The Evolution of LEGO Since 1950

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LEGO (https://en.wikipedia.org/wiki/Lego) is one of the most popular building toy brands in existence. In the lifetime of the company, the playsets of LEGO have adopted over 600 unique themes, including many well-known liscenced properties like Star Wars and Harry Potter, and several of its own, like Ninjago and Bionicle. In the beginning, however, LEGO only had a few of its own themes, and its sets consisted of little more than rectangularly prismatic bricks that simply varied in their dimensions. Here, we would like to see precisely how LEGO has progressed into what it is today.

Data Overview

The dataset (https://www.kaggle.com/rtatman/lego-database/data) we will be using contains several csvs with information on every LEGO set released between 1950 and 2017. With it, we can look at data such as the size, colors, themes, and complexities of the sets during each of these years.

Dependencies

In [148]:

```
# Here are all the dependencies we will need for our analysis
import pandas as pd
import matplotlib.pyplot as plt
import imageio
import zipfile
%matplotlib inline
```

Loading

In [149]:

```
# Simply have the .zip in the same directory and we can extract all the csvs wit
h code
zip_ref = zipfile.ZipFile('lego-database.zip', 'r')
zip_ref.extractall('lego-database')
zip_ref.close()
```

In [150]:

```
# Let's load all the csvs at once here
colors = pd.read_csv("lego-database/colors.csv")
inventory_parts = pd.read_csv("lego-database/inventory_parts.csv")
parts = pd.read_csv("lego-database/parts.csv")
inventory_sets = pd.read_csv("lego-database/inventory_sets.csv")
sets = pd.read_csv("lego-database/sets.csv")
inventories = pd.read_csv("lego-database/inventories.csv")
part_categories = pd.read_csv("lego-database/part_categories.csv")
themes = pd.read_csv("lego-database/themes.csv")
```

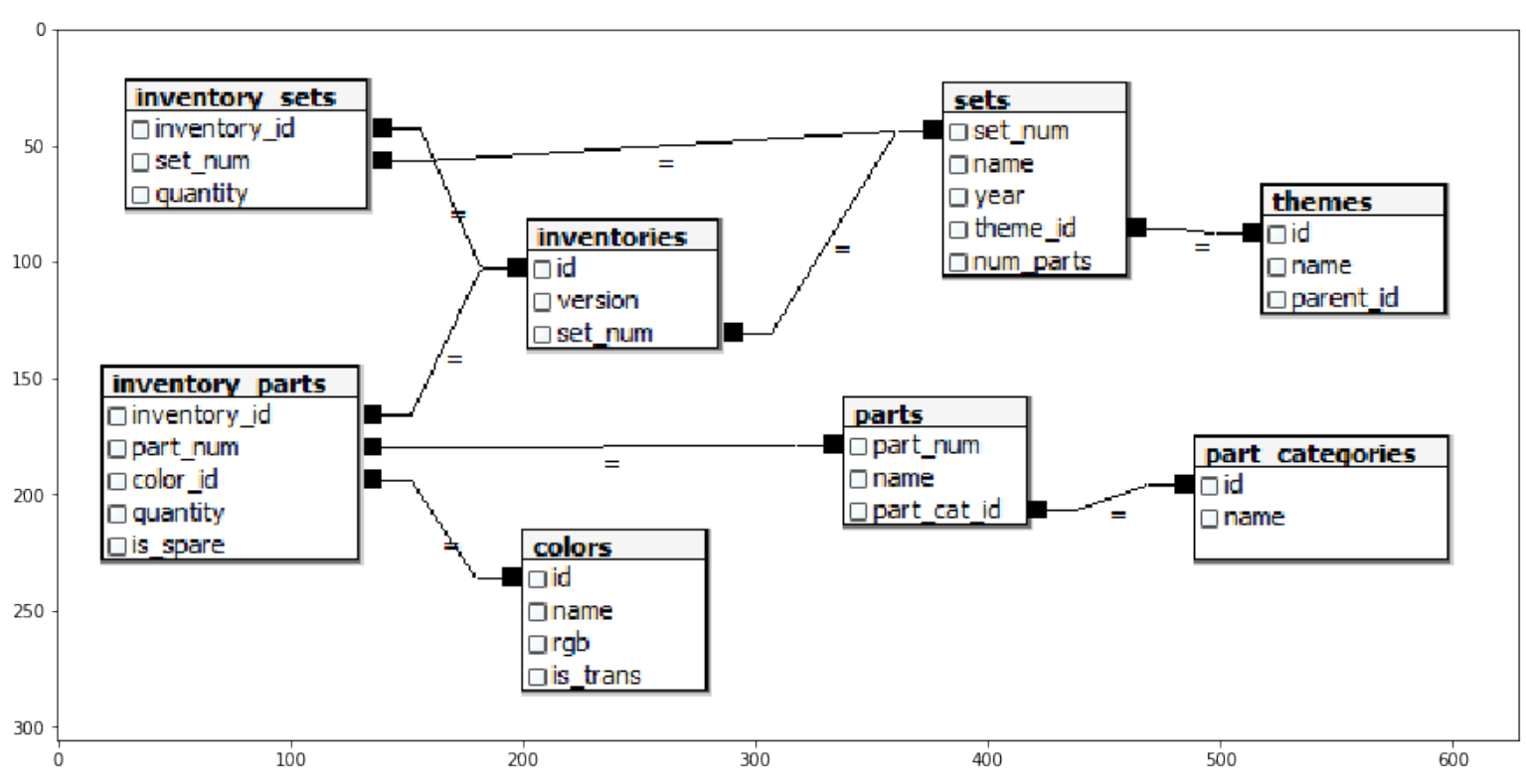
The Schema

In [151]:

```
# The dataset also contained this image about the schema
# We will be using it as a reference to relate the csvs to each other
img = imageio.imread("lego-database/downloads_schema.png")
plt.figure(figsize=(15,15))
plt.imshow(img)
```

Out[151]:

```
<matplotlib.image.AxesImage at 0x12252fb00>
```



Question 1: How have LEGO themes changed over time?

Let us begin the analysis of LEGO's evolution with the evolution of its themes. LEGO themes have come and gone and some have gotten more sets than others. Has LEGO been getting more diverse in its themes?

How many LEGO themes have been released, debuted, and discontinued every year?

