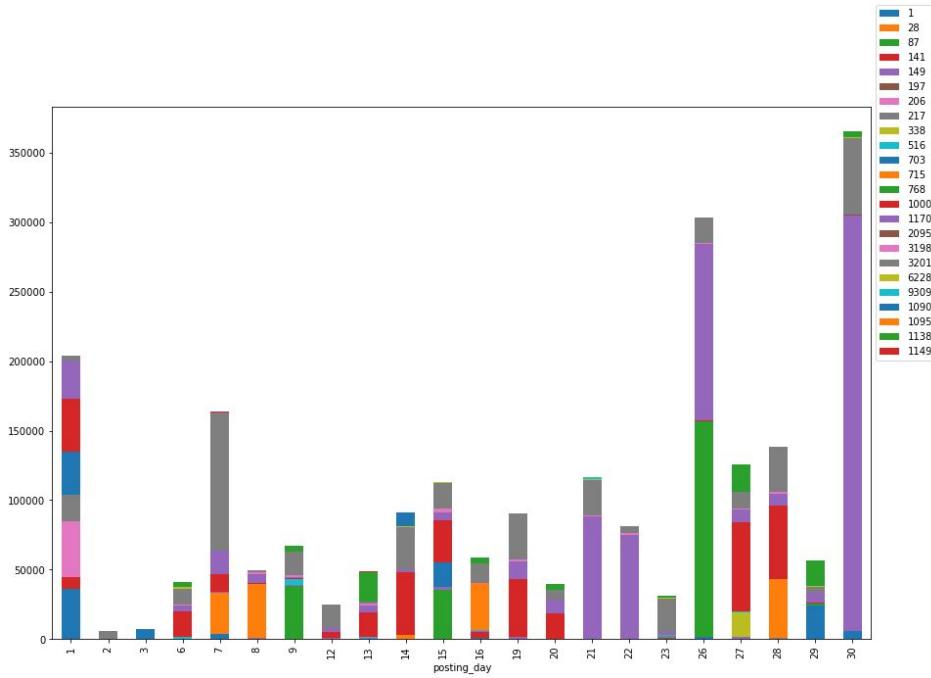
Fig 55. Donation trend for the month of August 2016

