ASA (Atractiveness Score Analysis)

July 2, 2022

1 Ranking of Mobile Network Operators in Georgia

[1]:
```
from IPython.display import display, HTML

display(HTML("""<img alt="Ranking of Mobile Network Operators in Georgia"␣
 ↪src="ranking.png"></img>"""))
```

```
<IPython.core.display.HTML object>
```

2 Mobile Communication Companies in Georgia ranked by Attractiveness Score

Lets explore which mobile communication companies are operating in Georgia, how many subscribers do each of them serve, and how attractive each of them is.

Here an attractiveness of a company, or more specifically the “Attractiveness Score” which is defined later in this document, measures an ability of company to attract and retain subscribers.

Finally, best performing companies according to the “Attractiveness Score”, for each year we have data for, and per category of subscribers (categories being “All subscribers” combined, “Legal Entity subscribers” and “Natural Person subscribers”), are found via this analysis and are listed towards the end of this notebook.

[2]:
```
from datetime import datetime, timedelta
nb_st = datetime.utcnow()
print(f"\nNotebook START time: {nb_st} UTC\n")
```

```

Notebook START time: 2022-07-02 18:51:26.696441 UTC

```

[3]:
```
%%HTML
<style>
@media (max-width: 540px) {
  .output .output_subarea {
    max-width: 100%;
  }
}
```

```
</style>
<script>
  function code_toggle() {
    if (code_shown){
      $('div.input').hide('500');
      $('#toggleButton').val('  Show Python Code')
    } else {
      $('div.input').show('500');
      $('#toggleButton').val('  Hide Python Code')
    }
    code_shown = !code_shown
  }

  $( document ).ready(function(){
    code_shown=false;
    $('div.input').hide();
    $('div.input:contains("%%HTML")').removeClass( "input")
    $('div.input:contains("%%capture")').removeClass("input")
  });
</script>
<form action="javascript:code_toggle()">
  <input type="submit" id="toggleButton" value="  Show Python Code"
         class="btn btn-default btn-lg">
</form>
```

```
<IPython.core.display.HTML object>
```

2.1 Index

[4]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
sns.set_theme()
```

3 Data

The data used in this analysis is retrieved on May 18, 2022 from the website of the Communications Commission of Georgia: comcom.ge.

3.1 Import the data

[5]:
```python
def import_data_en(excel_path: str) -> pd.DataFrame:
    df = (pd
          .read_excel(excel_path)
          .sort_values("Month", ascending=True)
          .reset_index(drop=True))
    # English version of the original source contains some
    # untranslated names, fixing it here:
    df = df.replace({
        '     ': 'Silknet',
        '       ': 'Globalcell',
        '     ': 'Gmobile',
        '    ': 'Asanet'  # AKA gosim
    })
    # the 'Subscribers' column actually contains subscriber information
    # per company, renaming it accordingly:
    df.rename({'Subscribers': 'CompanySubscribers'}, axis=1, inplace=True)
    return df
```

[6]:
```python
all_df = import_data_en('data/EN/all.xlsx')
legal_entities_df = import_data_en('data/EN/legal_entities.xlsx')
natural_persons_df = import_data_en('data/EN/natural_persons.xlsx')
```

```
all_df.head()
```

```
[6]:         Month       Company  CompanySubscribers
     0 2010-01-01  Veon Georgia              352683
     1 2010-01-01      Magticom             1365722
     2 2010-01-01       Geocell             1390239
     3 2010-02-01  Veon Georgia              383348
     4 2010-02-01      Magticom             1335633
```

3.2 Definition of number of subscribers in the context of the given data:

Total Number of subscribers (sim cards), which, during the corresponding period (month, quarter), have used company services at least once (made or received call, sent or received SMS/MMS), used internet or other value added service, or were charged a subscription fee (including company employees and excluding test cards).

3.3 Interval of time covered by the given data

```
[7]: start_month, end_month = all_df['Month'].min(), all_df['Month'].max()

     print("\nGiven data covers the interval of time "
           f"from {start_month:%B %Y} to {end_month:%B %Y} (inclusive).\n")
```

```
Given data covers the interval of time from January 2010 to February 2022
(inclusive).
```

3.4 Mobile Companies operationg in Georgia

List of companies with their respective number of active months during the time period covered by the given data:

```
[8]: def get_active_monts_df(df: pd.DataFrame) -> pd.DataFrame:
         return (df['Company']
                 .value_counts()
                 .reset_index()
                 .rename({"Company": "Active Months", "index": "Company"}, axis=1))

     all_df_active_months = get_active_monts_df(all_df)
     print("# of active months for All Subscribers")
     display(all_df_active_months)
```

```
# of active months for All Subscribers

        Company  Active Months
0  Veon Georgia            146
1      Magticom            146
```

```
2       Silknet            122
3       Geocell            106
4    Globalcell             86
5       Gmobile             41
6        Asanet              1
```

[9]:
```
legal_entities_df_active_months = get_active_monts_df(legal_entities_df)
print("# of active months for Legal Entities")
display(legal_entities_df_active_months)
```

```
# of active months for Legal Entities

        Company  Active Months
0  Veon Georgia            146
1      Magticom            146
2       Silknet            122
3       Geocell            106
4    Globalcell             86
5       Gmobile              1
6        Asanet              1
```

[10]:
```
natural_persons_df_active_months = get_active_monts_df(natural_persons_df)
print("# of active months for Natural Persons")
display(natural_persons_df_active_months)
```

```
# of active months for Natural Persons

        Company  Active Months
0  Veon Georgia            146
1      Magticom            146
2       Silknet            122
3       Geocell            106
4    Globalcell             86
5       Gmobile             40
```

[11]:
```
company_name_list = all_df['Company'].value_counts().index.to_list()

company_colors = {
    'Veon Georgia': 'y',
    'Magticom': 'r',
    'Silknet': 'tab:blue',
    'Geocell': 'tab:purple',
    'Globalcell': 'tab:orange',
    'Gmobile': 'tab:brown',
    'Asanet': 'tab:green',
}
company_color_palette = [
    company_colors[company] for company in company_name_list]
print("\nAttempting to make colors of companies similar to their "
      "respective brand/logo colors: \n")
display(list(zip(company_name_list, company_color_palette)))
```

```
Attempting to make colors of companies similar to their respective brand/logo
colors:
```

```
[('Veon Georgia', 'y'),
 ('Magticom', 'r'),
 ('Silknet', 'tab:blue'),
 ('Geocell', 'tab:purple'),
 ('Globalcell', 'tab:orange'),
 ('Gmobile', 'tab:brown'),
 ('Asanet', 'tab:green')]
```

3.5 Date of merger of the Silknet and Geocell

[12]:
```
Geocell_last_month = (all_df
                       .loc[all_df['Company']=='Geocell', 'Month']
                       .tail(1)
                       .item())
Silknet_Geocell_merger_month = (all_df
                                 .loc[all_df['Month']>Geocell_last_month,
                                      'Month']
                                 .head(1)
                                 .item())


def get_Silknet_before_merger_subscribers(df: pd.DataFrame) -> int:
    return df.loc[
        (df['Month']==Geocell_last_month) & (df['Company']=='Silknet'),
        'CompanySubscribers'].item()


def get_Silknet_Geocell_merger_subscribers(df: pd.DataFrame) -> int:
    return df.loc[(df['Month']==Silknet_Geocell_merger_month)
                  & (df['Company']=='Silknet'), 'CompanySubscribers'].item()


print(f'\n{Silknet_Geocell_merger_month:%B %Y} is the date of Merger'
      ' of the Silknet and Geocell.\n')
```

```
November 2018 is the date of Merger of the Silknet and Geocell.
```

3.6 Date of COVID-19 Start

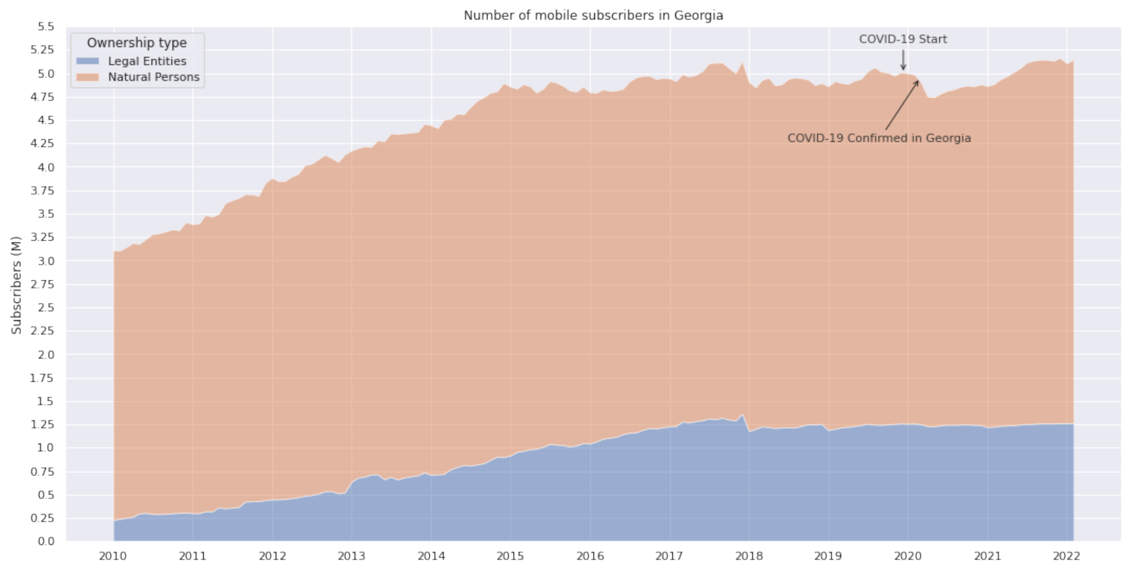
[13]:
```
# December 12, 2019:
# A cluster of patients in Wuhan, Hubei Providence, China
# begin to experience shortness of breath and fever.
COVID19_start_date = pd.Timestamp(year=2019, month=12, day=12)