In [152]:

```
# First, we'll have to count the number of distinct themes released each year.
themes_per_year = sets.groupby("year").theme_id.nunique()
themes_per_year.head()
```

Out[152]:

```
year
1950    2
1953    1
1954    2
1955    4
1956    3
Name: theme_id, dtype: int64
```

In [153]:

```
# Next, we'll find the number of themes released for the first time each year.
# This will take some manipulation. First we'll get the first year of each theme
firstyears = sets.groupby("theme_id").year.min()
firstyears.head()
```

Out[153]:

```
theme_id
1    1982
2    1986
3    1998
4    1977
5    1999
Name: year, dtype: int64
```

In [154]:

```
# Now, we can get the number of times each year is a first for a theme
new_themes_per_year = firstyears.value_counts().sort_index()
new_themes_per_year.head()
```

Out[154]:

```
1950    2
1954    1
1955    2
1957    1
1960    1
Name: year, dtype: int64
```

In [155]:

```
# We'll do the exact same for years where themes end
dead_themes_per_year = sets.groupby("theme_id").year.max().value_counts().sort_i
ndex()
dead_themes_per_year.head()
```

Out[155]:

```
1955    1
1957    1
1963    2
1964    2
1965    1
Name: year, dtype: int64
```

In [156]:

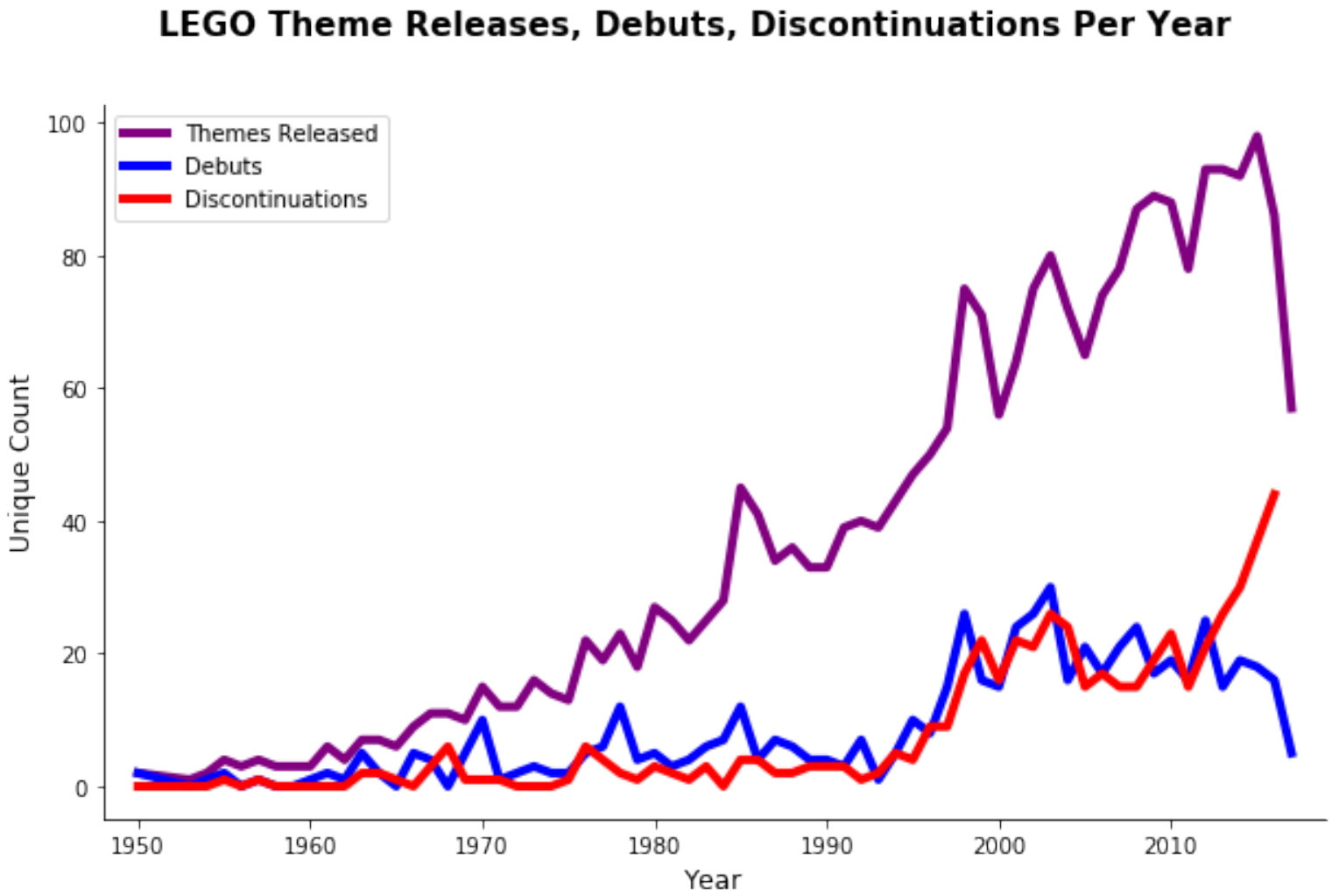
```
# And we'll create a DataFrame so we can have column names and plot it with a le
gend
theme_lifetimes = pd.DataFrame()
theme_lifetimes["Themes Released"] = themes_per_year
theme_lifetimes["Debuts"] = new_themes_per_year
theme_lifetimes["Discontinuations"] = dead_themes_per_year
theme_lifetimes.fillna(0, inplace=True)
# We remove the last number of discontinuations because it is automatically equa
l
# to the number of releases by virtue of it being the last year
theme_lifetimes.at[2017, "Discontinuations"] = None
theme_lifetimes.head()
```

Out[156]:

	Themes Released	Debuts	Discontinuations
year			
1950	2	2.0	0.0
1953	1	0.0	0.0
1954	2	1.0	0.0
1955	4	2.0	1.0
1956	3	0.0	0.0

In [157]:

```
# Finally, we'll plot it with a line graph
fig, ax = plt.subplots(figsize=(10,6))
theme_lifetimes.plot(ax = ax, color = ['purple', 'blue', 'red'], linewidth = 4)

# Adjusting the labels and axes
fig.suptitle("LEGO Theme Releases, Debuts, Discontinuations Per Year",
             fontsize = 15, fontweight = 'bold')

ax.set_xlim(1948, 2019)
ax.set_xlabel("Year", fontsize=12)
ax.set_ylabel("Unique Count", fontsize=12)
ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
```



As we can see here, the number of themes released has increased rapidly over the years. This is possibly because themes do not die nearly as often, so LEGO has kept piling on the themes. Discontinuations and debuts have been low in comparison. Interestingly, though, the number of discontinuations began spiking around 1995 and is near the number of 2017 releases in 2016.

How many sets are of the top LEGO themes?

In [158]:

```
# We will need to match the themes with their ids for this analysis
set_themes = sets.join(themes.set_index('id'), on='theme_id', rsuffix = '_theme'
)
set_themes.head()
```

Out[158]:

	set_num	name	year	theme_id	num_parts	name_theme	parent_id
0	00-1	Weetabix Castle	1970	414	471	Castle	411.0
1	0011-2	Town Mini-Figures	1978	84	12	Supplemental	67.0
2	0011-3	Castle 2 for 1 Bonus Offer	1987	199	2	Lion Knights	186.0
3	0012-1	Space Mini-Figures	1979	143	12	Supplemental	126.0
4	0013-1	Space Mini-Figures	1979	143	12	Supplemental	126.0

In [159]:

```
# Getting all-time the count of each theme, descending order
theme_counts = set_themes.groupby('name_theme').name_theme.count().sort_values(a
scending=False)
theme_counts.shape
```