## I. September (09)



**Fig 56. Donation trend by donor codes from 2012-2017 for the month of September**

## September, 2011



**Fig 57. Donation trend for the month of September 2011**

## September, 2012

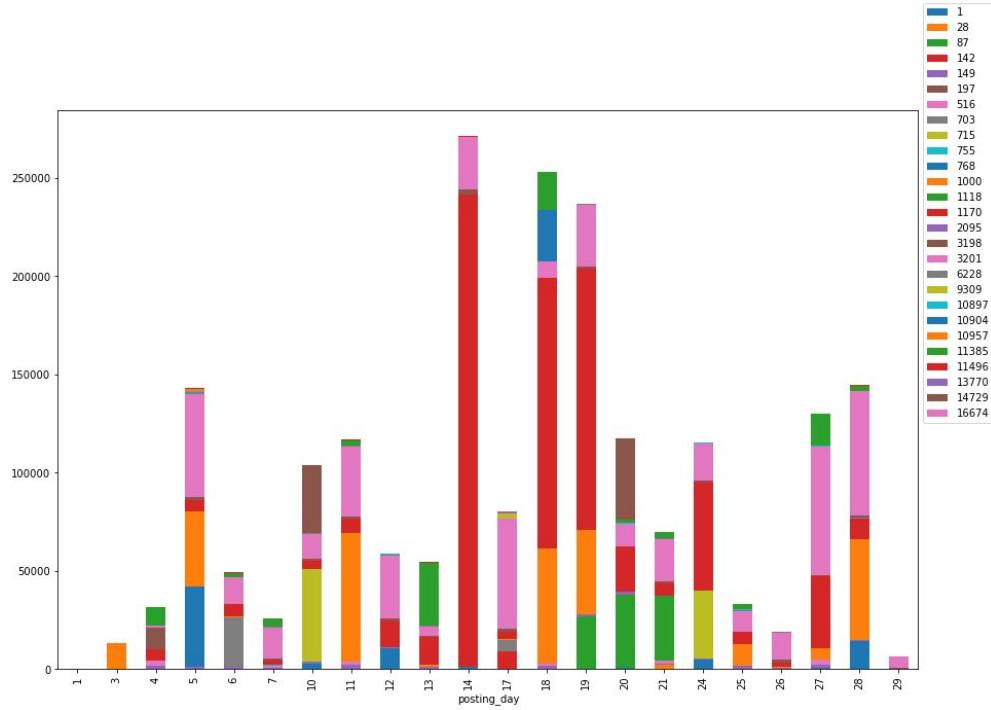


Fig 58. Donation trend for the month of **September 2012**

## September, 2013

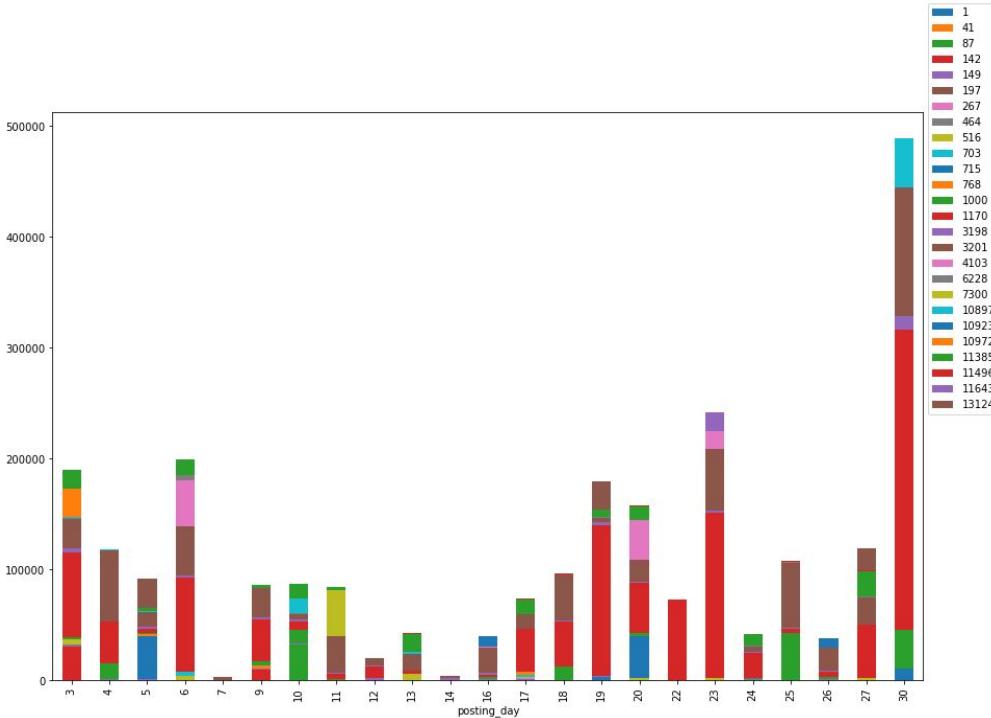


Fig 59. Donation trend for the month of **September 2013**

## September, 2014

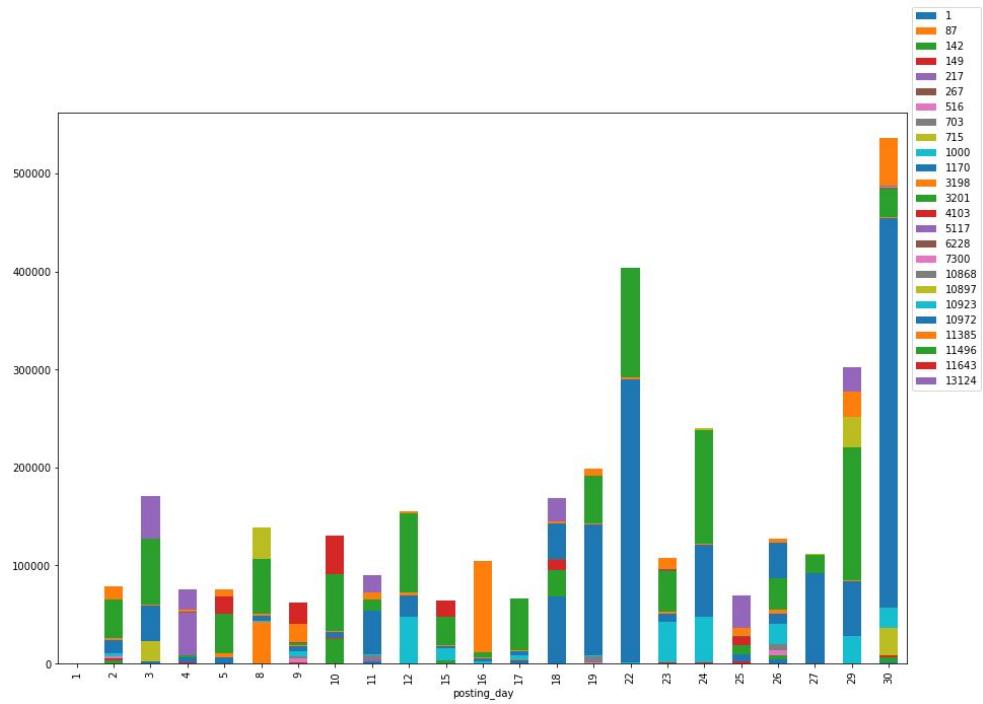


Fig 60. Donation trend for the month of September 2014

## September, 2015

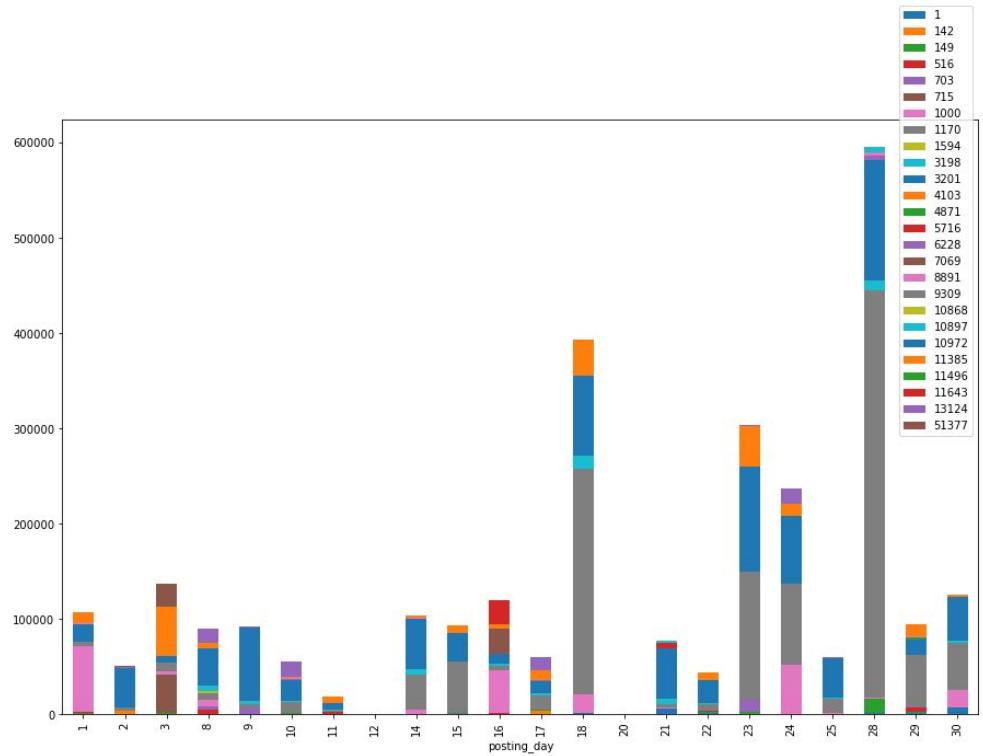


Fig 61. Donation trend for the month of September 2015

**September, 2016**

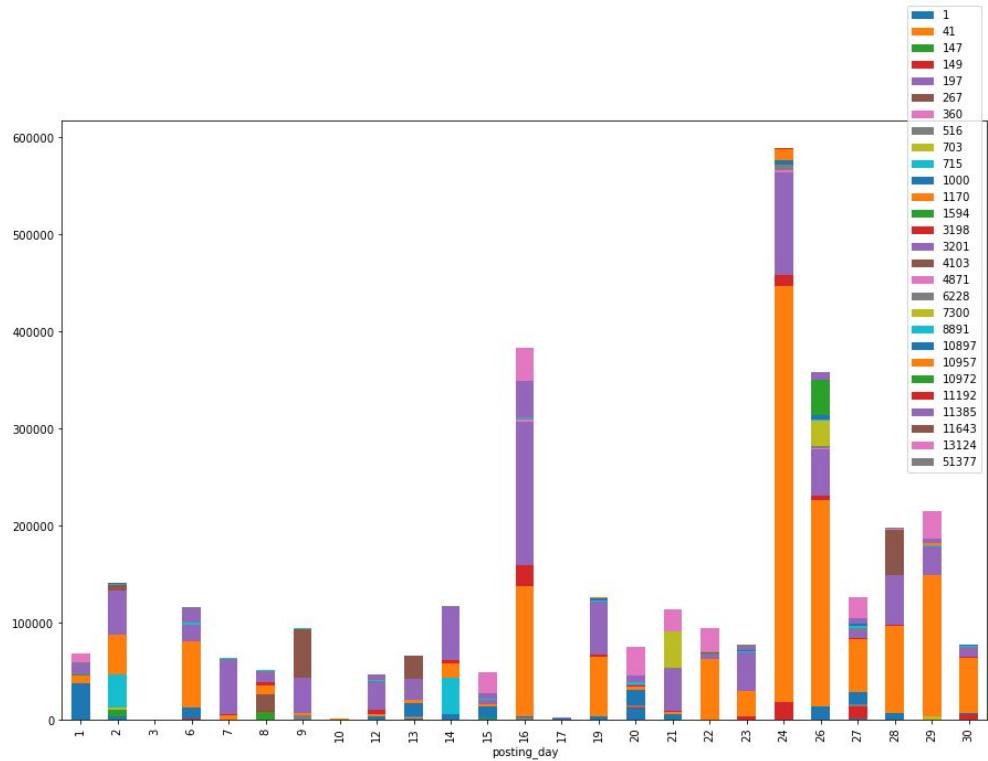