# February 26, 2020:
# Georgia officially confirmed its first COVID-19 case.
# Citizen of Georgia who returned from Iran came back
# to the Georgian border via Azerbaijan.
COVID19_start_date_Georgia = pd.Timestamp(year=2020, month=2, day=26)


def get_total_subscribers_on_the_date(df: pd.DataFrame,
                                      date: pd.Timestamp) -> int:
    # FIXME ignoring edge cases:
    observed_date_before = df.loc[(df['Month'] <= date),
                                  'Month'].tail(1).item()
    observed_date_after = df.loc[(df['Month'] >= date),
                                 'Month'].head(1).item()
    subscribers_before = df.loc[(df['Month'] == observed_date_before),
                                'CompanySubscribers'].sum()
    subscribers_after = df.loc[(df['Month'] == observed_date_after),
                               'CompanySubscribers'].sum()
    return int((subscribers_before+subscribers_after) / 2)

print(f"COVID-19 start dates:\n - {COVID19_start_date:%B %d, %Y}: China")
print(f" - {COVID19_start_date_Georgia:%B %d, %Y}: Georiga")
```

```
COVID-19 start dates:
 - December 12, 2019: China
 - February 26, 2020: Georiga
```

4 Total number of subscribers

[14]:
```
years_df = (all_df
            .assign(Year=lambda df: [x.year for x in df['Month']])
            .groupby('Year').first().reset_index()
            .assign(MonthNum=lambda df: df['Month'].astype(int)))
```

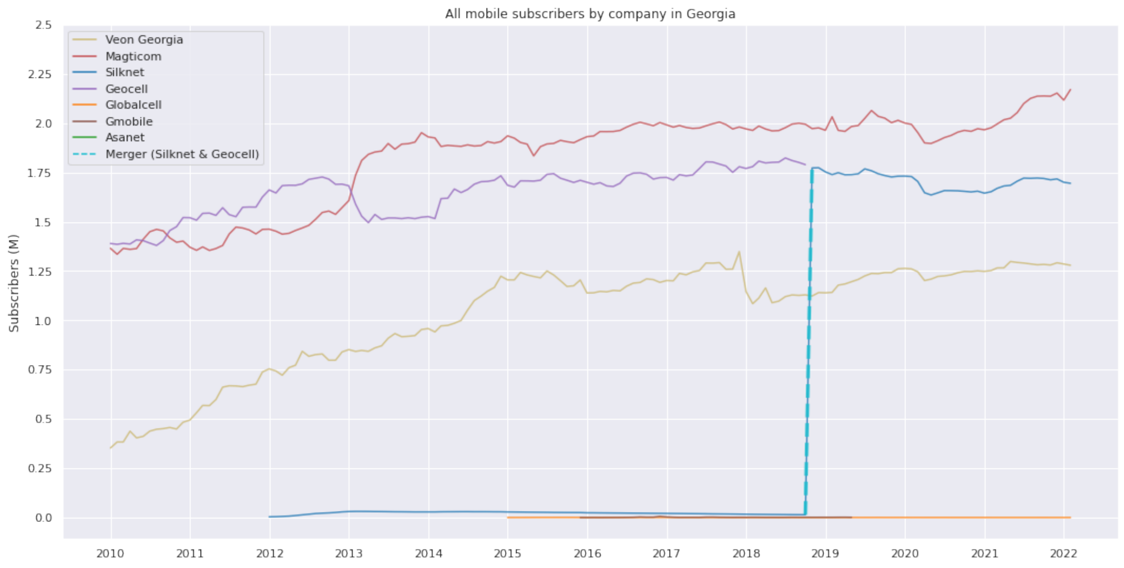
[15]:
```
fig = plt.figure(figsize=(18, 9))
plt.title("Number of mobile subscribers in Georgia")
plt.stackplot(
    all_df['Month'].unique(),
    legal_entities_df.groupby("Month").sum()['CompanySubscribers'],
    natural_persons_df.groupby("Month").sum()['CompanySubscribers'],
    labels=['Legal Entities', 'Natural Persons'],
    alpha=0.5
)
COVID19_xy = np.array([
    COVID19_start_date,
    get_total_subscribers_on_the_date(all_df, COVID19_start_date)
])
COVID19_Georgia_xy = np.array([
    COVID19_start_date_Georgia,
    get_total_subscribers_on_the_date(all_df, COVID19_start_date_Georgia)
])
plt.gca().annotate(
    "COVID-19 Start",
    xy=COVID19_xy,
    xytext=COVID19_xy + np.array([pd.Timedelta(days=0), 3.5e5]),
    arrowprops={'arrowstyle': '->', 'fc': 'k', 'ec': 'k', 'alpha': 0.85},
    fontsize=11, va="center", ha="center", alpha=0.85
)
plt.gca().annotate(
    "COVID-19 Confirmed in Georgia",
    xy=COVID19_Georgia_xy,
    xytext=COVID19_Georgia_xy - np.array([pd.Timedelta(days=185), 6.5e5]),
    arrowprops={'arrowstyle': '->', 'fc': 'k', 'ec': 'k', 'alpha': 0.85},
    fontsize=11, va="center", ha="center", alpha=0.85
)
plt.gca().set(
    yticks=np.arange(0, 5.6, 0.25) * 1e6,
    yticklabels=np.arange(0, 5.6, 0.25), ylabel='Subscribers (M)',
    xticks=years_df['Month'], xticklabels=years_df['Year'], xlabel='')
plt.legend(loc='upper left', title='Ownership type')
plt.show()
plt.close(fig)
```



5 Number of subscribers by company

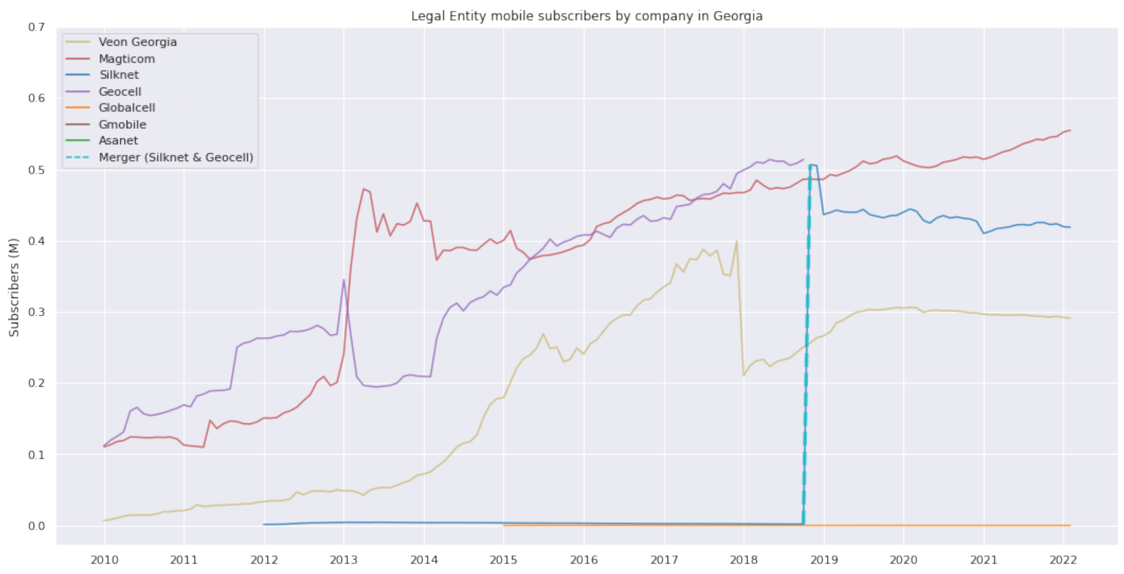
5.1 All subscribers

[16]:
```
def plot_number_of_subscribers_by_company(
        df: pd.DataFrame(),
        title: str,
        yticks_range: np.ndarray = np.arange(0, 2.75, 0.25)):
    companies = [
        company
        for company in company_name_list if company in df['Company'].unique()]
    company_color_palette = [
        company_colors[company]
        for company in company_name_list if company in companies]
    fig=plt.figure(figsize=(18, 9))
    plt.title(title)
    ax = sns.lineplot(
        data=df,
        x='Month',
        y='CompanySubscribers',
        hue='Company',
        hue_order=companies,
        palette=company_color_palette,
        alpha=0.8,
    )
    with plt.rc_context({'lines.linestyle': '--'}):
        sns.lineplot(
            x=[Geocell_last_month, Silknet_Geocell_merger_month],
            y=[get_Silknet_before_merger_subscribers(df),
               get_Silknet_Geocell_merger_subscribers(df)],
            hue=['Merger (Silknet & Geocell)', 'Merger (Silknet & Geocell)'],
            palette=['tab:cyan'],
            alpha=0.8,
            linewidth=3.5,
            ax=ax
        )
    ax.set(
        yticks=yticks_range * 1e6,
        yticklabels=np.round(yticks_range, decimals=2),
        ylabel='Subscribers (M)',
        xticks=years_df['Month'], xticklabels=years_df['Year'], xlabel='')
    plt.legend(loc='upper left')
    plt.show()
    plt.close(fig)