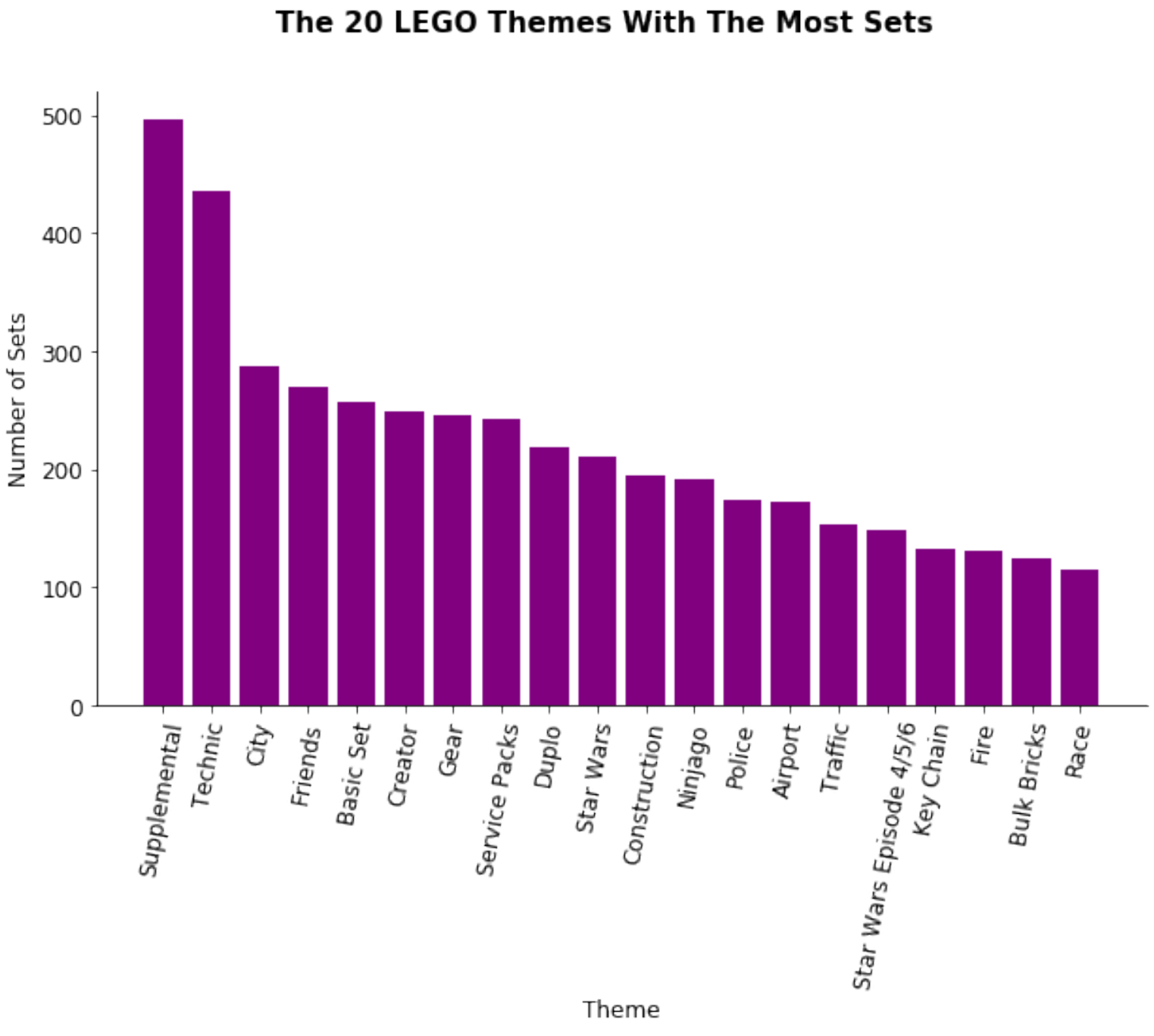
Out[159]:

```
(386,)
```

Since there are this many themes, let us look at only the top 20. How many sets have each of these top themes ever taken the form of?

In [160]:

```
# Setting up a bar graph with size, color and fonts
top_themes = theme_counts[:20]

fig, ax = plt.subplots(figsize = (10,6))
ax.bar(top_themes.index, top_themes, color = 'purple')

# Titles & axis labels
ax.tick_params(axis='x', rotation=80)
ax.tick_params(labelsize=12)
fig.suptitle("The 20 LEGO Themes With The Most Sets", fontsize = 15, fontweight
= 'bold')
ax.set_xlabel("Theme", fontsize=12)
ax.set_ylabel("Number of Sets", fontsize=12)
ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
```



In this bar graph we can see that the Supplemental theme has had nearly 500 sets over the years. Out of these top 20, the only two liscensed themes are both Star Wars.

Question 2: Has LEGO been getting more colorful?

Long, long ago, LEGO was once just composed of primary colors and rectangles. We now know there are over 100 colors of bricks, even transparent ones. Let us see how these colors have emerged over the years.

How many LEGO colors have been released, debuted, and discontinued every year?

In [161]:

```
# Let's now do exactly what we did with the themes, but with the colors.
# We'll first have to join the sets with their brick colors.
sets_inv_ids = sets.set_index("set_num").join(inventories.set_index("set_num"))
sets_inv_ids.head()
```

Out[161]:

	name	year	theme_id	num_parts	id	version
set_num						
00-1	Weetabix Castle	1970	414	471	5574.0	1.0
00-2	Weetabix Promotional House 1	1976	413	147	13813.0	1.0
00-3	Weetabix Promotional House 2	1976	413	149	898.0	1.0
00-4	Weetabix Promotional Windmill	1976	413	126	1073.0	1.0
00-6	Special Offer	1985	67	3	2836.0	1.0

In [162]:

```
# Now we'll join on the inventory ids
sets_inv_ids.rename(columns={"id":"inventory_id"}, inplace = True)
sets_inv_ids.set_index("inventory_id", inplace=True)
sets_inv_ids.head()
```

Out[162]:

	name	year	theme_id	num_parts	version
inventory_id					
5574.0	Weetabix Castle	1970	414	471	1.0
13813.0	Weetabix Promotional House 1	1976	413	147	1.0
898.0	Weetabix Promotional House 2	1976	413	149	1.0
1073.0	Weetabix Promotional Windmill	1976	413	126	1.0
2836.0	Special Offer	1985	67	3	1.0

In [163]:

```
# And now we have the sets with their parts
sets_inventory_parts = sets_inv_ids.join(inventory_parts.set_index("inventory_id
"))
sets_inventory_parts.head()
```

Out[163]:

	name	year	theme_id	num_parts	version	part_num	color_id	c
inventory_id								
1.0	McDonald's Sports Set Number 6 - Orange Vest S...	2004	460	4	1.0	48379c01	72.0	1
1.0	McDonald's Sports Set Number 6 - Orange Vest S...	2004	460	4	1.0	48395	7.0	1
1.0	McDonald's Sports Set Number 6 - Orange Vest S...	2004	460	4	1.0	mcsport6	25.0	1
1.0	McDonald's Sports Set Number 6 - Orange Vest S...	2004	460	4	1.0	paddle	0.0	1
3.0	Emma's Splash Pool	2012	494	43	1.0	11816pr0005	78.0	1

In [164]:

```
# To verify that we joined correctly, this DataFrame should be rather large
sets_inventory_parts.shape
```

Out[164]:

(581211, 9)

In [165]:

```
# Now to sort of recycle some code
colors_per_year = sets_inventory_parts.groupby("year").color_id.nunique()
colors_per_year.head()
```

Out[165]:

```
year
1950    10
1953     5
1954     7
1955     7
1956     5
Name: color_id, dtype: int64
```