Fig 62. Donation trend for the month of September 2016

**I. October (10)**

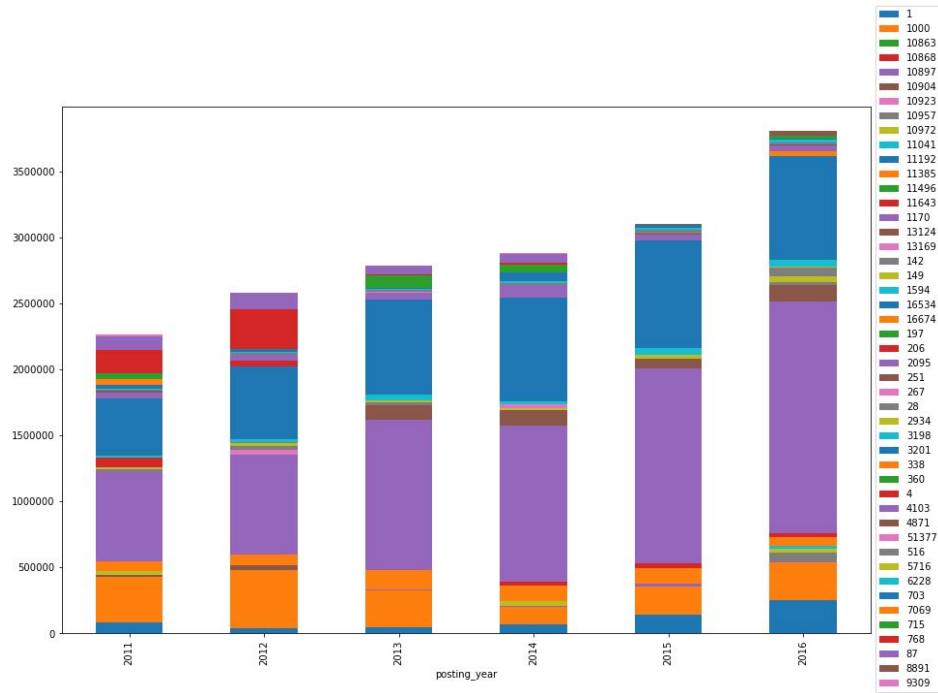


Fig 63. Donation trend by donor codes from 2012-2017 for the month of October

## October, 2011

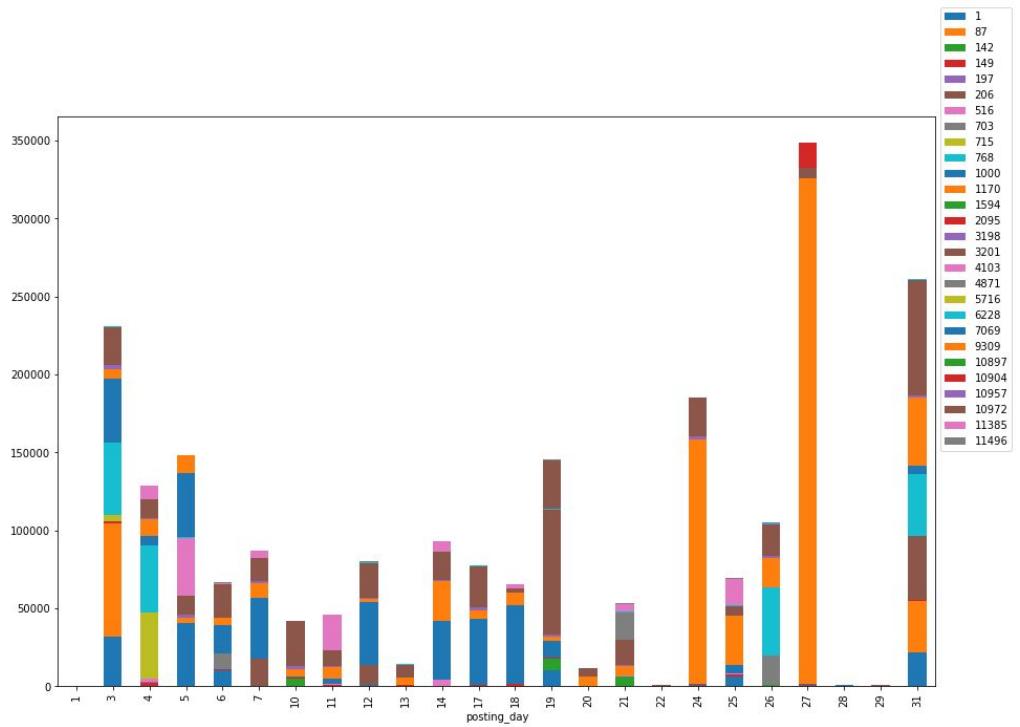


Fig 64. Donation trend for the month of October 2011

## October, 2012

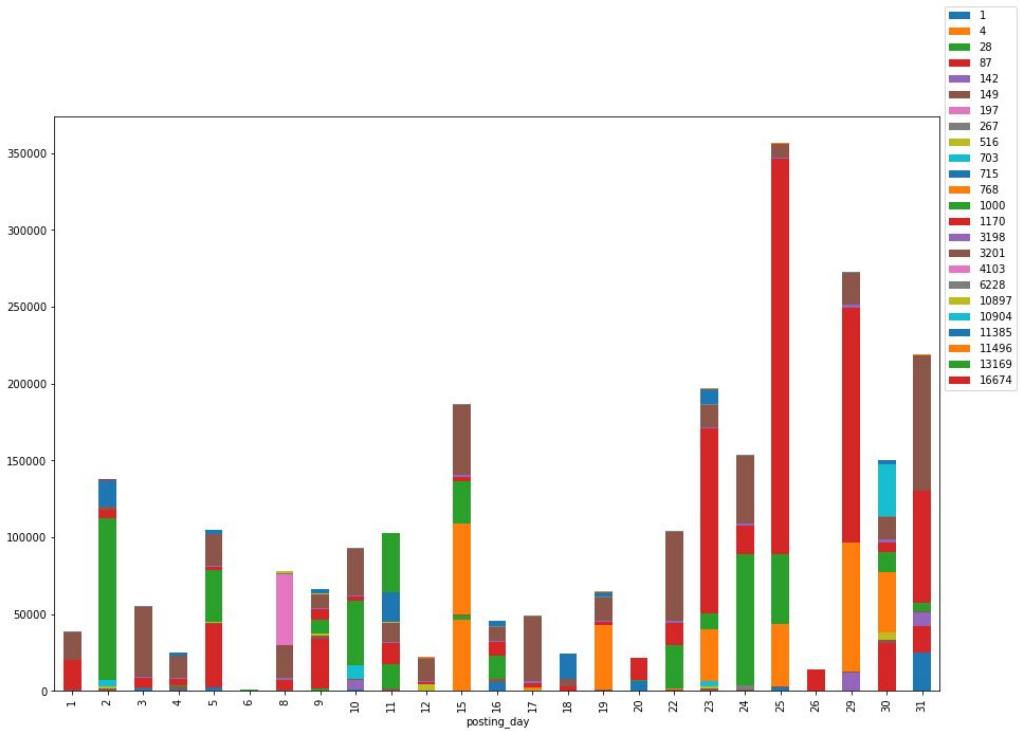


Fig 65. Donation trend for the month of October 2012

## October, 2013

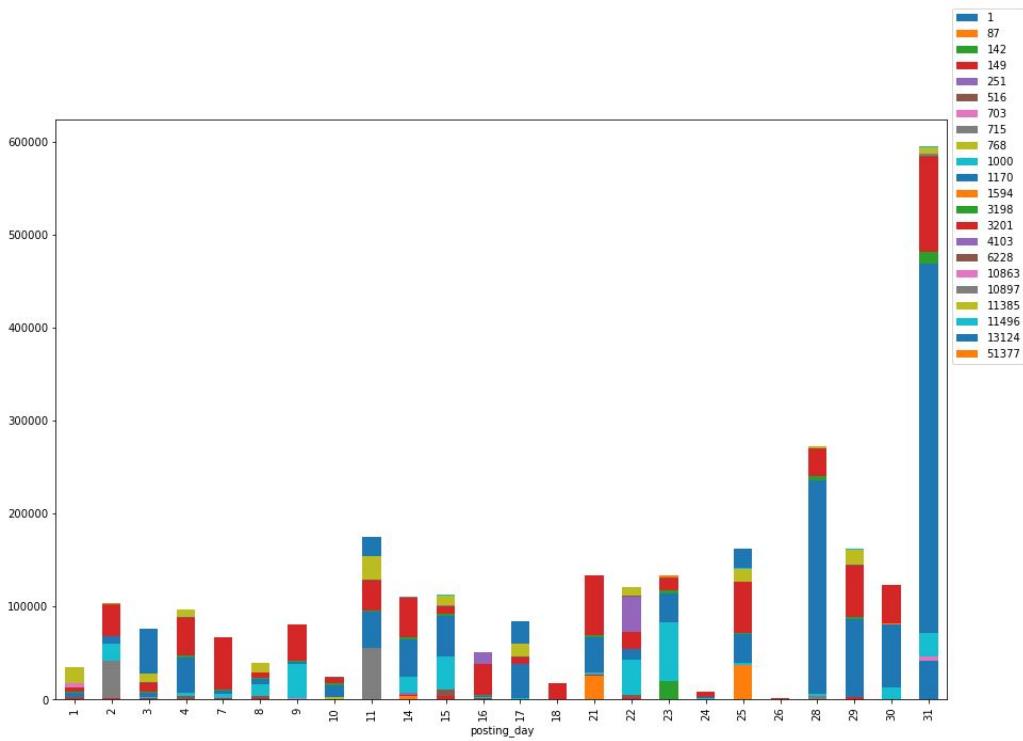


Fig 66. Donation trend for the month of **October 2013**

## October, 2014

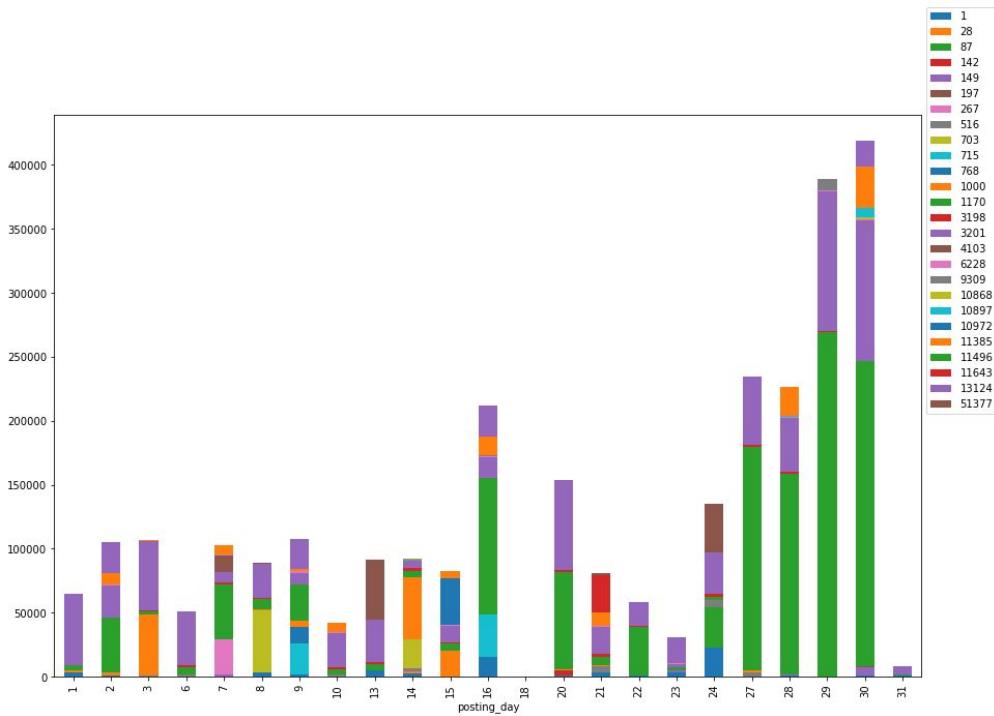
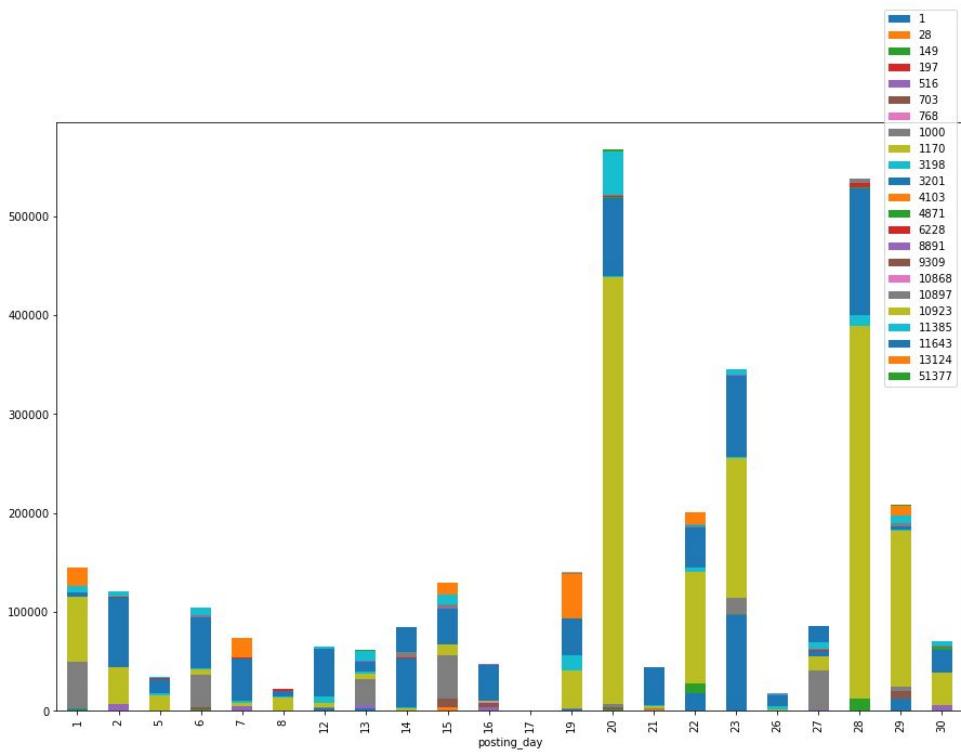


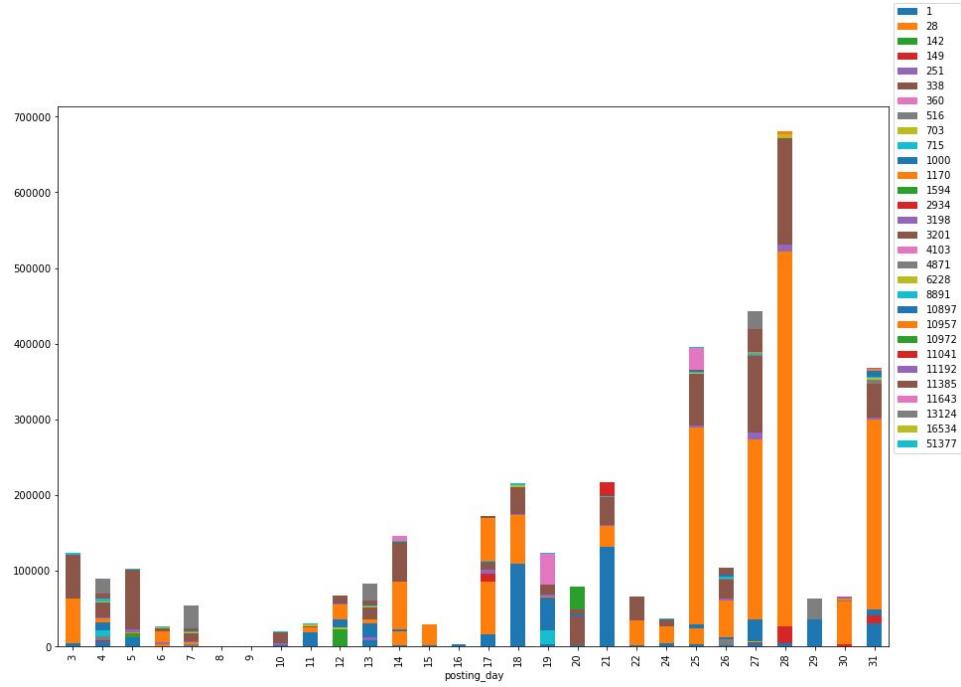
Fig 67. Donation trend for the month of **October 2014**