plot_number_of_subscribers_by_company(
    all_df,
    "All mobile subscribers by company in Georgia")
```



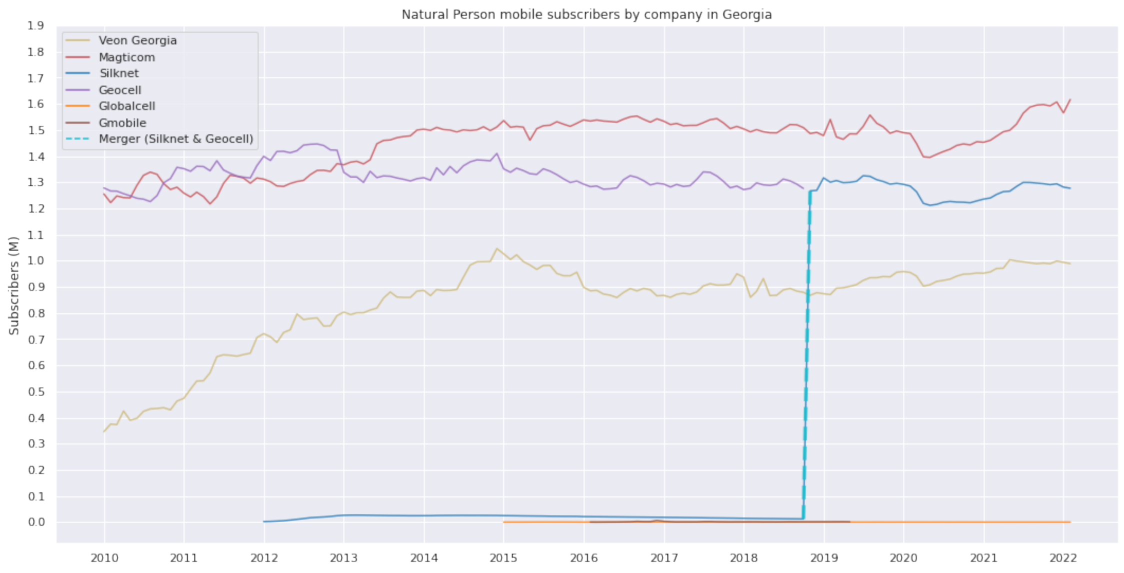
5.2 Legal Entity subscribers

[17]:
```
plot_number_of_subscribers_by_company(
    legal_entities_df,
    "Legal Entity mobile subscribers by company in Georgia",
    yticks_range=np.arange(0, 0.8, 0.1))
```



5.3 Natural Person subscribers

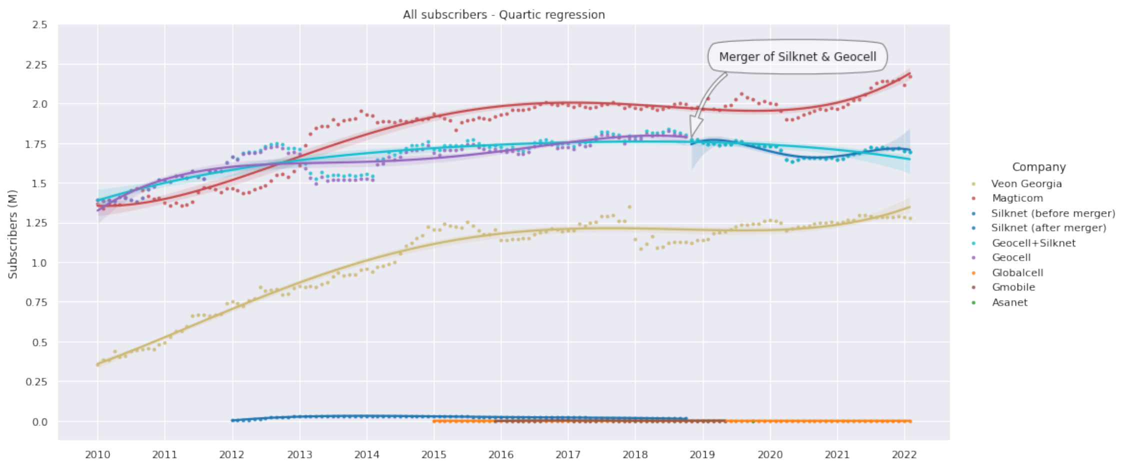
[18]:
```
plot_number_of_subscribers_by_company(
    natural_persons_df,
    "Natural Person mobile subscribers by company in Georgia",
    yticks_range=np.arange(0, 2, 0.1))
```



6 Trend of number of sybscribers by company

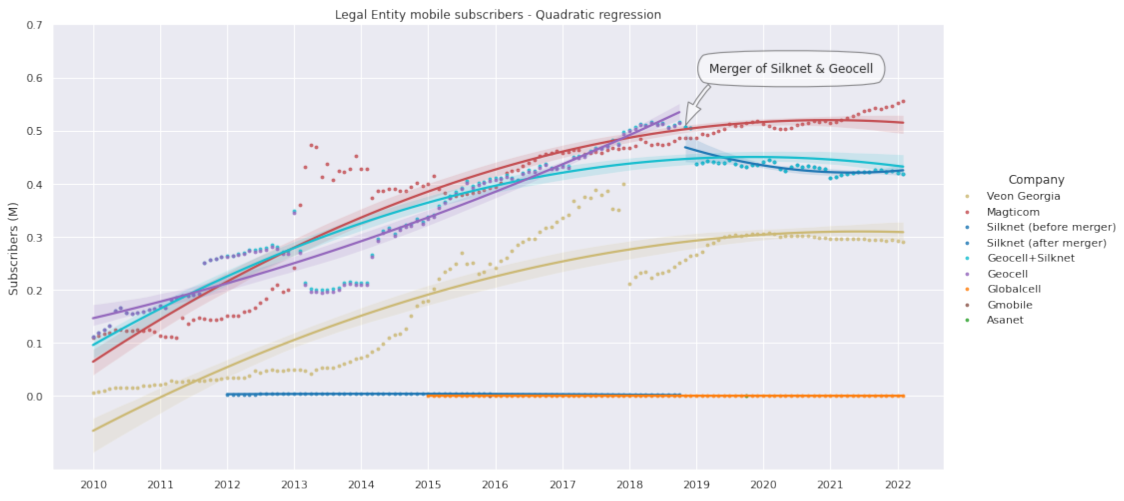
6.1 All subscribers trend

[19]:
```
def plot_trend_by_company_regression(
        subscribers_df: pd.DataFrame,
        title: str,
        yticks_range: np.ndarray = np.arange(0, 2.75, 0.25),
        merger_v_offset=5.2e5,
        regression_order=4):
    companies = [
        company
        for company in company_name_list
        if company in subscribers_df['Company'].unique()]
    company_color_palette=[
        company_colors[company]
        for company in company_name_list if company in companies]
    silknet_idx = companies.index('Silknet')
    companies[silknet_idx:silknet_idx+1] = [
        'Silknet (before merger)', 'Silknet (after merger)', 'Geocell+Silknet']
    company_color_palette[silknet_idx:silknet_idx+1] = [
        'tab:blue', 'tab:blue', 'tab:cyan']
    df = pd.concat([
        subscribers_df,
        subscribers_df
            .loc[(subscribers_df['Company']=='Silknet')
                 | (subscribers_df['Company']=='Geocell')]
            .groupby('Month').sum().reset_index()
            .assign(Company='Geocell+Silknet'),
    ], axis=0, ignore_index=True)
    df.loc[(df['Company']=='Silknet')
           & (df['Month']<Silknet_Geocell_merger_month),
           'Company'] = 'Silknet (before merger)'
    df.loc[(df['Company']=='Silknet'), 'Company'] = 'Silknet (after merger)'

    df = df.assign(MonthNum=lambda df: df['Month'].astype(int))

    grid = sns.lmplot(
        data=df,
        x='MonthNum',
        y='CompanySubscribers',
        hue='Company',
        hue_order=companies,
        palette=company_color_palette,
        height=7, aspect=2,
        ci=99,
        scatter_kws={"s": 8},
        order=regression_order,
    )
    plt.title(title + " - {} regression".format(
        {
            1: 'Linear',
            2: 'Quadratic',
            3: 'Cubic',
            4: 'Quartic',
            5: 'Quintic',
            6: 'Sextic',
        }[regression_order]))

    grid.ax.set(
        yticks=yticks_range * 1e6,
        yticklabels=np.round(yticks_range, decimals=2),
        ylabel='Subscribers (M)',
        xticks=years_df['MonthNum'], xticklabels=years_df['Year'], xlabel='')

    merger_xy = np.array([
        df.loc[df['Month']==Silknet_Geocell_merger_month,
               'MonthNum'].head(1).item(),
        get_Silknet_Geocell_merger_subscribers(subscribers_df)])

    grid.ax.annotate(
        "Merger of Silknet & Geocell",
        xy=merger_xy,
        xytext=merger_xy + np.array([5e16, merger_v_offset]),
        arrowprops={
            'arrowstyle': ('simple,head_length=1.8,'
                           'head_width=1.2,tail_width=0.3'),
            'connectionstyle': 'arc3,rad=0.45',
            'fc': 'w', 'ec': 'k', 'lw': 1.1, 'alpha': 0.5,
        },
        bbox={'boxstyle': 'round4', 'alpha': 0.5, 'pad': 1.1,
              'fc': 'w', 'ec': 'k', 'lw': 1.1},
        fontsize=12, va="center", ha="center",
    )
    plt.show()
    plt.close()