In [166]:

```
new_colors_per_year = sets_inventory_parts.groupby("color_id").year.min().value_
counts().sort_index()
new_colors_per_year.head()
```

Out[166]:

```
1950    10
1954     1
1955     1
1956     1
1957     2
Name: year, dtype: int64
```

In [167]:

```
dead_colors_per_year = sets_inventory_parts.groupby("color_id").year.max().value
_counts().sort_index()
dead_colors_per_year.head()
```

Out[167]:

```
1993    1
1997    1
1999    2
2000    1
2002    1
Name: year, dtype: int64
```

In [168]:

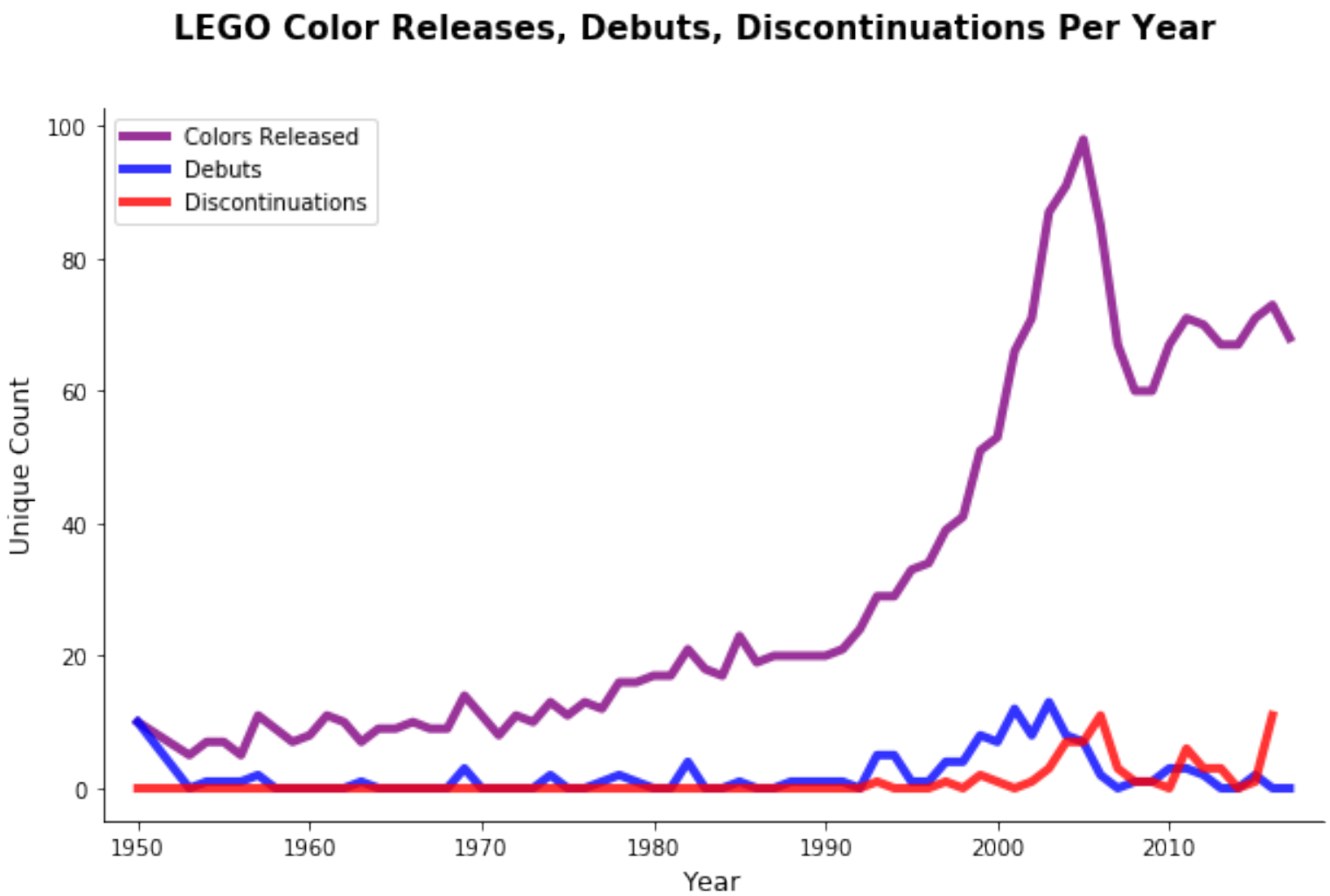
```
# You know the drill
color_lifetimes = pd.DataFrame()
color_lifetimes["Colors Released"] = colors_per_year
color_lifetimes["Debuts"] = new_colors_per_year
color_lifetimes["Discontinuations"] = dead_colors_per_year
color_lifetimes.fillna(0, inplace=True)
color_lifetimes.at[2017, "Discontinuations"] = None
color_lifetimes.head()
```

Out[168]:

	Colors Released	Debuts	Discontinuations
year			
1950	10	10.0	0.0
1953	5	0.0	0.0
1954	7	1.0	0.0
1955	7	1.0	0.0
1956	5	1.0	0.0

In [169]:

```
fig, ax = plt.subplots(figsize=(10,6))
color_lifetimes.plot(ax = ax, color = ['purple', 'blue', 'red'], linewidth = 4,
alpha = 0.8)

# Adjusting the labels and axes
fig.suptitle("LEGO Color Releases, Debuts, Discontinuations Per Year",
             fontsize = 15, fontweight = 'bold')

ax.set_xlim(1948, 2019)
ax.set_xlabel("Year", fontsize=12)
ax.set_ylabel("Unique Count", fontsize=12)
ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
```



Just like with the themes, the colors have been rapidly piling on. However, unlike with the themes, LEGO has seldom debuted or discontinued a color, though it seems there were some major spikes in the last two decades

How has LEGO's color distribution changed?

In [170]:

```
# Let's get the rgb for each of these colors
rgb = colors.rename(columns={'id':'color_id'}).set_index('color_id')
rgb.head()
```

Out[170]:

	name	rgb	is_trans
color_id			
-1	Unknown	0033B2	f
0	Black	05131D	f
1	Blue	0055BF	f
2	Green	237841	f
3	Dark Turquoise	008F9B	f

In [171]:

```
sets_parts_colors = sets_inventory_parts.set_index('color_id').join(rgb, rsuffix
= '_color')
sets_parts_colors.set_index('name_color', inplace = True)
sets_parts_colors.head()
```

Out[171]:

	name	year	theme_id	num_parts	version	part_num	quantity	is_s
name_color								
Unknown	Royal Coach	2000	319	85	1.0	belvfair6	1.0	f
Unknown	Royal Coach	2000	319	85	1.0	belvfem26	1.0	f
Unknown	Royal Coach	2000	319	85	1.0	belvmale13	1.0	f
Unknown	Flower Stand	1985	390	20	1.0	fab6e	1.0	f
Unknown	The Enchanted Palace	1999	319	216	1.0	belvfair4	1.0	f

In [172]:

```
# How about we look at the color distribution in the beginning, middle and now?
# That's 1950, 2017, and ..
(1950 + 2017) // 2
```

Out[172]:

```
1983
```

In [173]:

```
# Here we're just filtering for these years
spc_beginning = sets_parts_colors[sets_parts_colors.year == 1950]
spc_middle = sets_parts_colors[sets_parts_colors.year == 1983]
spc_now = sets_parts_colors[sets_parts_colors.year == 2017]
spc_now.head()
```