## October, 2015



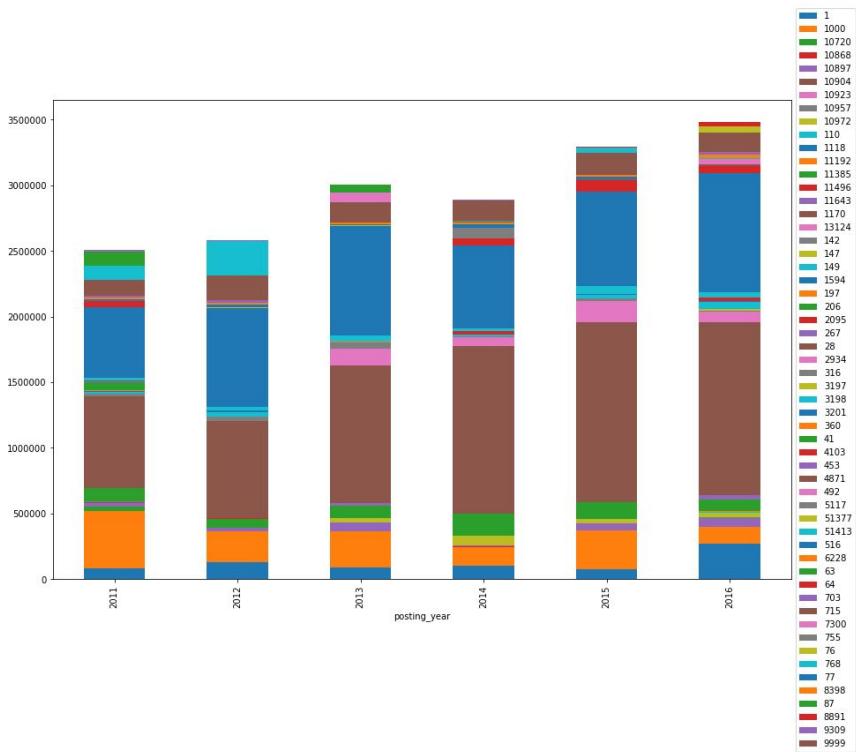
**Fig 68. Donation trend for the month of October 2015**

## October, 2016



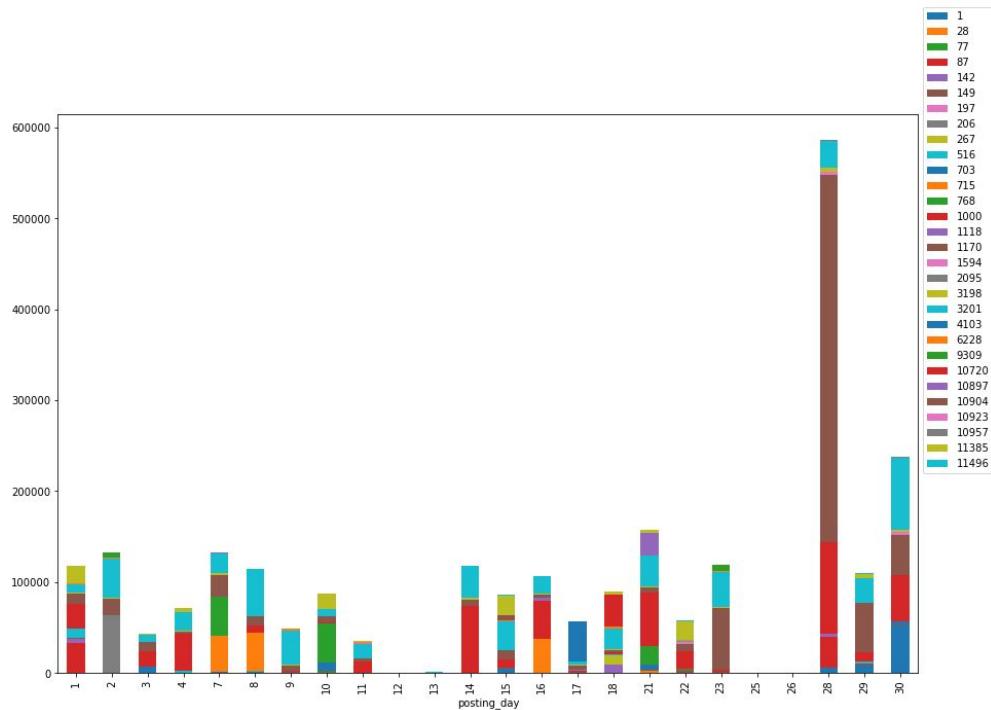
**Fig 69. Donation trend for the month of October 2016**