plot_trend_by_company_regression(all_df, "All subscribers", regression_order=4)
```



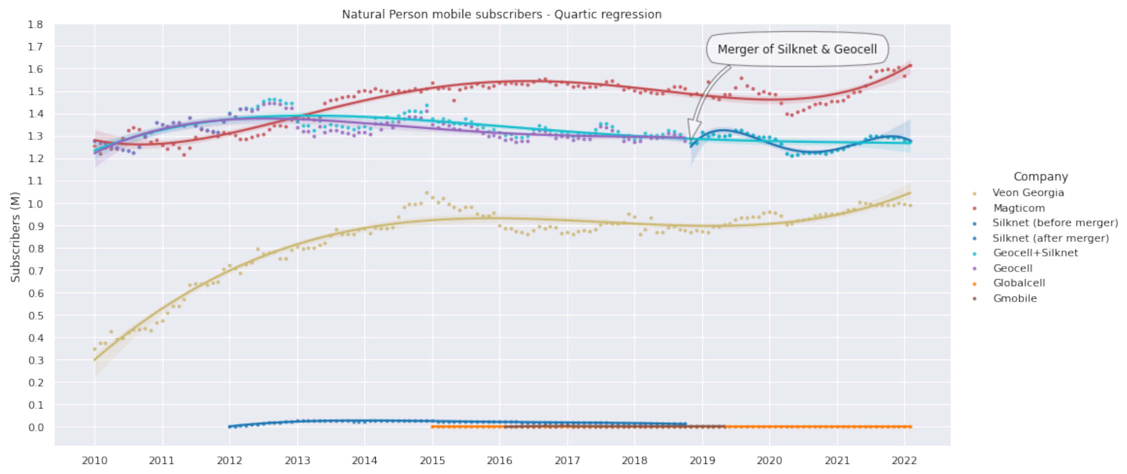
6.2 Legal Entity subscribers trend

```
[20]: plot_trend_by_company_regression(
          legal_entities_df, "Legal Entity mobile subscribers",
          yticks_range=np.arange(0, 0.8, 0.1), merger_v_offset=1.1e5,
          regression_order=2)
```



6.3 Natural Person subscribers trend

```
[21]: plot_trend_by_company_regression(
          natural_persons_df, "Natural Person mobile subscribers",
          yticks_range=np.arange(0, 1.9, 0.1), merger_v_offset=4.2e5,
          regression_order=4)
```



7 Performance of Companies

```
[22]: def get_total_subscribers_df(df: pd.DataFrame) -> pd.DataFrame:
          return (df
                  .groupby('Month')['CompanySubscribers']
                  .sum()
                  .reset_index()
                  .rename({'CompanySubscribers': 'MarketSubscribers'}, axis=1)
                  .assign(
                      MarketSubscribersDelta=lambda df: np.concatenate([
                          np.array([0]),
                          df.iloc[1:]['MarketSubscribers'].to_numpy()
                          - df.iloc[:-1]['MarketSubscribers'].to_numpy()
                      ])
                  )
                 )


      def compute_subscriber_and_market_features(df: pd.DataFrame) -> pd.DataFrame:
          df = (df
                .join(get_total_subscribers_df(df)[['Month', 'MarketSubscribers',
                                                    'MarketSubscribersDelta']]
                      .set_index('Month'), on='Month')
                .groupby('Company')
                .apply(lambda group_df: group_df.assign(
                    CompanySubscribersDelta=lambda df: np.concatenate([
                        np.array([0]),
                        (df.iloc[1:]['CompanySubscribers'].to_numpy()
                         - df.iloc[:-1]['CompanySubscribers'].to_numpy())
                    ])
                ))
                .assign(
                    CompanySubscribersShare=lambda df: (df['CompanySubscribers']
                                                        / df['MarketSubscribers']),
                    CompanySubscribersShareOld=lambda df: np.concatenate([
                        np.array([0]),
                        df['CompanySubscribersShare'].to_numpy()[:-1]
                    ])
                )
               )
          df.loc[(df['Company']=='Silknet')
                 & (df['Month']==Silknet_Geocell_merger_month),
                 'CompanySubscribersDelta'] = 0  # merger... not an actual growth...
          return df

      print("New/Changed columns after applying the "
            "`compute_subscriber_and_market_features()` function to DataFrame:\n-",
            "\n- ".join(list(compute_subscriber_and_market_features(all_df).columns
                             .difference(all_df.columns))))
```

```
New/Changed columns after applying the
`compute_subscriber_and_market_features()` function to DataFrame:
- CompanySubscribersDelta
- CompanySubscribersShare
- CompanySubscribersShareOld
- MarketSubscribers
- MarketSubscribersDelta
```

[23]:
```
print("\nDescriptive statistics of monthly changes in the number "
      "of All Subscribers:\n")
with pd.option_context('display.float_format', '{:0.2f}'.format):
    display(compute_subscriber_and_market_features(all_df)[[
        'MarketSubscribersDelta', 'CompanySubscribersDelta'
    ]].describe())
```

```
Descriptive statistics of monthly changes in the number of All Subscribers:
```

	MarketSubscribersDelta	CompanySubscribersDelta
count	648.00	648.00
mean	11789.52	3189.55
std	50117.14	21336.14
min	-221244.00	-202065.00
25%	-14333.00	-1159.50
50%	13623.00	13.00
75%	44137.00	8334.75
max	136533.00	128717.00

```
[24]: print("\nDescriptive statistics of monthly changes in the number "
            "of Legal Entity Subscribers:\n")
      with pd.option_context('display.float_format', '{:0.2f}'.format):
          display(compute_subscriber_and_market_features(legal_entities_df)[[
              'MarketSubscribersDelta', 'CompanySubscribersDelta'
          ]].describe())
```

```
Descriptive statistics of monthly changes in the number of Legal Entity
Subscribers:


       MarketSubscribersDelta  CompanySubscribersDelta
count                  608.00                   608.00
mean                  7090.89                  1716.18
std                  26092.10                 13841.48
min                -184415.00               -188934.00
25%                  -1151.00                   -72.00
50%                   6477.50                   108.50
75%                  16116.00                  3833.00
max                 115523.00                118730.00
```

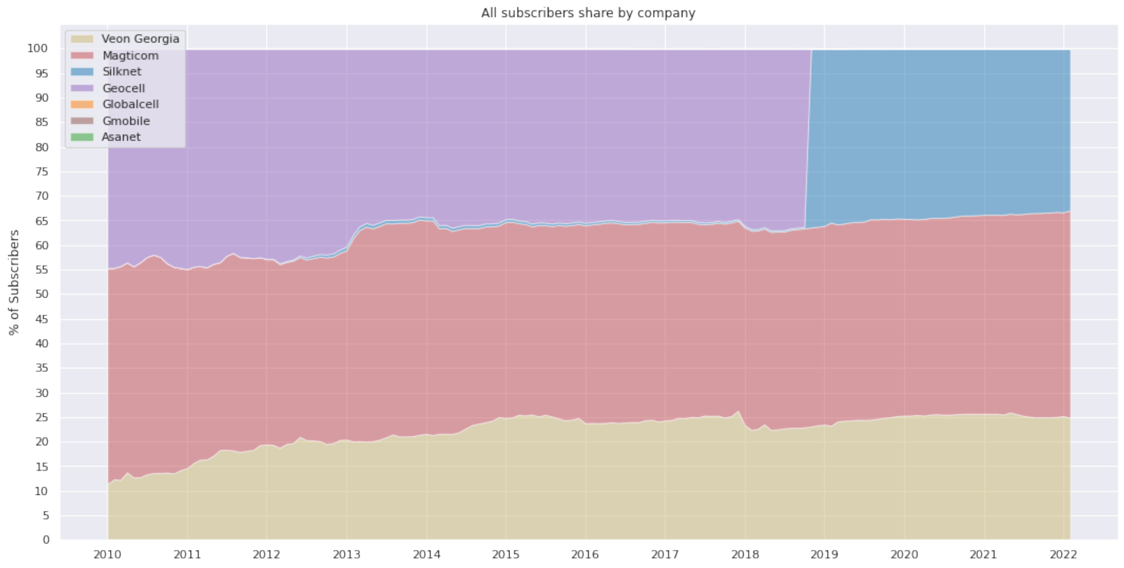
```
[25]: print("\nDescriptive statistics of monthly changes in the number "
            "of Natural Person Subscribers:\n")
      with pd.option_context('display.float_format', '{:0.2f}'.format):
          display(compute_subscriber_and_market_features(natural_persons_df)[[
              'MarketSubscribersDelta', 'CompanySubscribersDelta'
          ]].describe())
```

```
Descriptive statistics of monthly changes in the number of Natural Person
Subscribers:


       MarketSubscribersDelta  CompanySubscribersDelta
count                  646.00                   646.00
mean                  4840.02                  1584.16
std                  41158.06                 16627.51
min                -132445.00                -84790.00
25%                 -23975.50                 -3381.00
50%                   4341.00                    -1.00
75%                  32419.00                  5354.75
max                 127319.00                 61788.00
```

8 Share Of Subscribers by company

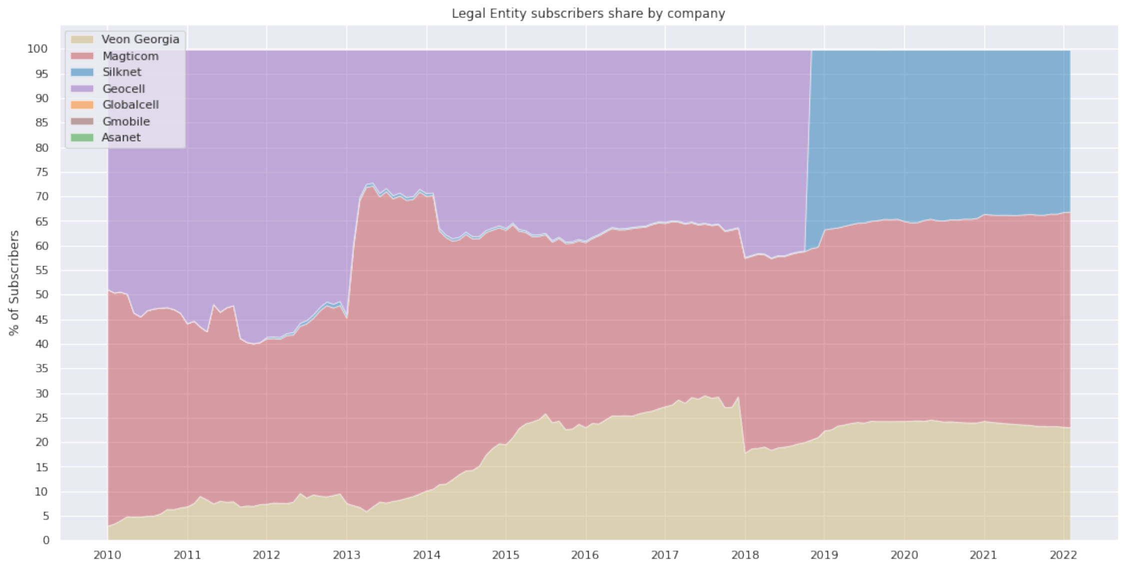
8.1 All subscribers share

```
[26]: def plot_market_share_of_companies(df: pd.DataFrame, title: str):
          df = compute_subscriber_and_market_features(df)

          companies = [
              company for company in company_name_list
              if company in df['Company'].unique()]
          company_color_palette=[
              company_colors[company] for company in company_name_list
              if company in companies]

          company_subscribers = (df[['Month','Company','CompanySubscribersShare']]
                                 .pivot(index='Month',columns='Company')
                                 .T.reset_index(drop=True, level=0).T
                                 .fillna(0)[companies]
                                 .to_dict(orient='list')
                                )

          fig=plt.figure(figsize=(18,9))
          plt.title(title)
          plt.stackplot(
              df['Month'].unique(),
              company_subscribers.values(),
              labels=company_subscribers.keys(),
              colors=company_color_palette,
              alpha=0.5
          )
          plt.gca().set(
              yticks=np.arange(0, 1.01, 0.05), yticklabels=np.arange(0, 101, 5),
              ylabel='% of Subscribers',
              xticks=years_df['Month'], xticklabels=years_df['Year'], xlabel='')
          plt.legend(loc='upper left')
          plt.show()
          plt.close(fig)


      plot_market_share_of_companies(all_df, "All subscribers share by company")
```



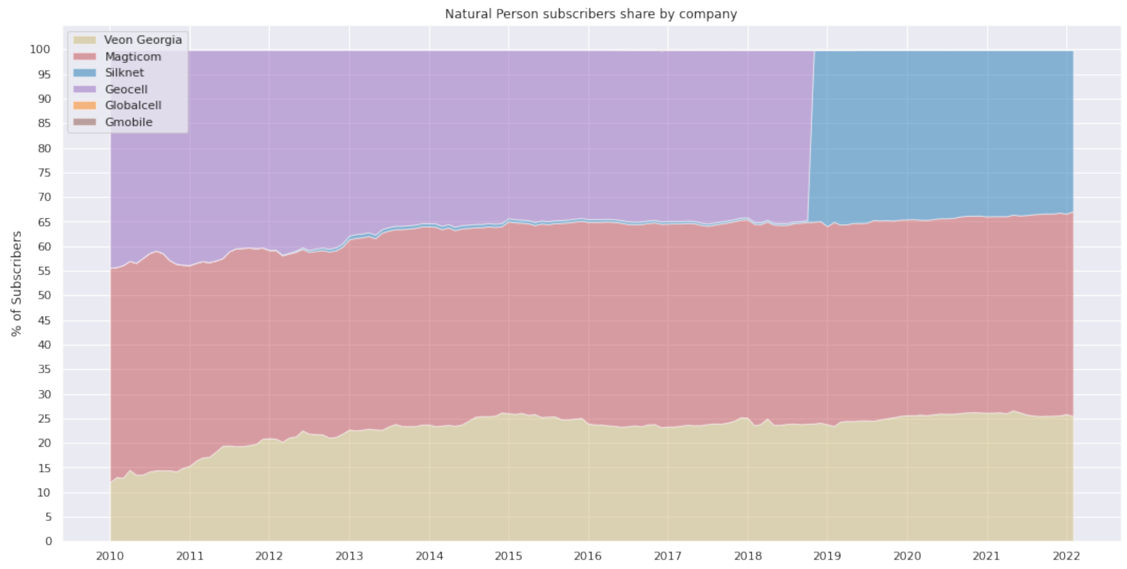
8.2 Legal Entity subscribers share