Out[173]:

	name	year	theme_id	num_parts	version	part_num	quantity	is_
name_color								
Unknown	Dragon's Forge	2017	435	1118	1.0	10050	1.0	f
Unknown	Dragon's Forge	2017	435	1118	1.0	19857pat0001	1.0	f
Unknown	Dragon's Forge	2017	435	1118	1.0	24484	1.0	f
Unknown	Dragon's Forge	2017	435	1118	1.0	25276	1.0	f
Unknown	Dragon's Forge	2017	435	1118	1.0	25277	1.0	f

In [174]:

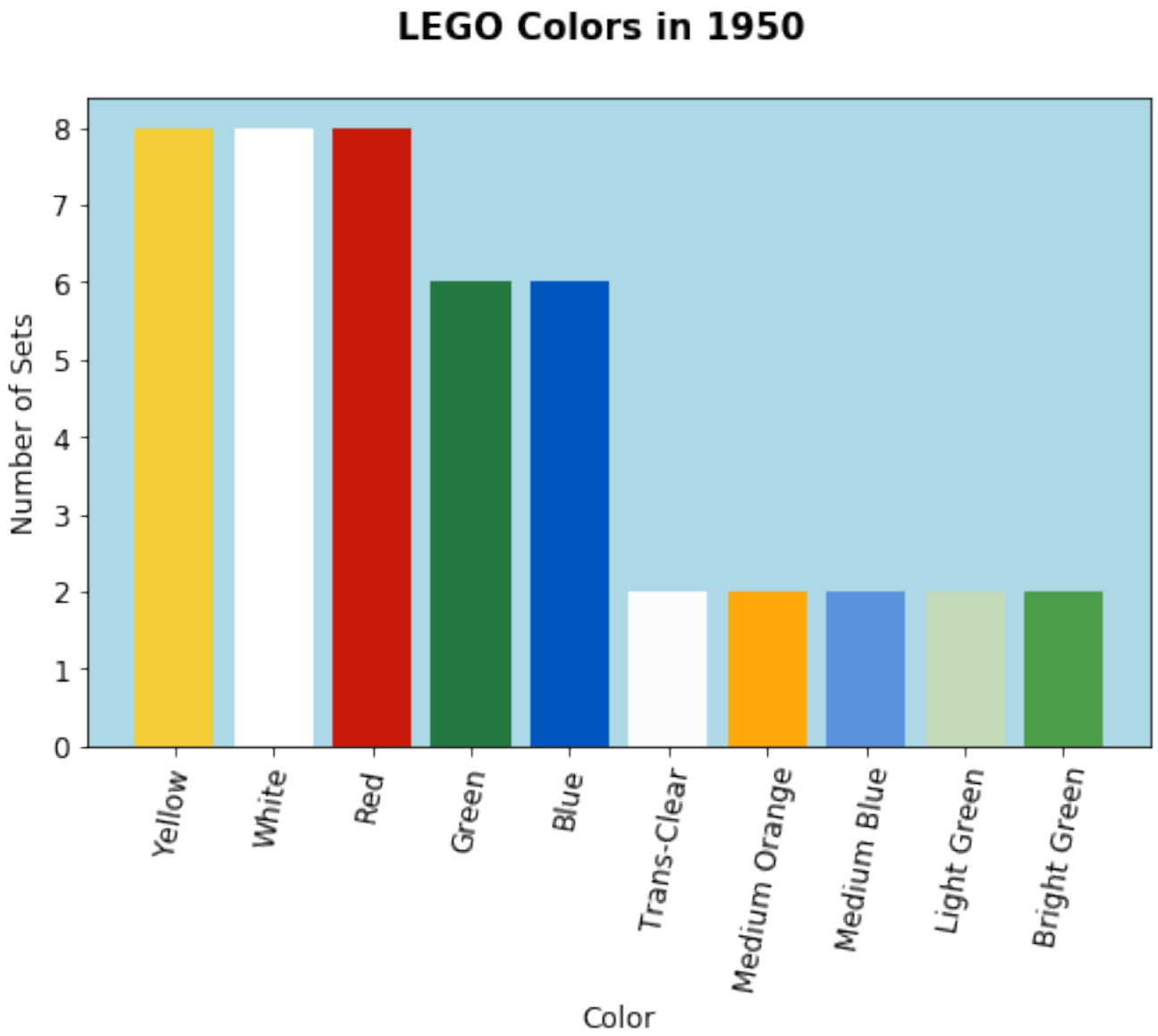
```
# This time we can do something interesting and color the bar graphs with the rg
bs
# First we'll need some manipulation
# Let's do it in a function since we're doing it thrice

def color_axes(spc):
    # Here we're getting the number of times each color was released that year
    color_counts = spc.groupby("name_color").rgb.count().sort_values(ascending =
False)
    # And listing the respective rgbs
    color = []
    colormap = spc.rgb
    for color_name in color_counts.index.tolist():
        color_rgb = colormap[color_name]
        if type(color_rgb) == str:
            color.append('#'+color_rgb)
        else:
            color.append('#'+color_rgb.min())
    return color_counts, color
```

In [175]:

```
# Now we can plot the colors for these three years
fig, ax = plt.subplots(figsize=(8,5))
ax.set_facecolor('lightblue')
color_counts, color = color_axes(spc_beginning)
ax.bar(color_counts.index, color_counts, color=color)

# Titles & axis labels
ax.tick_params(axis='x', rotation=80)
ax.tick_params(labelsize=12)

fig.suptitle("LEGO Colors in 1950", fontsize = 15, fontweight = 'bold')
ax.set_xlabel("Color", fontsize=12)
ax.set_ylabel("Number of Sets", fontsize=12)
```

Out[175]:

Text(0,0.5,'Number of Sets')