## **K. November (11)**



**Fig 70. Donation trend by donor codes from 2012-2017 for the month of November**

## **November, 2011**



**Fig 71. Donation trend for the month of November 2011**

## November, 2012

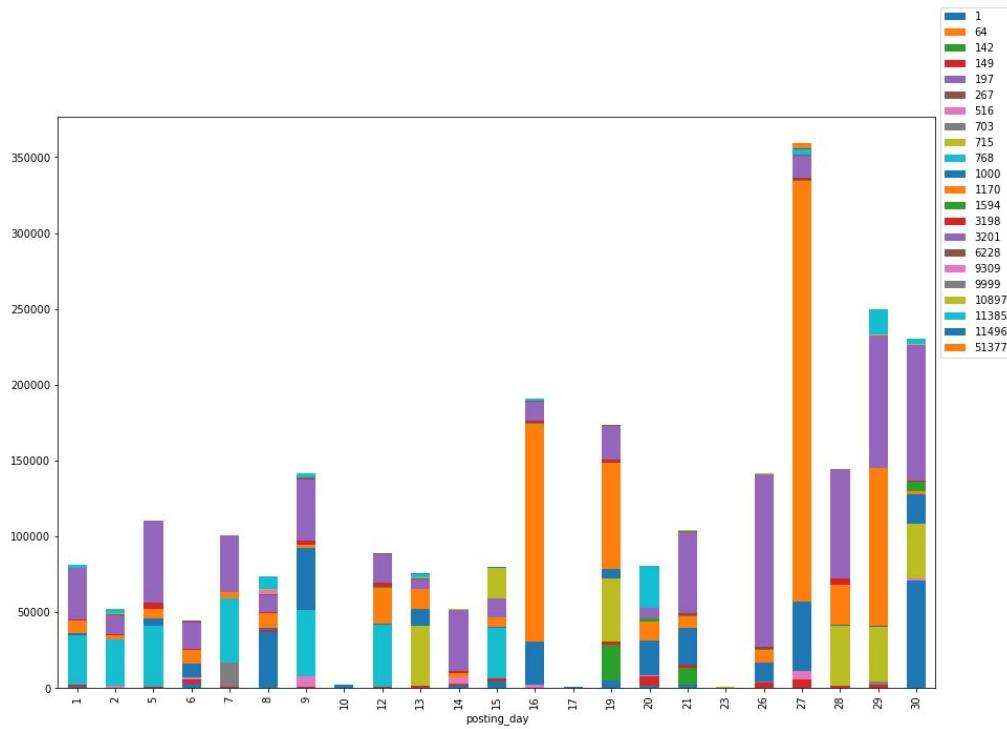


Fig 72. Donation trend for the month of November 2012

## November, 2013

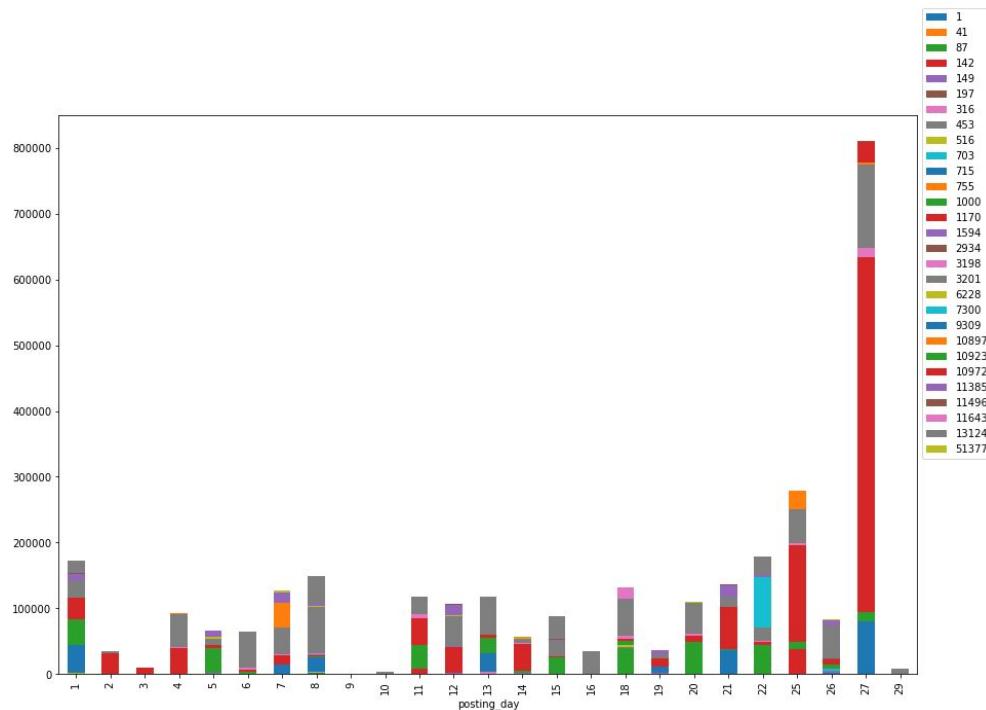


Fig 73. Donation trend for the month of November 2013

## November, 2014

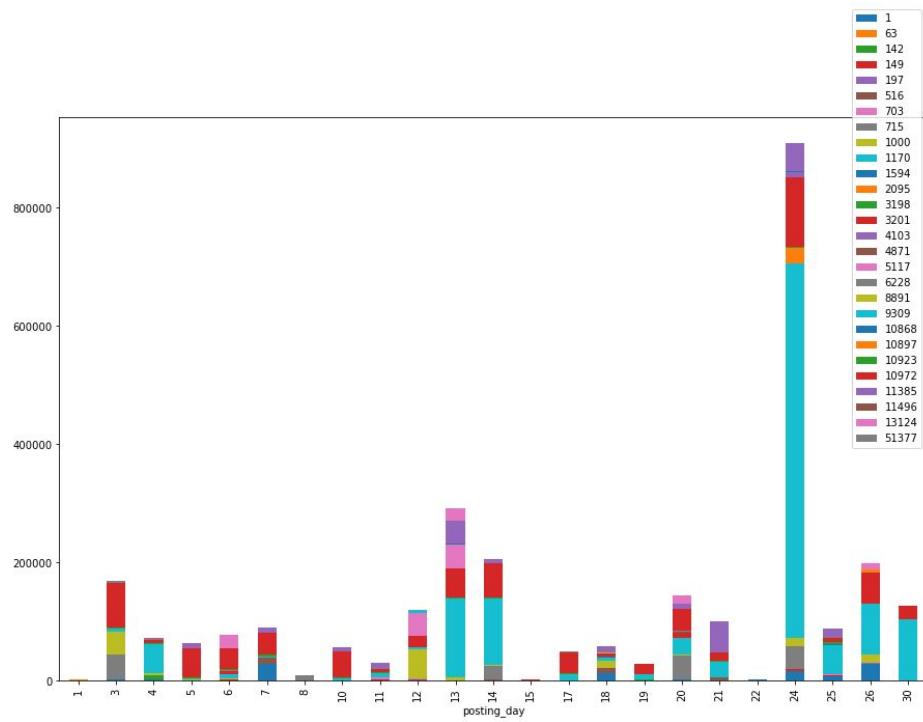


Fig 74. Donation trend for the month of November 2014

## November, 2015

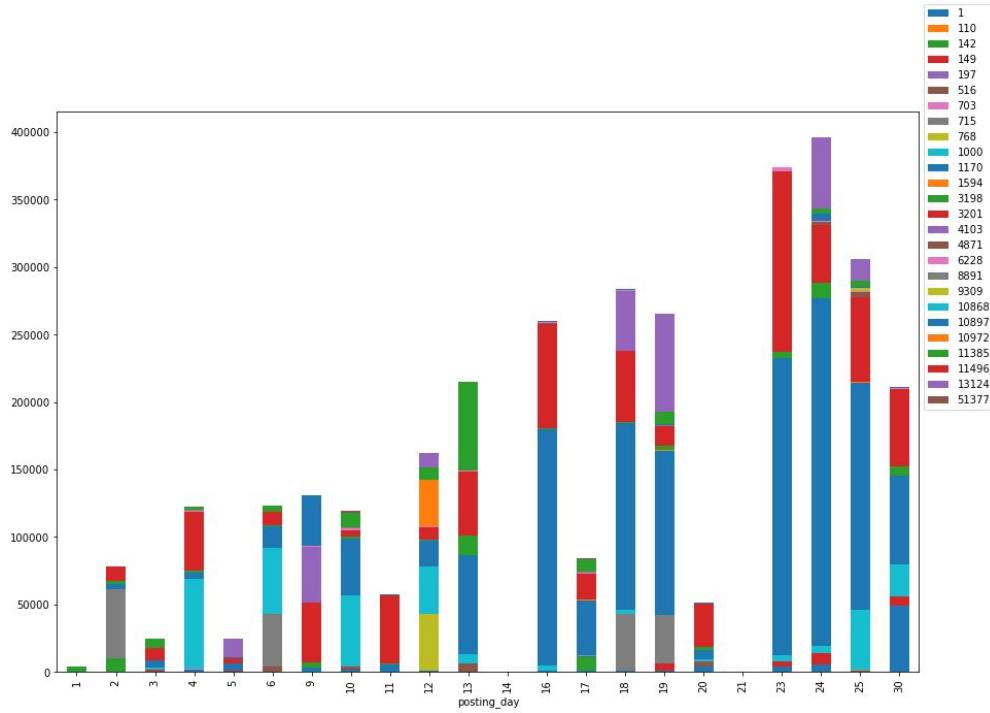
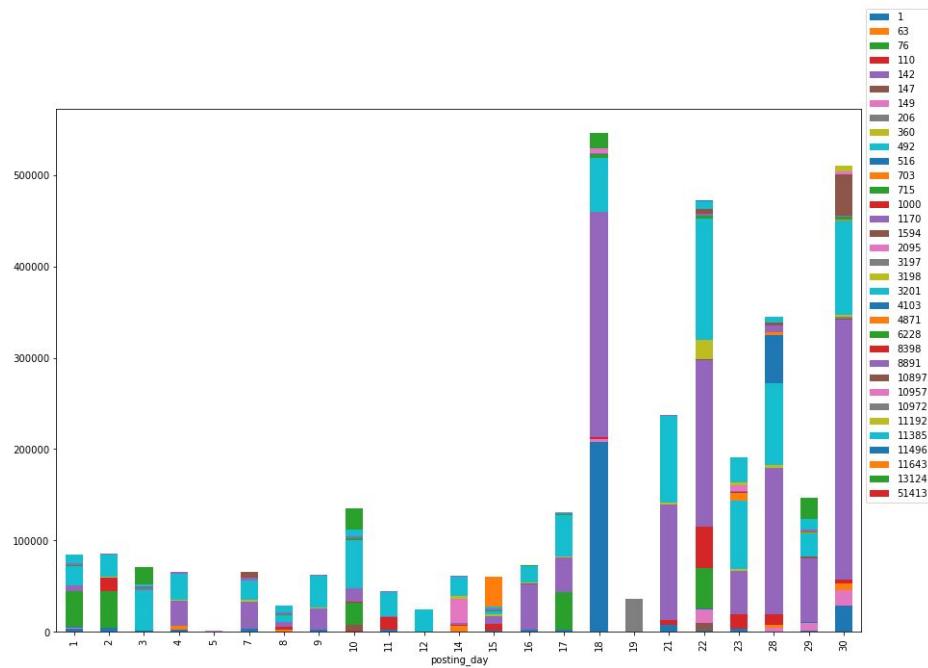


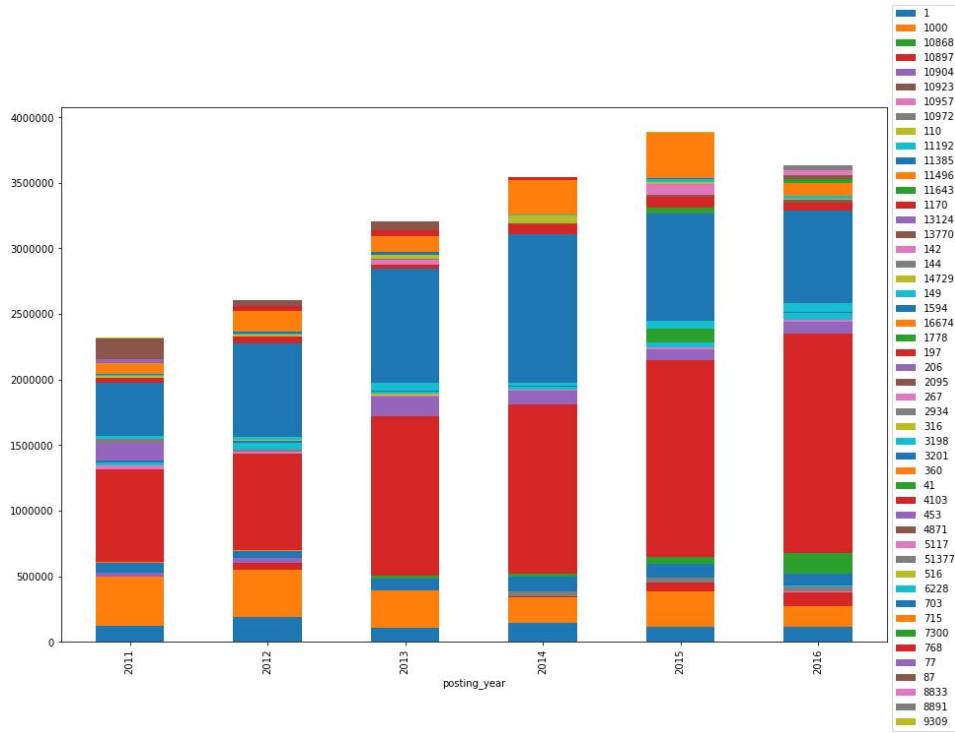
Fig 75. Donation trend for the month of November 2015