```
[27]: plot_market_share_of_companies(legal_entities_df,
                                      "Legal Entity subscribers share by company")
```



8.3 Natural Person subscribers share

[28]:
```
plot_market_share_of_companies(natural_persons_df,
                               "Natural Person subscribers share by company")
```



9 The formula of The Atractiveness Score

NOTE: This is a very simple and straightforward formula, so I did not attempt to research if this or variations of it already exist, I just created it independently. If the formula is familiar to you from any other credible sources, please provide your feedback by the means indicated in the end of this notebook in order for me to give a due credit to whoever might be using the exact same formula earlier.

"Attractiveness Score" as used in this notebook is intended to be a company performance metric measuring an ability of a company to literally attract subscribers and further retain them, generating a growth of the number of its subscribers in the process.

First, let's define an "Attractiveness Score" of a company in terms of the variable/feature names available and computed in this notebook:

`AttractivenessScore = CompanySubscribersDelta - (0.5 * ('CompanySubscribersShareOld' + 'CompanySubscribersShare') * MarketSubscribersDelta)`

Where the `CompanySubscribersDelta` is a change in number of subscribers of a company in a given period (Month/Year), the `MarketSubscribersDelta` is a change in number of subscribers in the total market in the same period and the `0.5 * ('CompanySubscribersShareOld' + 'CompanySubscribersShare')` is an average share of subscribers of a company out of the total market in the same period.

Second, let's define mathematically the same formula for the sake of clarity:

Let n^c be a number of subscribers of a company and let n^m be a number of total subscribers in the market (i.e. sum of subscribers of all companies in the market). Then we can define the $AtractivenessScore$ of a company for any time period T, $AtractivenessScore_T$, as follows:

$$AtractivenessScore_T = \sum_{i=1}^{N} (n^c_{t_i} - n^c_{t_{i-1}}) - \frac{1}{2}(\frac{n^c_{t_{i-1}}}{n^m_{t_{i-1}}} + \frac{n^c_{t_i}}{n^m_{t_i}})(n^m_{t_i} - n^m_{t_{i-1}})$$

where T is a given time period (Month/Quarter,Year etc.) for which the score is calculated; $N > 0,\ N \in \mathbb{N}$ is a number of observations made within the T time period; $\{t_1, t_2, t_3, , t_N\} \in T$ are respective times of each observation during the time period; $i > j \iff t_i > t_j$ i.e. observation times are indexed from oldest to newest; $n^{c_{t_i}} \in \mathbb{N},\ n^{c_{t_i}} \geq 0$ is an observed number of subscribers of a company for the respective t_i time; $n^m_{t_i} \in \mathbb{N},\ n^m_{t_i} \geq 0$ is an observed total number of subscribers in the market for the respective t_i time;

By denoting $\Delta n^c_{t_i} = (n^c_{t_i} - n^c_{t_{i-1}})$, $\Delta n^m_{t_i} = (n^m_{t_i} - n^m_{t_{i-1}})$ and $\bar{s}^c_{t_i} = \frac{1}{2}(\frac{n^c_{t_{i-1}}}{n^m_{t_{i-1}}} + \frac{n^c_{t_i}}{n^m_{t_i}})$ the above formula becomes:

$$AtractivenessScore_T = \sum_{i=1}^{N} \Delta n^c_{t_i} - \bar{s}^c_{t_i} \Delta n^m_{t_i}$$

Finally, going back from the mathematical formula to the variable/feature names actually used in this notebook, the correspondence between the two is as follows:

- `CompanySubscribersDelta` $\iff \Delta n^c_{t_i}$
- `MarketSubscribersDelta` $\iff \Delta n^m_{t_i}$
- `0.5 * ('CompanySubscribersShareOld' + 'CompanySubscribersShare')` $\iff \bar{s}^c_{t_i}$

I added the $\Delta n^c_{t_i}$ component to the formula for an obvious reasons, as it is a change in number of subscribers of a company, which should be by definition one of the best indicators of attractiveness of a company, but it can contain noises, such as noises originated from growing or shrinking of the market itself (i.e. change in total number of subscribers in the market), so I added the $-\bar{s}^c_{t_i}\Delta n^m_{t_i}$ component of the formula with the purpose to absorb some of those noises and yield more accurate metric better focusing on the portion of a change in number of subscribers which is actually driven by the attractiveness of the company itself and not by external factors like shrinking or groving market. Assumption behind this part of the formula is that in the events of growing or shrinking of the market if the companies are equally attractive then they would grow or shrink proportionally.

This formula is influenced by the data given in this analysis, as it was made speciphically for this data, which contains a limited information (i.e. mainly a number of subscribers), the intention was to make formula able to extract valuable insights from the given data. Although we cannot access directly performances of companies in the *PR & marketing* or *customer satisfaction* and other areas of their operations just by using this limited data, we still can use the `AttractivenessScore` obtained with this formula as a proxy into those performances combined without need for a more information, and as the formula also cancels some inherent noise of the data, the resulting metric is supposedly more close to a real world performance of the scored companies in terms of attracting subscribers.

[29]:
```python
def compute_attractiveness_score(df: pd.DataFrame) -> pd.DataFrame:
    return compute_subscriber_and_market_features(df).assign(
        AttractivenessScore = lambda df: (
            df['CompanySubscribersDelta']
            - (0.5 * (df['CompanySubscribersShareOld']
                      + df['CompanySubscribersShare'])
               * df['MarketSubscribersDelta'])
        )
    )
```

10 Monthly Attractiveness Scores of Companies

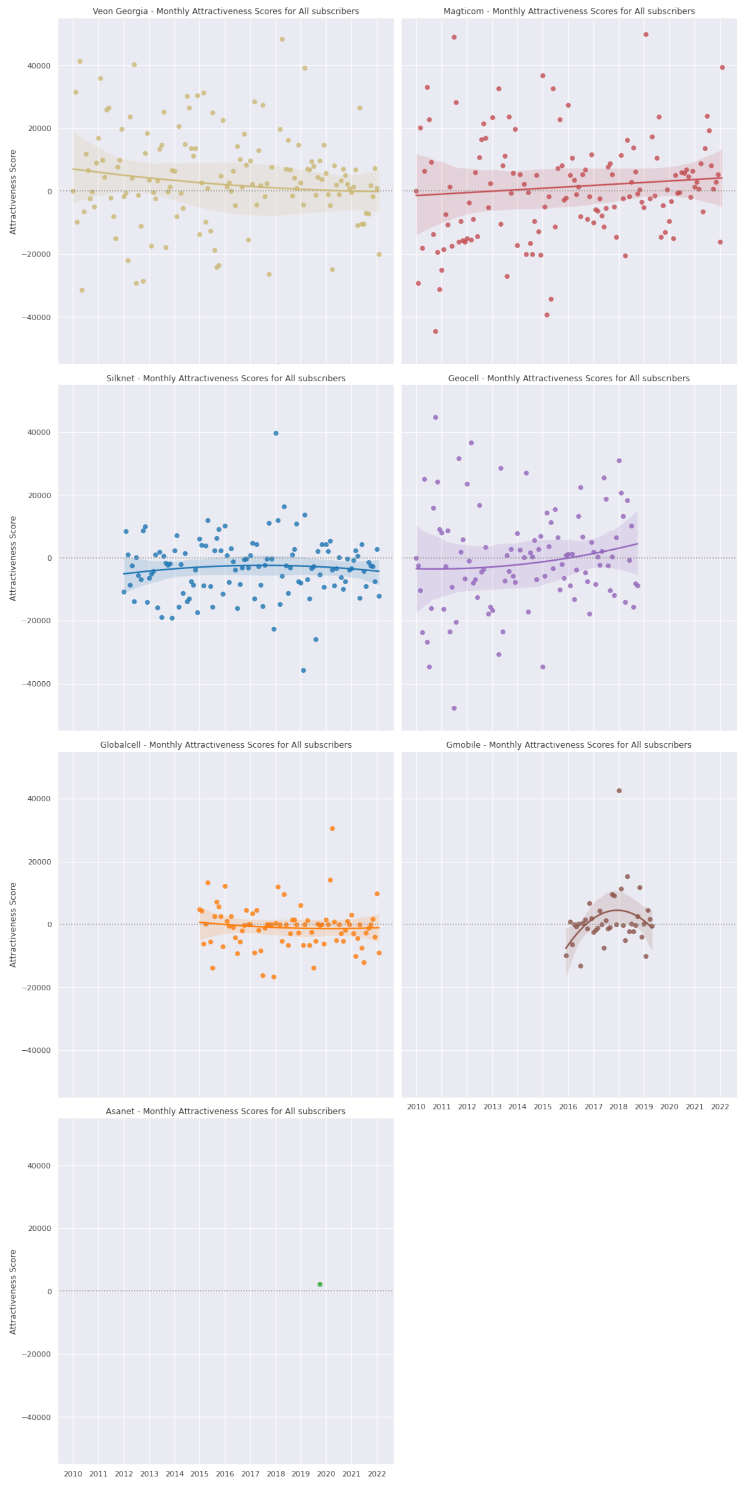
10.1 Monthly Scores for All subscribers

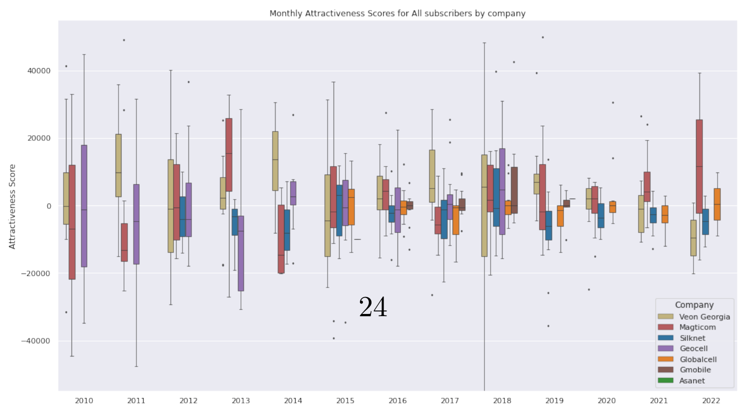
[30]:
```
display(compute_attractiveness_score(all_df)['AttractivenessScore'].describe())
```

```
count       648.000000
mean         90.636727
std       18255.137182
min     -176201.147065
25%       -7301.075624
50%         -20.258358
75%        6489.583900
max      120434.423264
Name: AttractivenessScore, dtype: float64
```

[31]:
```
def plot_attractiveness_score_of_companies(df: pd.DataFrame, title: str):
    df = df.assign(MonthNum=lambda df: df['Month'].astype(int),
                   Year=lambda df: [x.year for x in df['Month']])
    df = compute_attractiveness_score(df)

    companies = [
        company for company in company_name_list
        if company in df['Company'].unique()]
    company_color_palette = [
        company_colors[company] for company in company_name_list
        if company in companies]

    grid = sns.FacetGrid(df, col="Company", hue="Company", col_order=companies,
                         hue_order=companies, palette=company_color_palette,
                         col_wrap=2, height=7.5)
    grid.refline(y=0, linestyle=":")  # Draw a horizontal line at zero
    grid.map(sns.regplot, 'MonthNum', 'AttractivenessScore', marker='o',
             order=2, ci=98)
    grid.set_titles(col_template=f"{{col_name}} - {title}",
                    row_template="{row_name}")
    grid.set(
        ylabel='Attractiveness Score',
        xticks=years_df['MonthNum'], xticklabels=years_df['Year'], xlabel='',
        ylim=(-55000, 55000)
    )
```

```python
    grid.fig.tight_layout(w_pad=1)
    # Add additional axis to plot boxplot in the end:
    grid.figure.add_axes([0.075, -0.27, 0.915, 0.25])
    ax = sns.boxplot(data=df, x='Year', y='AttractivenessScore',
                     hue='Company', hue_order=companies,
                     palette=company_color_palette,
                     linewidth=0.7, fliersize=1.7)
    ax.set_title(f"{title} by company")
    ax.set(
        ylabel='Attractiveness Score',
        xlabel='',
        ylim=(-55000, 55000)
    )
    plt.show()