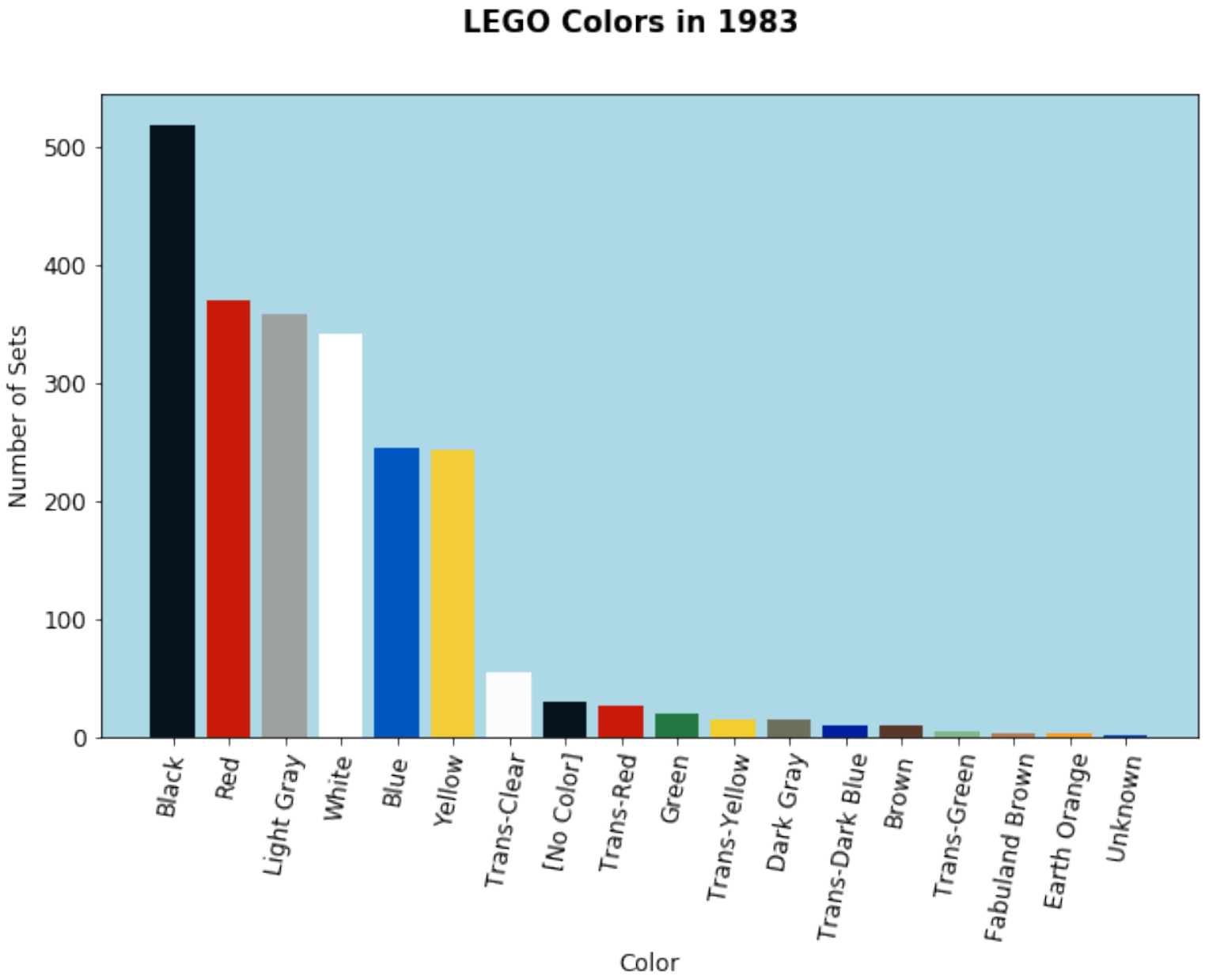


In [176]:

```
fig, ax = plt.subplots(figsize=(10,6))
ax.set_facecolor('lightblue')
color_counts, color = color_axes(spc_middle)
ax.bar(color_counts.index, color_counts, color=color)

# Titles & axis labels
ax.tick_params(axis='x', rotation=80)
ax.tick_params(labelsize=12)

fig.suptitle("LEGO Colors in 1983", fontsize = 15, fontweight = 'bold')
ax.set_xlabel("Color", fontsize=12)
ax.set_ylabel("Number of Sets", fontsize=12)
```

Out[176]:

Text(0,0.5,'Number of Sets')

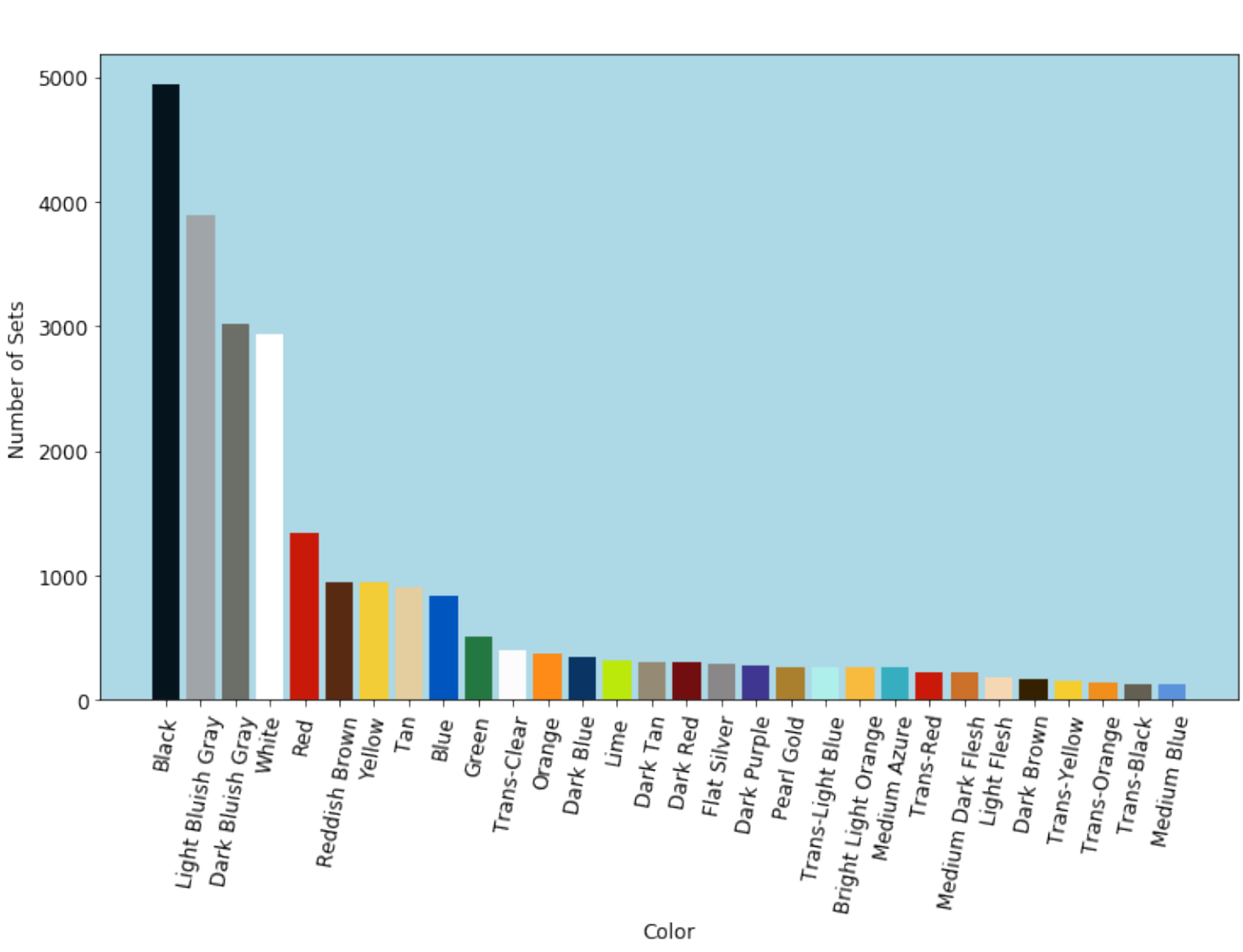


In [177]:

```
fig, ax = plt.subplots(figsize=(12,7))
ax.set_facecolor('lightblue')
color_counts, color = color_axes(spc_now)

# This time, we'll just to the top 30
color_counts = color_counts[:30]
color = color[:30]

ax.bar(color_counts.index, color_counts, color=color)


# Titles & axis labels
ax.tick_params(axis='x', rotation=80)
ax.tick_params(labelsize=12)

fig.suptitle("LEGO Colors in 2017", fontsize = 15, fontweight = 'bold')
ax.set_xlabel("Color", fontsize=12)
ax.set_ylabel("Number of Sets", fontsize=12)
```

Out[177]:

```
Text(0,0.5,'Number of Sets')
```



As we can see here, black and gray colors skyrocketed somwhere in the middle of LEGO's lifetime, even though there was no black or gray in LEGO's beginnings. Many blues have been introduced as well. Some of the most popular colors, however, have also remained so since the beginning, like red, white, and yellow. Those three happen to be the colors of the LEGO logo.