**November, 2016**



**Fig 76. Donation trend for the month of November 2016**

**L. December (12)**



**Fig 77. Donation trend by donor codes from 2012-2017 for the month of December**

## December, 2011

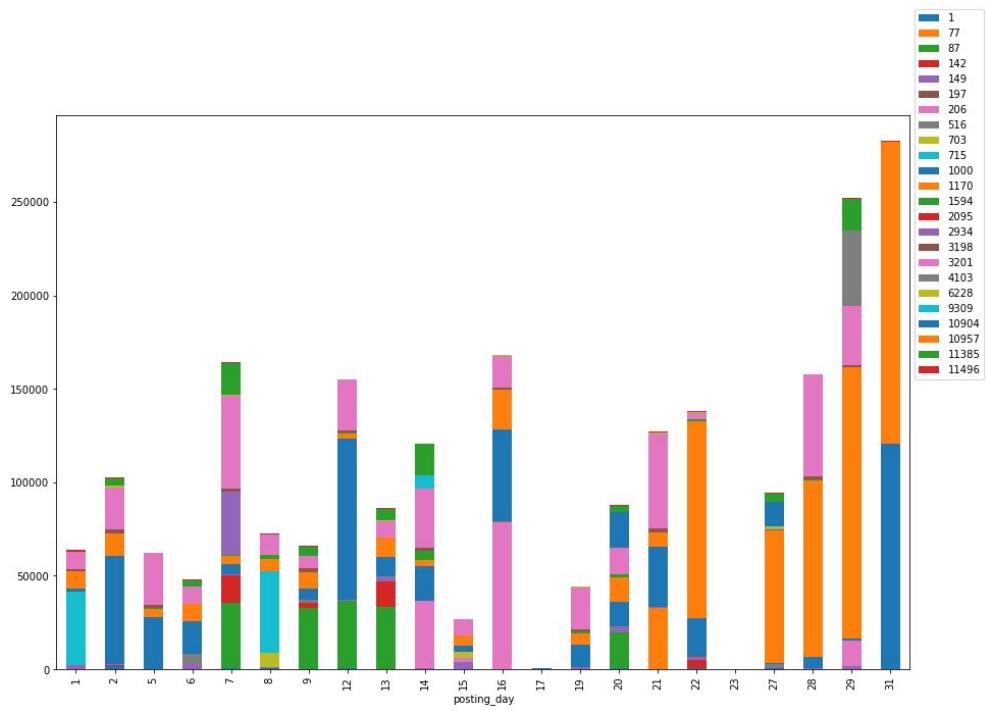


Fig 78. Donation trend for the month of December 2011

## December, 2012

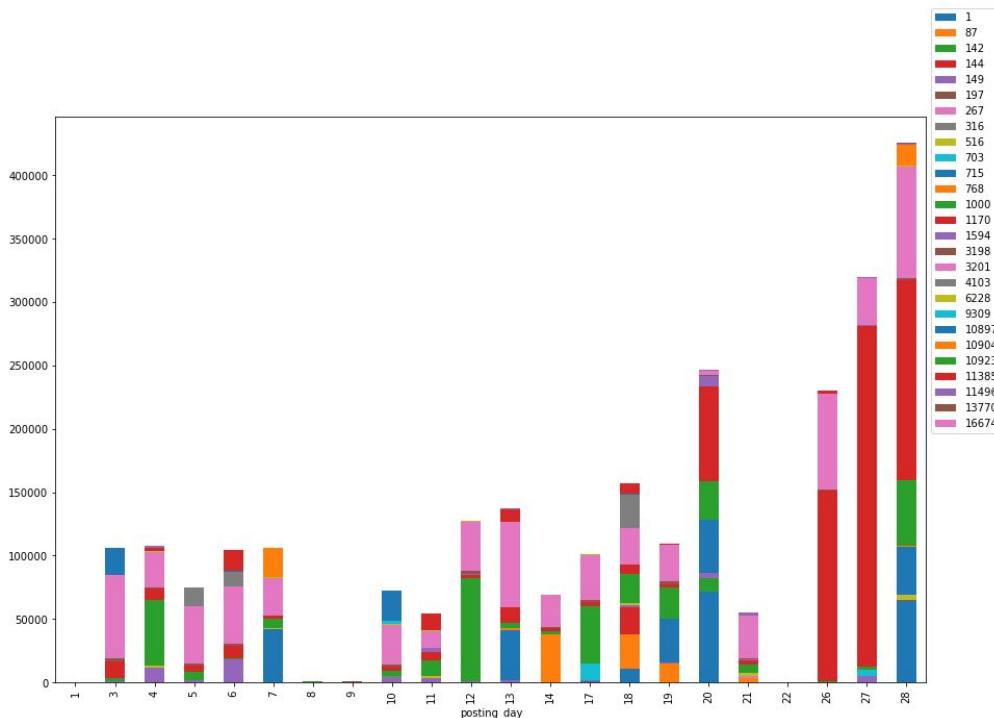


Fig 79. Donation trend for the month of December 2012

## December, 2013

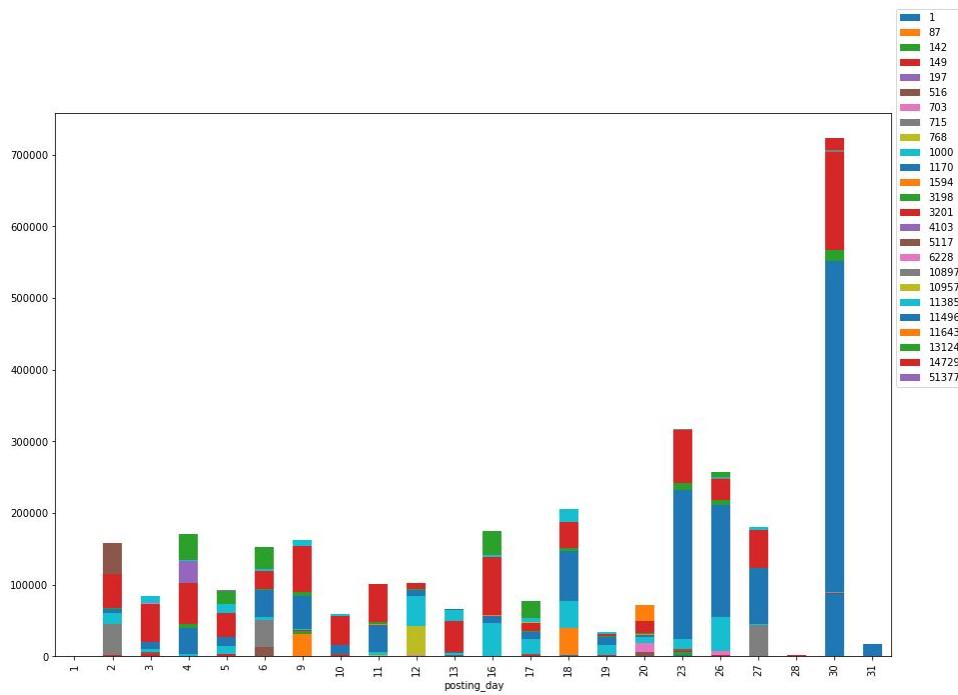


Fig 80. Donation trend for the month of December 2013

## December, 2014

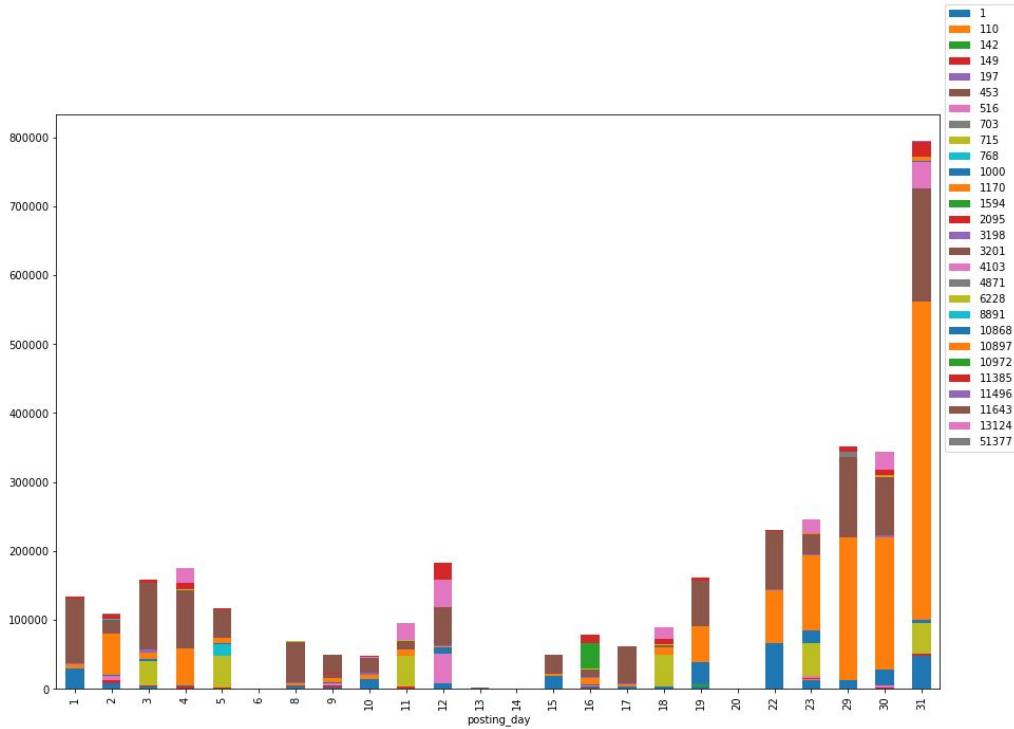


Fig 81. Donation trend for the month of December 2014

## December, 2015

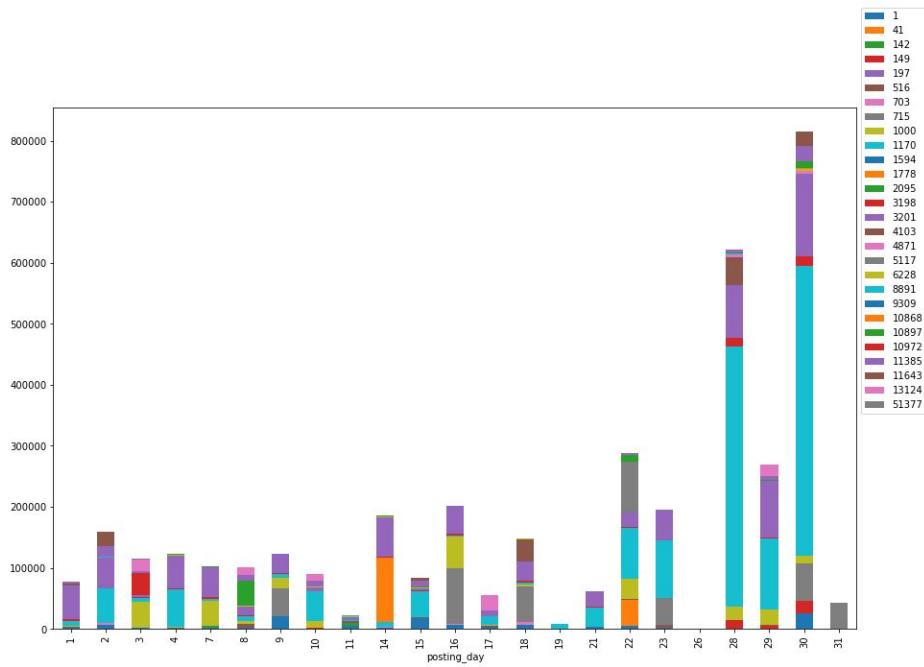


Fig 82. Donation trend for the month of December 2015

## December, 2016

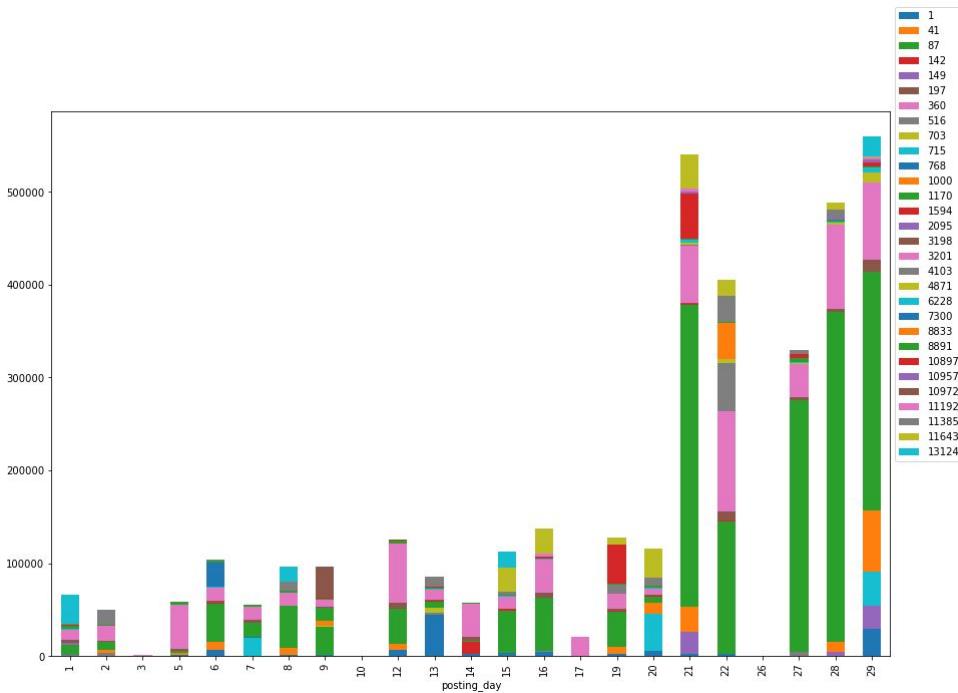


Fig 83. Donation trend for the month of December 2016

## **II. FOOD PURCHASE DATA ANALYSIS**

Next, we can analyse the trend for food quantities that have been purchased by FBCENC from FY 2006-2017.