plot_attractiveness_score_of_companies(
    all_df, "Monthly Attractiveness Scores for All subscribers")
```


Veon Georgia - Monthly Attractiveness Scores for All subscribers
Magticom - Monthly Attractiveness Scores for All subscribers
Silknet - Monthly Attractiveness Scores for All subscribers
Geocell - Monthly Attractiveness Scores for All subscribers
Globalcell - Monthly Attractiveness Scores for All subscribers
Gmobile - Monthly Attractiveness Scores for All subscribers
Asanet - Monthly Attractiveness Scores for All subscribers
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

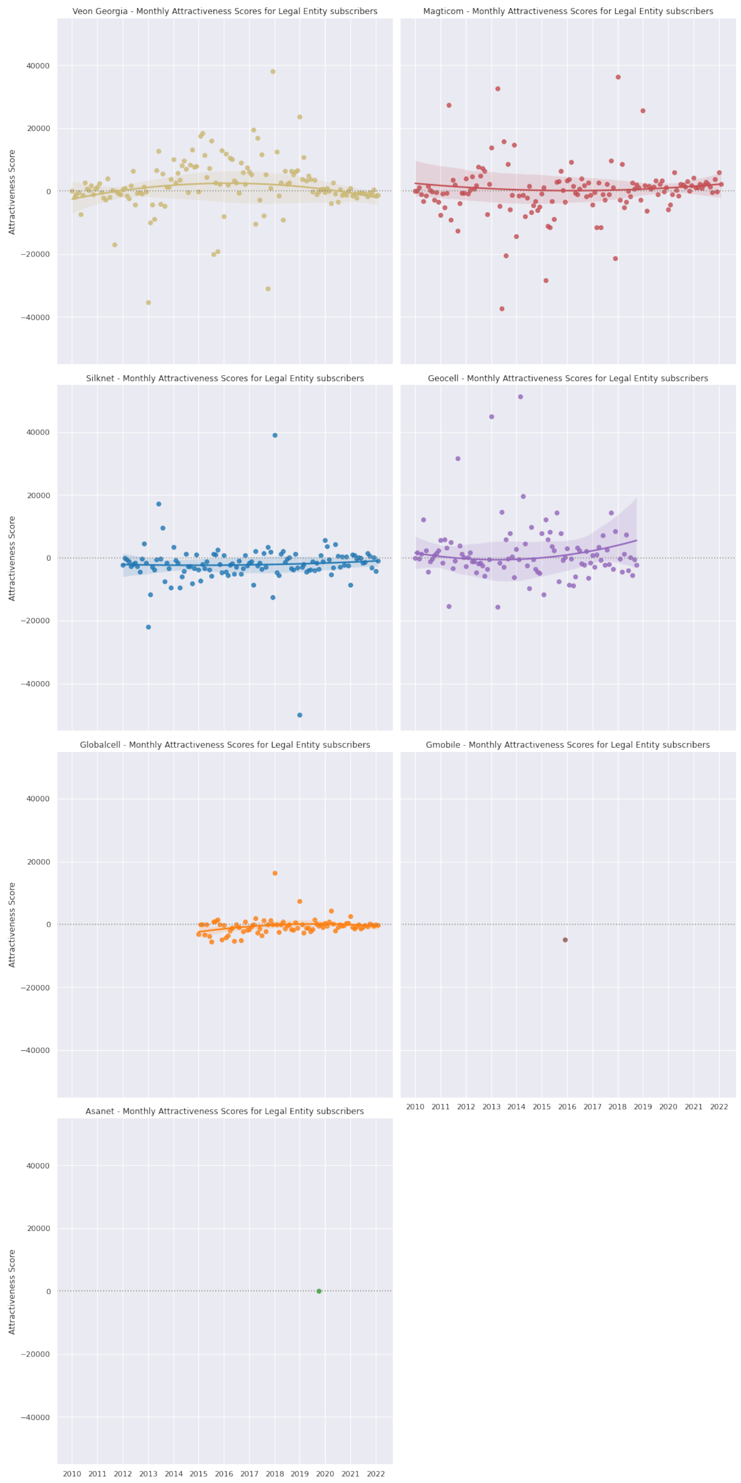

Monthly Attractiveness Scores for All subscribers by company
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Company
Veon Georgia
Magticom
Silknet
Geocell
Globalcell
Gmobile
Asanet

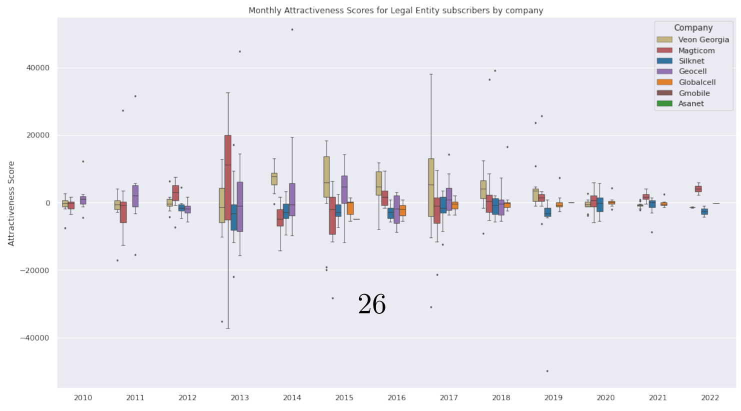
10.2 Monthly Scores for Legal Entity subscribers

[32]:
```
display(compute_attractiveness_score(
    legal_entities_df)['AttractivenessScore'].describe())
```

```
count       608.000000
mean        122.907280
std       12269.675349
min     -135937.797389
25%       -2536.133414
50%        -262.757392
75%        2240.071951
max      105826.940724
Name: AttractivenessScore, dtype: float64
```

[33]:
```
plot_attractiveness_score_of_companies(
    legal_entities_df,
    "Monthly Attractiveness Scores for Legal Entity subscribers")
```


Veon Georgia - Monthly Attractiveness Scores for Legal Entity subscribers
Magticom - Monthly Attractiveness Scores for Legal Entity subscribers
Silknet - Monthly Attractiveness Scores for Legal Entity subscribers
Geocell - Monthly Attractiveness Scores for Legal Entity subscribers
Globalcell - Monthly Attractiveness Scores for Legal Entity subscribers
Gmobile - Monthly Attractiveness Scores for Legal Entity subscribers
Asanet - Monthly Attractiveness Scores for Legal Entity subscribers
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

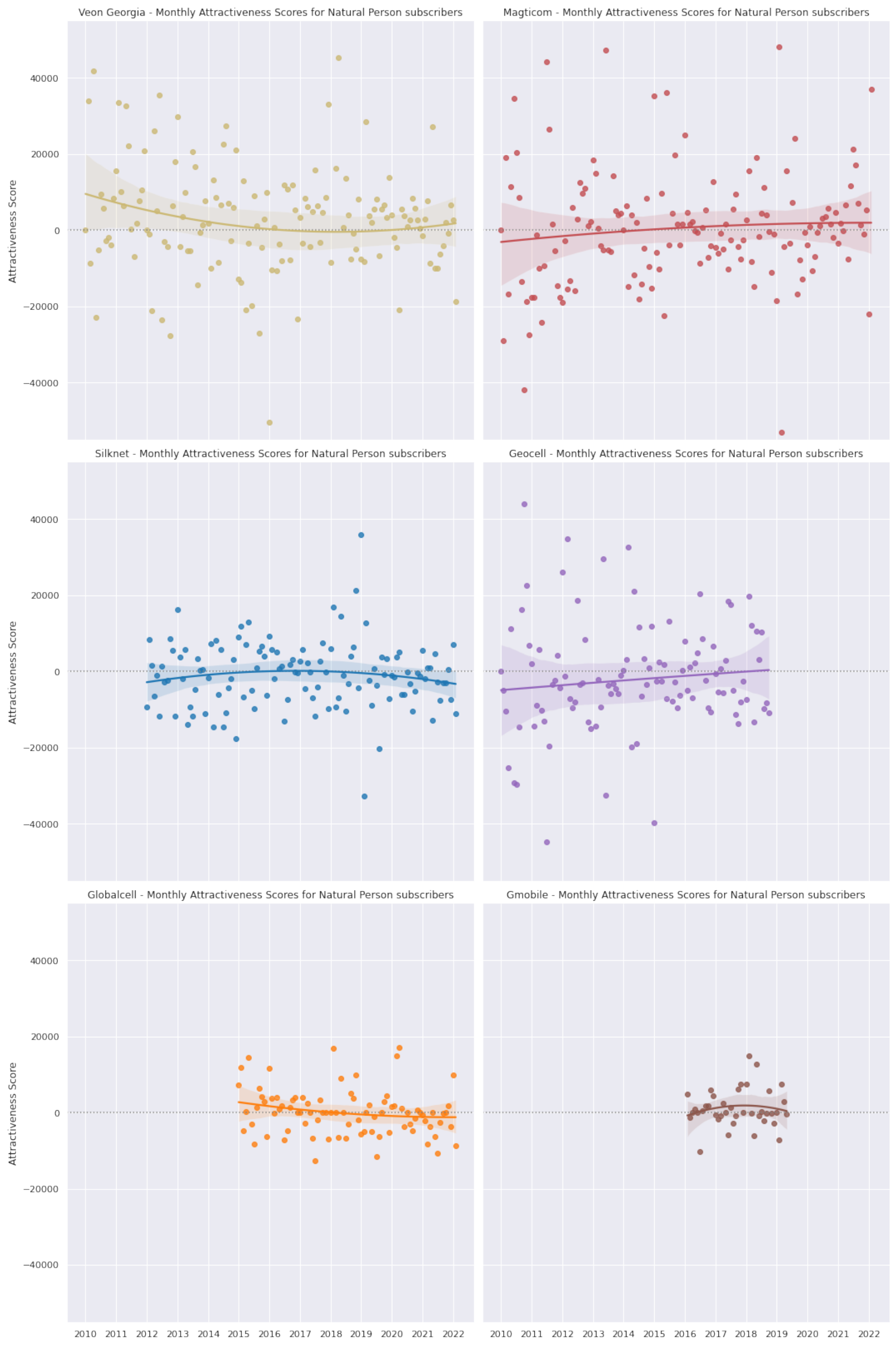

Monthly Attractiveness Scores for Legal Entity subscribers by company
Company
Veon Georgia
Magticom
Silknet
Geocell
Globalcell
Gmobile
Asanet
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

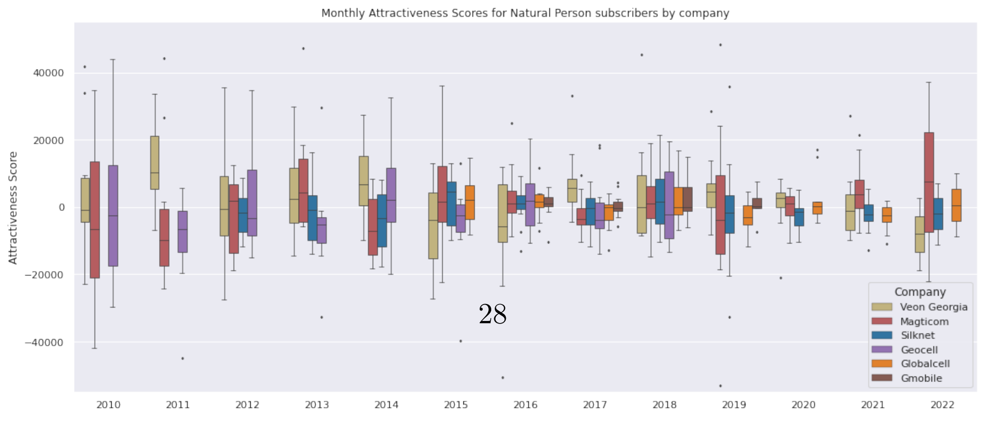
10.3 Monthly Scores for Natural Person subscribers

[34]:
```
display(compute_attractiveness_score(
    natural_persons_df)['AttractivenessScore'].describe())
```