Question 3: Have LEGO Sets been getting more complex?

We know that LEGO sets today take the form of far more than just houses and square cars. Thousands of new tiny parts with great variety of shapes have been introduced as sets become bigger, more intricate and more ambitious. Just precisely how has this evolution occured?

How many LEGO parts have been released, debuted, and discontinued every year?

In [193]:

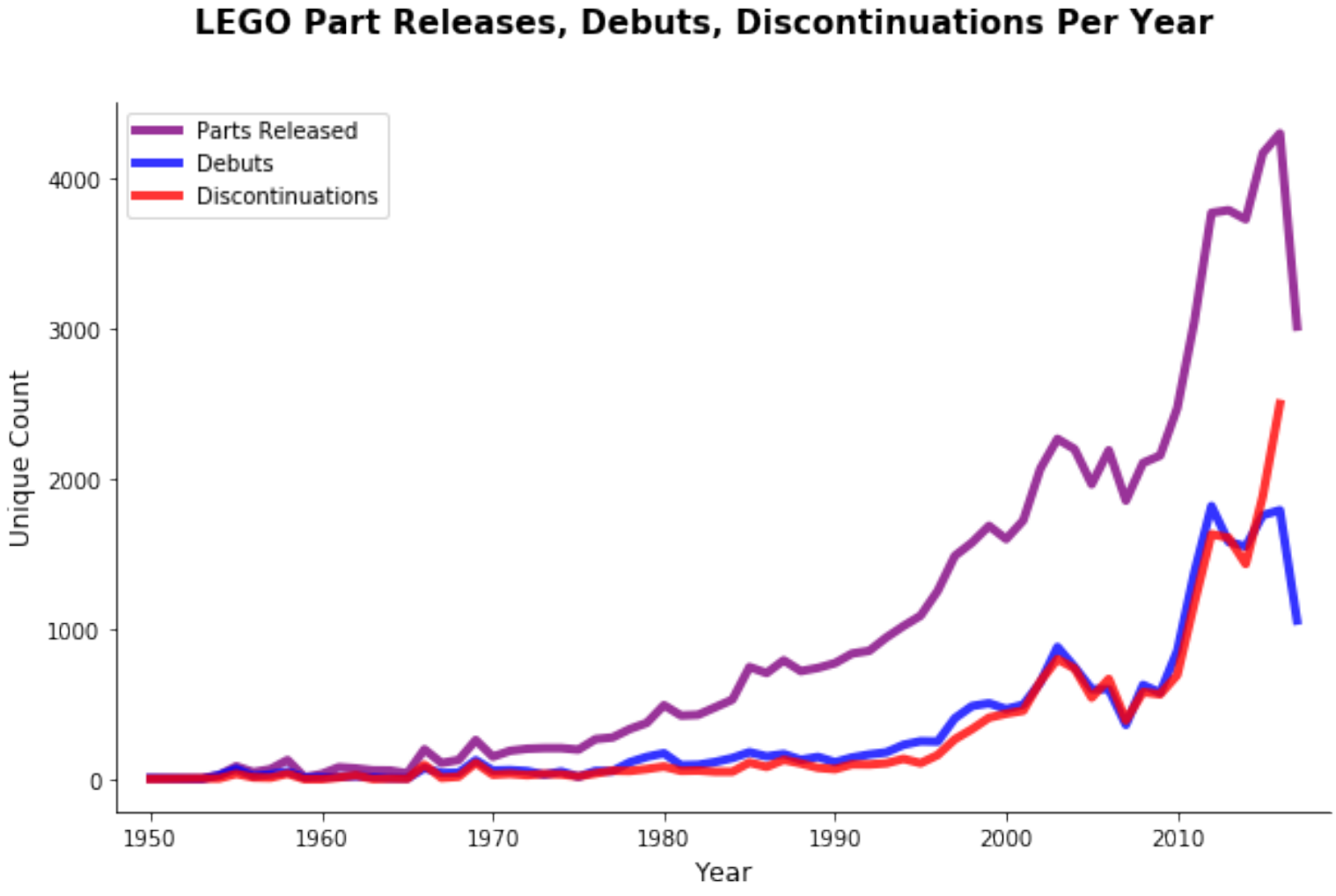
```
# Let's have one last triple line graph as we did with themes and colors, but wi
th parts
# You get the idea, we get the three numbers for each year
parts_per_year = sets_inventory_parts.groupby("year").part_num.nunique()
new_parts_per_year = sets_inventory_parts.groupby("part_num").year.min().value_c
ounts().sort_index()
dead_parts_per_year = sets_inventory_parts.groupby("part_num").year.max().value_
counts().sort_index()

# And we construct our DataFrame
part_lifetimes = pd.DataFrame()
part_lifetimes["Parts Released"] = parts_per_year
part_lifetimes["Debuts"] = new_parts_per_year
part_lifetimes["Discontinuations"] = dead_parts_per_year
part_lifetimes.fillna(0, inplace=True)
part_lifetimes.at[2017, "Discontinuations"] = None
part_lifetimes.head()
```

Out[193]:

	Parts Released	Debuts	Discontinuations
year			
1950	6	6	2.0
1953	6	2	5.0
1954	27	27	5.0
1955	86	68	36.0
1956	47	21	12.0

In [179]:

```
fig, ax = plt.subplots(figsize=(10,6))
part_lifetimes.plot(ax = ax, color = ['purple', 'blue', 'red'], linewidth = 4, a
lpha = 0.8)

# Adjusting the labels and axes
fig.suptitle("LEGO Part Releases, Debuts, Discontinuations Per Year",
             fontsize = 15, fontweight = 'bold')

ax.set_xlim(1948, 2019)
ax.set_xlabel("Year", fontsize=12)
ax.set_ylabel("Unique Count", fontsize=12)
ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
```



Well, *this* is unepected. These three lines have extremely similar shapes. In fact, the debut and discontinuation lines are almost completely aligned. Could this be explained by many parts being replaced? The rate of emerging new and dead parts is also beginning to approach that of regular releases.

How do we measure complexity?