- Quantity > 0
- Entry\_Type = 'Purchase'
- Fbc\_donor\_class = 'vendor'
- All entries are for unc\_donor\_code\_class = 'null' which means that the details from which vendor food has been purchased is not recorded

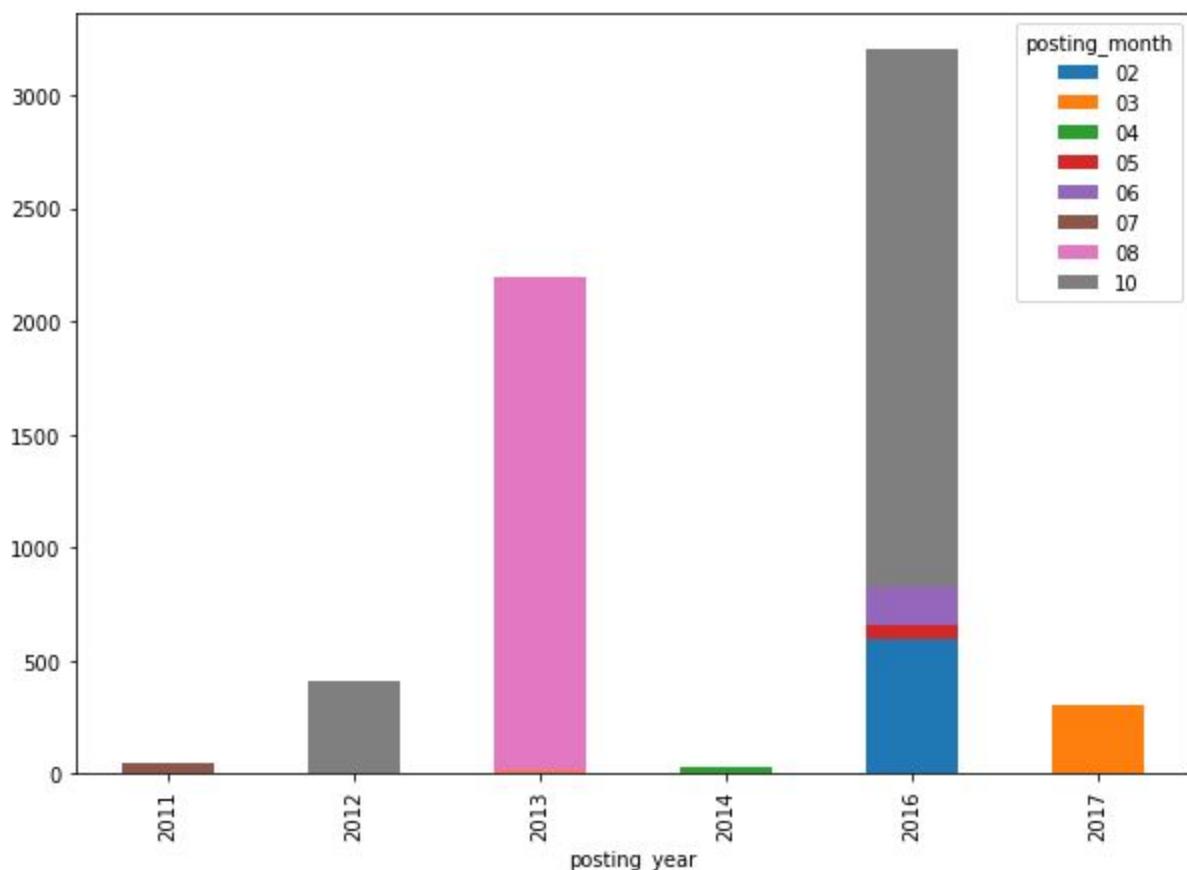
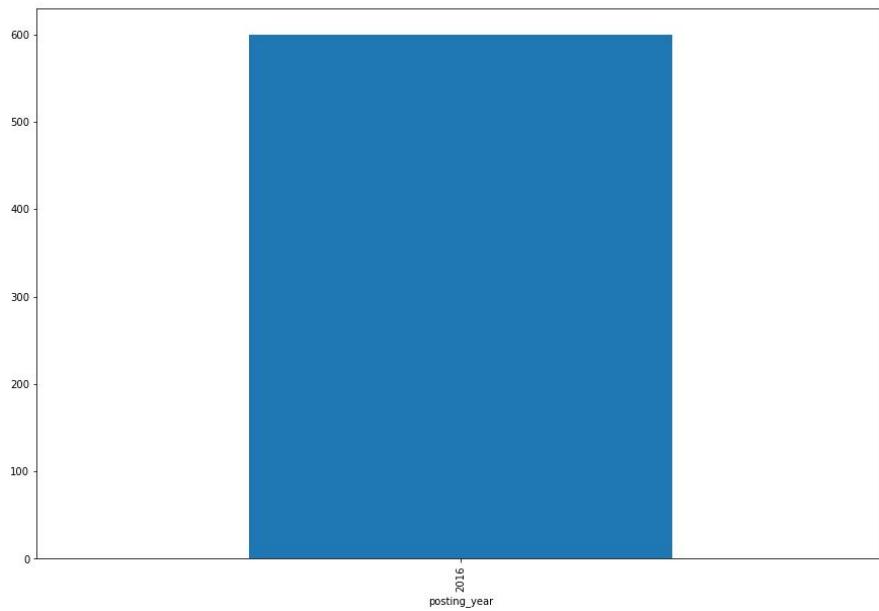


Fig 84. Purchase Trend over the years 2011 - 2017 for months

It can be observed that a large quantity of food was purchased in the year 2016.

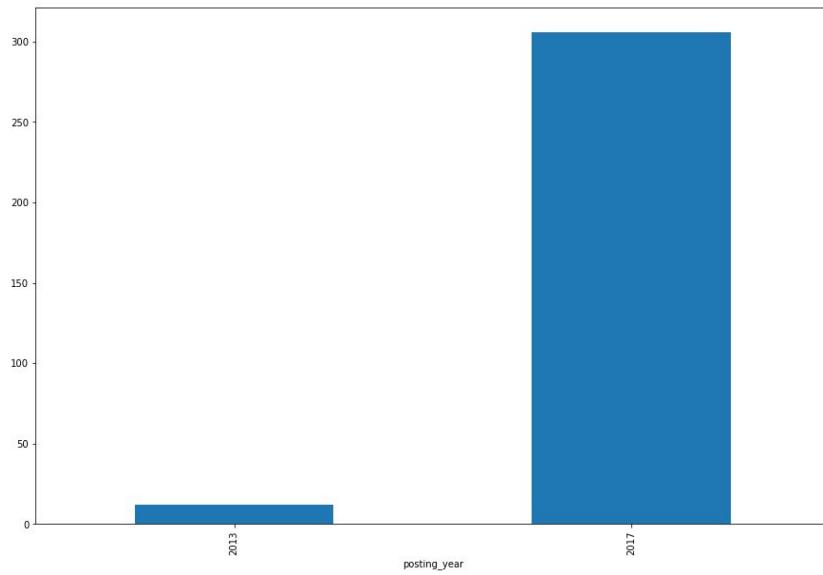
- A. **January (01)** - No purchase data available
- B. **February (02)** - Data available only for FY 2016 with 600 units of food purchased on Feb 18, 2016

 null

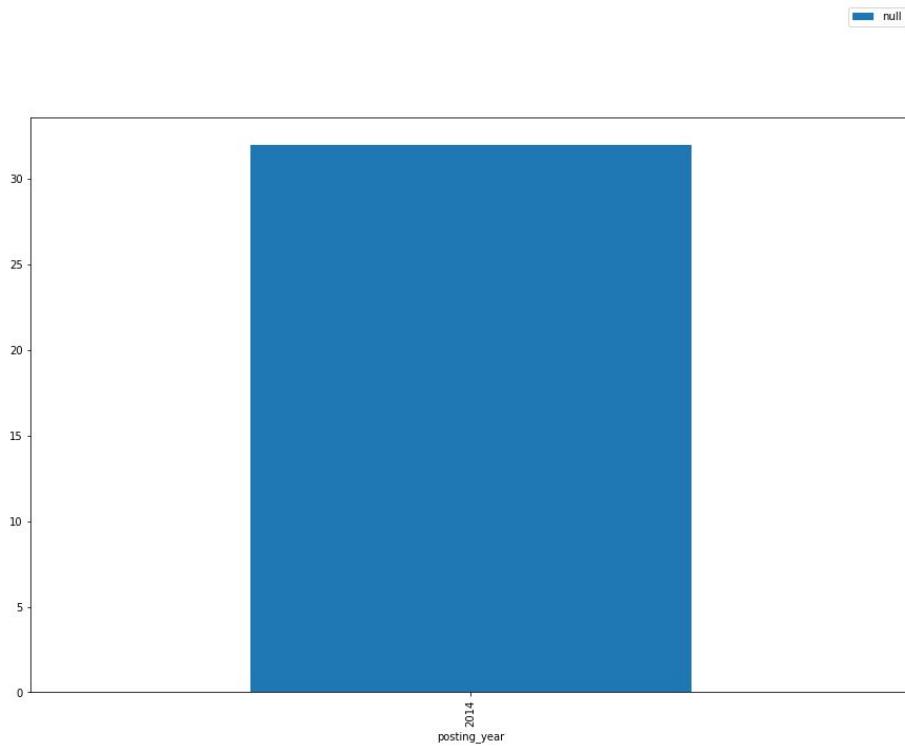


- C. **March (03)** - Food was purchased in the year of 2013 (12 units) and 2017 (306 units)

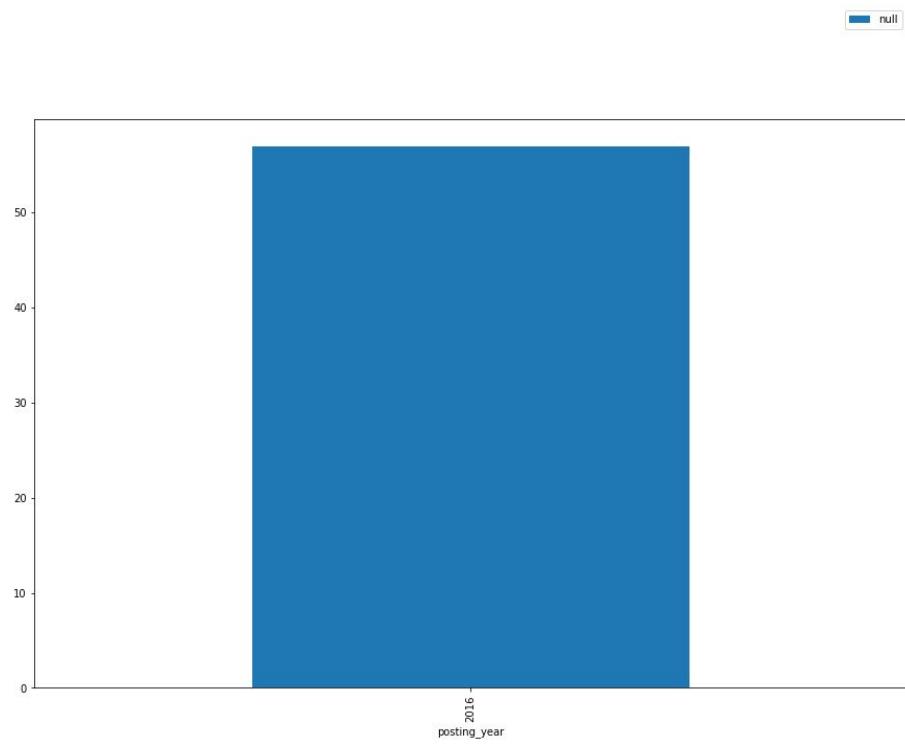
 null



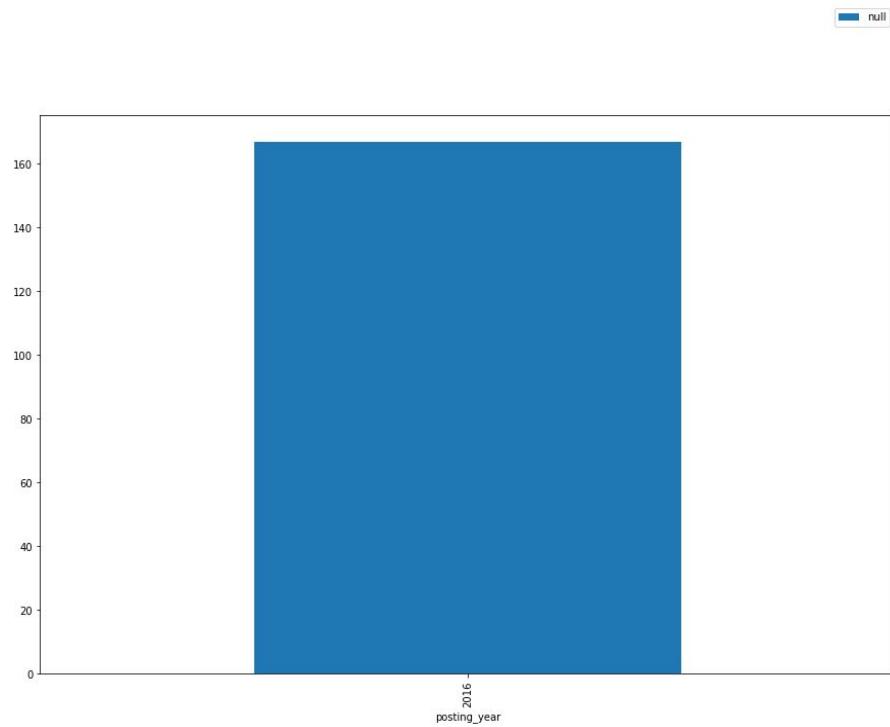
**D. April (04)** - Food was purchased in the year of 2014 (32 units)



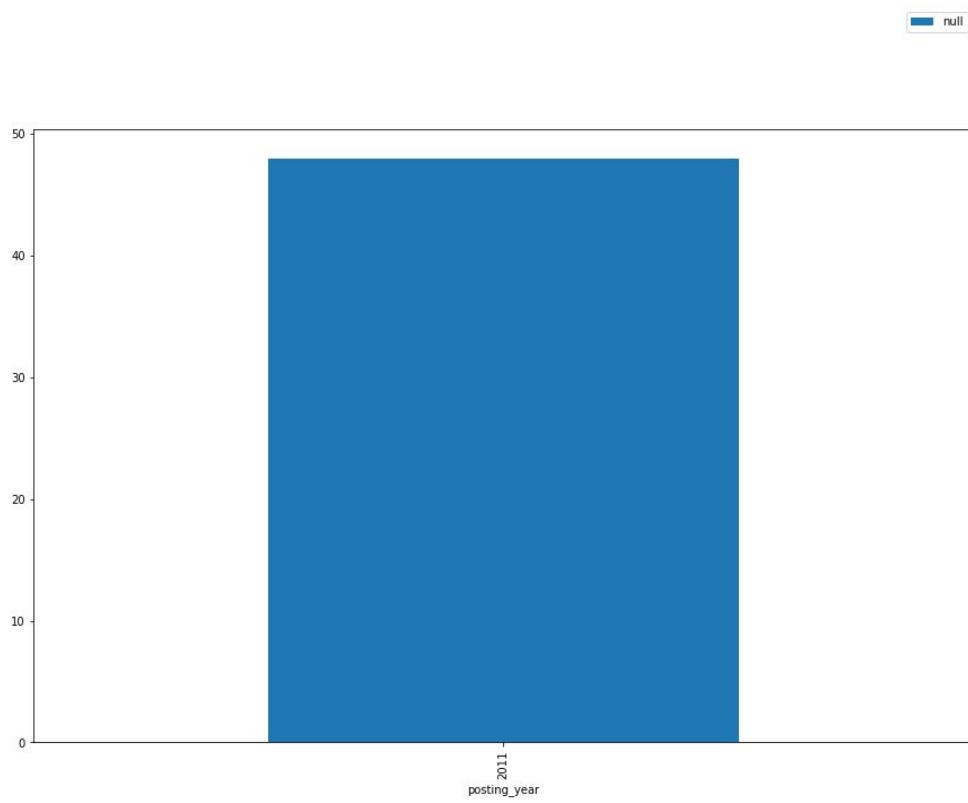
**E. May (05)** - Food was purchased in the year of 2016 (57 units)



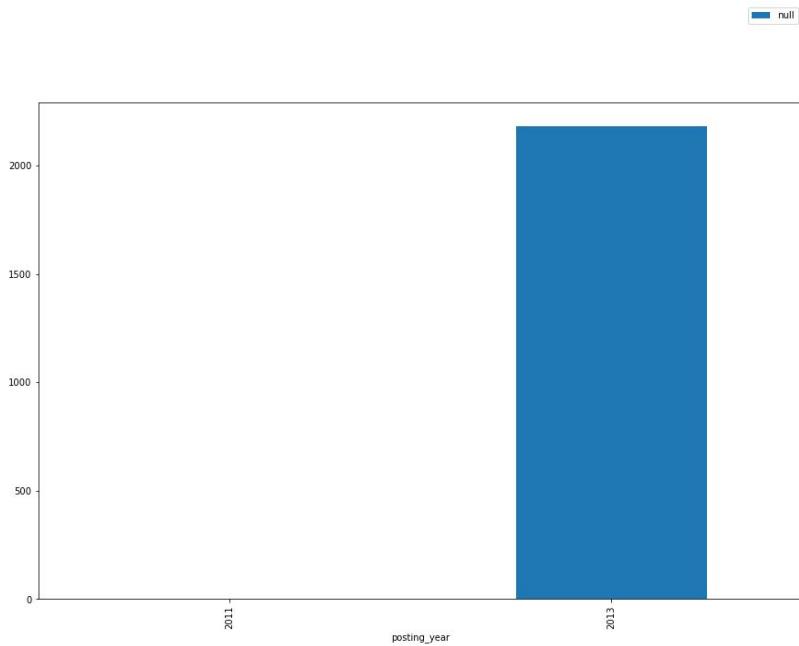
**F. June (06)** - Food was purchased in the year of 2016 (167 units)



**G. July (07)** - Food was purchased in the year of 2011 (48 units)

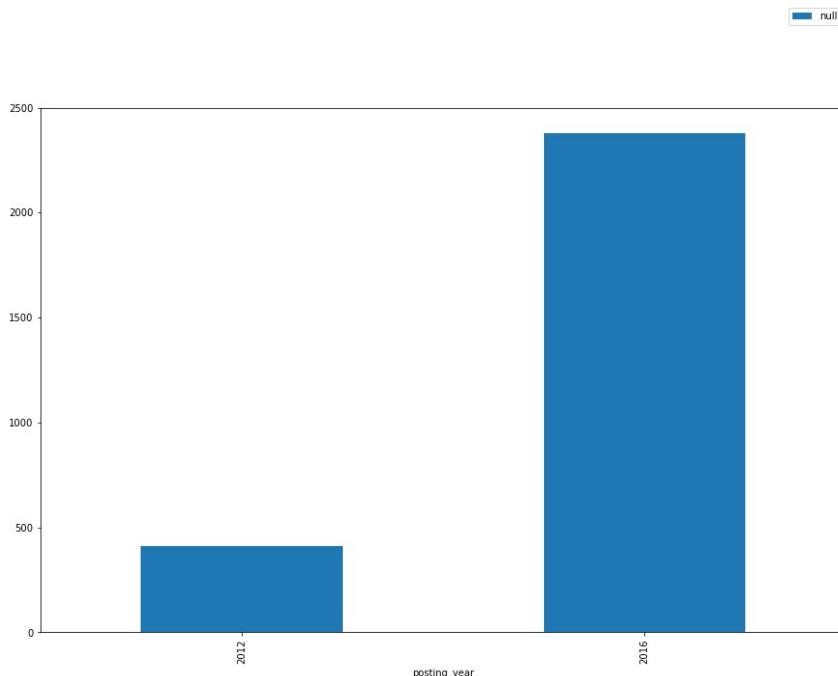


**H. August (08)** - Food was purchased in the year of 2011 (1 unit) and 2013 (2184 units)



**I. September (09)** - No purchase data available for any year

**J. October (10)** - Food was purchased in the year of 2012 (410 units) and 2016 (2380 units)



**K. November (11)** - No purchase data available for any year

**L. December (12)** - No purchase data available for any year

## **CONCLUSION**

Time series analysis of the data becomes essential to predict the incoming quantities of food at the food bank at a given period of time. The graphs generated in the Section above help us a great deal in becoming aware of the pattern of donation at a given part of the year. For example, we can observe that in the month of January a lot of donations are made towards the end of the month. This can be accredited to a variety of reasons, one of which could be the weather conditions in North Carolina. The food quality and safety becomes essential during donation or purchasing food. Also, a large proportion of food that comes into FBCENC is through donations and a very less amount of food is purchased by them. This is a great advantage since it helps FBCENC is saving up money and invest that in the operational cost of food safety and transportation to other donation agencies.

I would like to extend my acknowledgement to Dr. Min Chi for providing me this opportunity to work on this research project. This helped understand the working of Food Banks and how crucial data analysis becomes for real-world applications that can affect millions of people around.