In [180]:

```
# One way to measue the complexity of a LEGO set might be to take the unique cou
nt of it's parts
# Let's to exactly that
# First we'll match the parts with inventories once again
inventory_part_ids = inventory_parts.set_index("inventory_id")
inventory_ids = inventories.rename(columns={"id":"inventory_id"}).set_index("inv
entory_id")
inventory_part_ids = inventory_part_ids.join(inventory_ids)
inventory_part_ids.head()
```

Out[180]:

	part_num	color_id	quantity	is_spare	version	set_num
inventory_id						
1	48379c01	72	1	f	1	7922-1
1	48395	7	1	f	1	7922-1
1	mcsport6	25	1	f	1	7922-1
1	paddle	0	1	f	1	7922-1
3	11816pr0005	78	1	f	1	3931-1

In [181]:

```
# Now we join with the sets
sets_parts = sets.set_index("set_num").join(inventory_part_ids.set_index("set_nu
m"))
sets_parts.head()
```

Out[181]:

	name	year	theme_id	num_parts	part_num	color_id	quantity	is_spare
set_num								
00-1	Weetabix Castle	1970	414	471	29c01	4.0	8.0	f
00-1	Weetabix Castle	1970	414	471	29c01	15.0	6.0	f
00-1	Weetabix Castle	1970	414	471	3001a	15.0	25.0	f
00-1	Weetabix Castle	1970	414	471	3001a	4.0	9.0	f
00-1	Weetabix Castle	1970	414	471	3001a	1.0	4.0	f

In [182]:

```
# Verify the shape
sets_parts.shape
```

Out[182]:

```
(581211, 9)
```

In [183]:

```
# Now we can get the unique part count for each set
complexity = sets_parts.groupby("set_num").part_num.nunique()
complexity.head()
```

Out[183]:

```
set_num
00-1    26
00-2    38
00-3    31
00-4    39
00-6     0
Name: part_num, dtype: int64
```

In [184]:

```
# Now we have a DataFrame of sets with a complexity column
sets_complexity = sets.set_index("set_num")
sets_complexity["num_parts_unique"] = complexity
sets_complexity.head()
```

Out[184]:

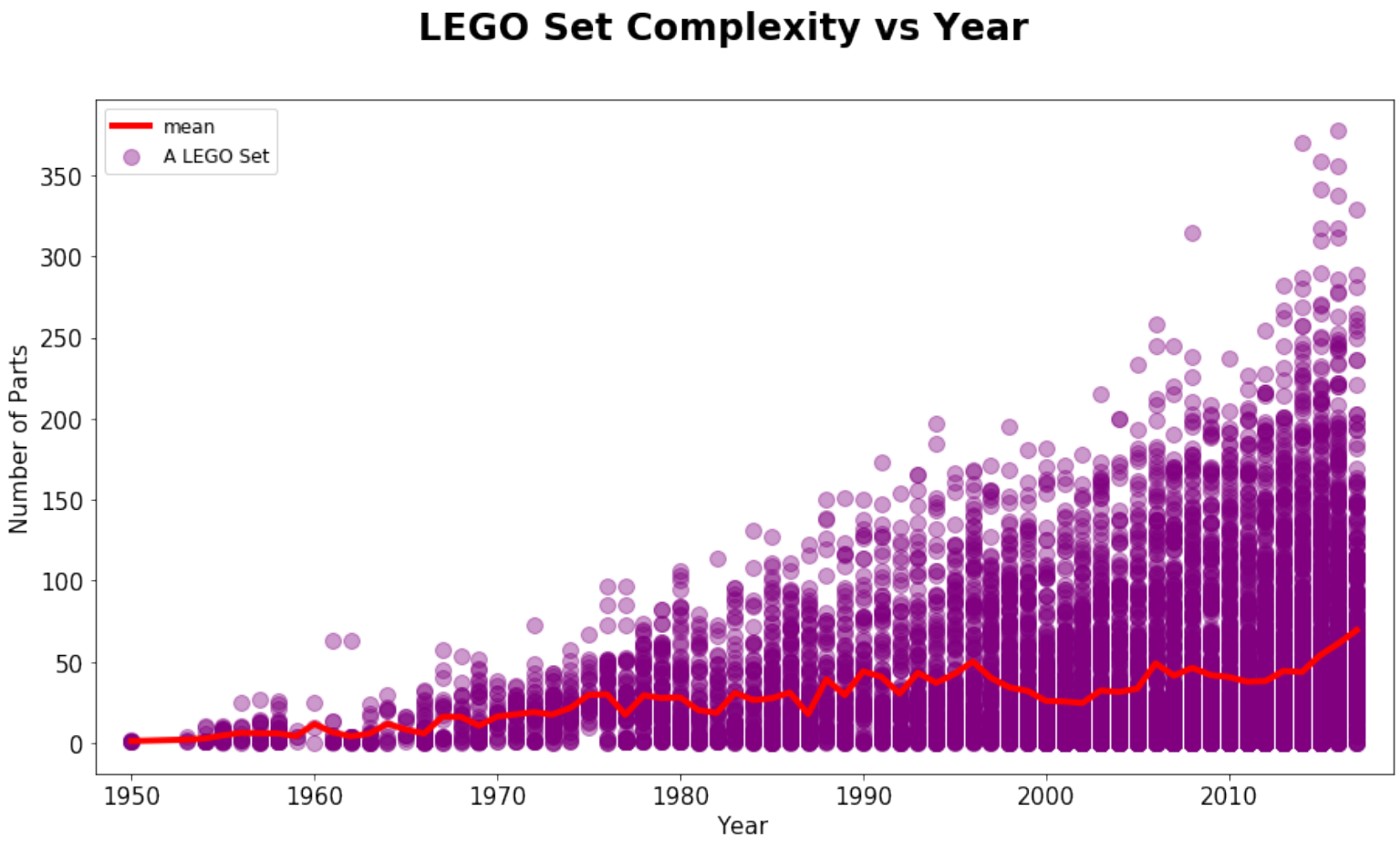
	name	year	theme_id	num_parts	num_parts_unique
set_num					
00-1	Weetabix Castle	1970	414	471	26
0011-2	Town Mini-Figures	1978	84	12	8
0011-3	Castle 2 for 1 Bonus Offer	1987	199	2	0
0012-1	Space Mini-Figures	1979	143	12	6
0013-1	Space Mini-Figures	1979	143	12	6

In [191]:

```
# Here let's plot the average complexities and scatter the individual ones
fig, ax = plt.subplots(figsize=(15,8))
ax.scatter(sets_complexity.year, sets_complexity.num_parts_unique, color = 'purp
le', alpha = 0.4, s = 100, linewidth=1)
ax.plot(sets_complexity.groupby('year').num_parts_unique.mean(), color = 'red',
linewidth = 4)
#ax.plot(sets_complexity.groupby('year').num_parts.mean(), color = 'red', linewi
dth = 4)

# We'll need a legend as well as the usual
ax.legend(["mean", "A LEGO Set"], fontsize = 12)
fig.suptitle("LEGO Set Complexity vs Year", fontsize = 24, fontweight = "bold")
ax.tick_params(labelsize = 15)
ax.set_xlim(1948,2019)
ax.set_xlabel("Year", fontsize=15)
ax.set_ylabel("Number of Parts",fontsize=15)
```

Out[191]:

Text(0,0.5,'Number of Parts')



Well, as we can see, LEGO sets have been getting slowly, slightly more complex on average every year. However, with each year, there have been more and more outliers of complexity. Some of the most complex sets have been released rather recently.

Conclusion

In summary, we have looked at LEGO's evolution over time in terms of themes, colors and parts and found some somewhat suprising things. It was also quite an exercise in data manipulation. With each passing year, LEGO releases and debutes more and more themes. More complex sets are released, and LEGO indeed becomes more colorful and varied in theme. Apparently, the LEGO brand is growing much faster than it's shrinking.