```
count      646.000000
mean        57.866318
std      13140.832671
min     -70452.871477
25%      -6092.321398
50%         -1.850429
75%       5634.597747
max      48164.333101
Name: AttractivenessScore, dtype: float64
```

[35]:
```
plot_attractiveness_score_of_companies(
    natural_persons_df,
    "Monthly Attractiveness Scores for Natural Person subscribers")
```


Veon Georgia - Monthly Attractiveness Scores for Natural Person subscribers
Magticom - Monthly Attractiveness Scores for Natural Person subscribers
Silknet - Monthly Attractiveness Scores for Natural Person subscribers
Geocell - Monthly Attractiveness Scores for Natural Person subscribers
Globalcell - Monthly Attractiveness Scores for Natural Person subscribers
Gmobile - Monthly Attractiveness Scores for Natural Person subscribers
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022


Monthly Attractiveness Scores for Natural Person subscribers by company
Attractiveness Score
40000
20000
0
−20000
−40000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Company
Veon Georgia
Magticom
Silknet
Geocell
Globalcell
Gmobile

11 Yearly Attractiveness Scores of Companies

Before starting yearly score calculations let's exclude companies that has operated less than a year in the relevant market.

[36]:
```
all_df_exclude = all_df_active_months.loc[
    all_df_active_months['Active Months'] < 12, 'Company']
print("Companies that operated less than a year for All Subscribers:")
print(", ".join(all_df_exclude.to_list())
      if len (all_df_exclude) else "No such company found...")
```

```
Companies that operated less than a year for All Subscribers:
Asanet
```

[37]:
```
legal_entities_df_exclude = legal_entities_df_active_months.loc[
    legal_entities_df_active_months['Active Months'] < 12, 'Company']
print("Companies that operated less than a year for Legal Entities:")
print(", ".join(legal_entities_df_exclude.to_list())
      if len(legal_entities_df_exclude) else "No such company found...")
```

```
Companies that operated less than a year for Legal Entities:
Gmobile, Asanet
```

[38]:
```
natural_persons_df_exclude = natural_persons_df_active_months.loc[
    natural_persons_df_active_months['Active Months'] < 12, 'Company']
print("Companies that operated less than a year for Natural Persons:")
print(", ".join(natural_persons_df_exclude.to_list())
      if len(natural_persons_df_exclude) else "No such company found...")
```

```
Companies that operated less than a year for Natural Persons:
No such company found…
```

[39]:
```
all_df = all_df.loc[~all_df['Company'].isin(all_df_exclude)]
legal_entities_df = legal_entities_df.loc[
    ~legal_entities_df['Company'].isin(legal_entities_df_exclude)]
natural_persons_df = natural_persons_df.loc[
    ~natural_persons_df['Company'].isin(natural_persons_df_exclude)]
```

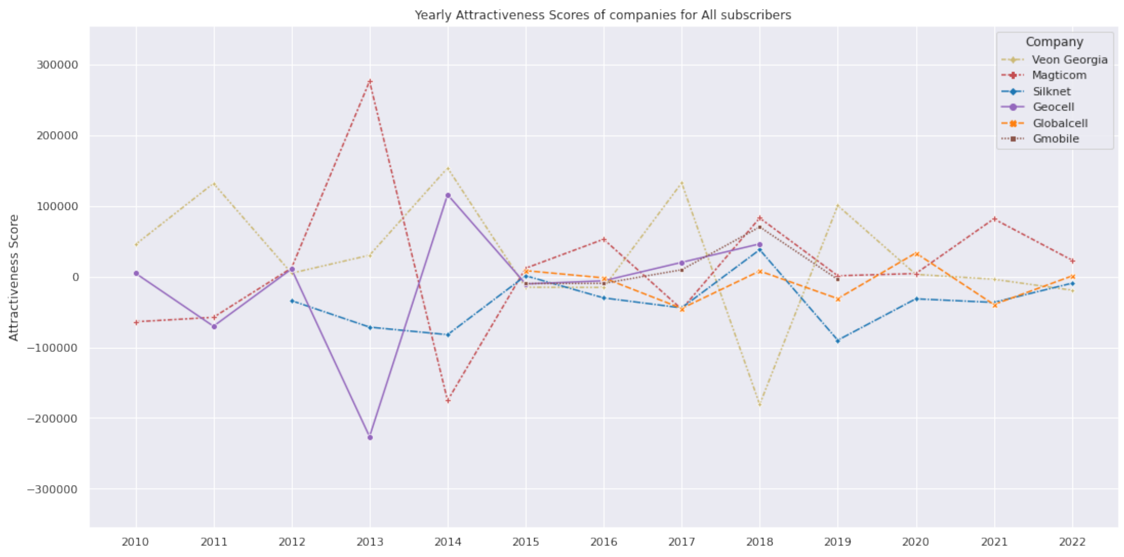
11.1 Yearly Scores for All subscribers

[40]:
```
def get_top_3_companies_per_year(df: pd.DataFrame) -> pd.DataFrame:
    df = df.assign(
        MonthNum=lambda df: df['Month'].astype(int),
        Year=lambda df: [x.year for x in df['Month']],
    )
```

```python
    df = (compute_attractiveness_score(df)
          .groupby(['Company', 'Year'])
          .aggregate({'AttractivenessScore': 'sum'}).reset_index()
          .groupby('Year')
          .apply(lambda df: (df
                             .sort_values('AttractivenessScore',
                                          ascending=False)
                             .head(3)
                             .reset_index(drop=True)))
          .reset_index(level=1).rename({'level_1': 'Place'}, axis=1)
          .pivot('Year', 'Place').rename({0: 1, 1: 2, 2: 3}, axis=1)
    )
    return df


def plot_yearly_attractiveness_score_of_companies(df: pd.DataFrame,
                                                   title: str):
    df = df.assign(
        MonthNum=lambda df: df['Month'].astype(int),
        Year=lambda df: [x.year for x in df['Month']]
    )
    df = compute_attractiveness_score(df)
    df = (df.groupby(['Company', 'Year'])
          .aggregate({'AttractivenessScore': 'sum'}).reset_index())

    companies = [
        company for company in company_name_list
        if company in df['Company'].unique()]
    company_color_palette = [
        company_colors[company] for company in company_name_list
        if company in companies]

    fig = plt.figure(figsize=(18, 9))
    ax = sns.lineplot(data=df, x='Year', y='AttractivenessScore',
                      hue='Company', hue_order=companies,
                      palette=company_color_palette,
                      style='Company', markers=True)
    ax.set(
        ylabel='Attractiveness Score',
        xticks=years_df['Year'], xticklabels=years_df['Year'], xlabel='',
        ylim=(-355000, 355000)
    )
    plt.title(title)
    plt.show()
    plt.close(fig)
```

```python
title = "Yearly Attractiveness Scores of companies for All subscribers"
print(f'\n{title}:\n')
all_top3_df = get_top_3_companies_per_year(all_df)
display(all_top3_df)
plot_yearly_attractiveness_score_of_companies(all_df, title)
```

```
Yearly Attractiveness Scores of companies for All subscribers:


            Company                            AttractivenessScore  \
Place             1             2             3                  1
Year
2010   Veon Georgia       Geocell      Magticom       45362.083982
2011   Veon Georgia      Magticom       Geocell      131984.657940
2012       Magticom       Geocell  Veon Georgia       12136.594211
2013       Magticom  Veon Georgia       Silknet      276248.323637
2014   Veon Georgia       Geocell       Silknet      153741.442115
2015       Magticom    Globalcell       Silknet       11834.482137
2016       Magticom    Globalcell       Geocell       52927.240468
2017   Veon Georgia       Geocell       Gmobile      132636.468918
2018       Magticom       Gmobile       Geocell       82995.183958
2019   Veon Georgia      Magticom       Gmobile      100574.478092
2020     Globalcell      Magticom  Veon Georgia       33395.204569
2021       Magticom  Veon Georgia       Silknet       81731.975640
2022       Magticom    Globalcell       Silknet       23383.519692


Place              2             3
Year
2010     4856.801673 -63840.835359
2011   -57561.318275 -70160.992134
2012    10839.125704   4863.307230
2013    30273.915515 -71402.706360
2014   115931.736293 -82111.949335
2015     8480.221206   1293.094662
2016    -1778.601784  -5913.157603
2017    20202.770120   9713.357893
2018    70269.224326  46335.943660
2019     1211.003561  -3914.082064
2020     4339.903478   3196.041334
2021    -3725.224280 -36470.176832
2022      854.293360  -9328.489339
```

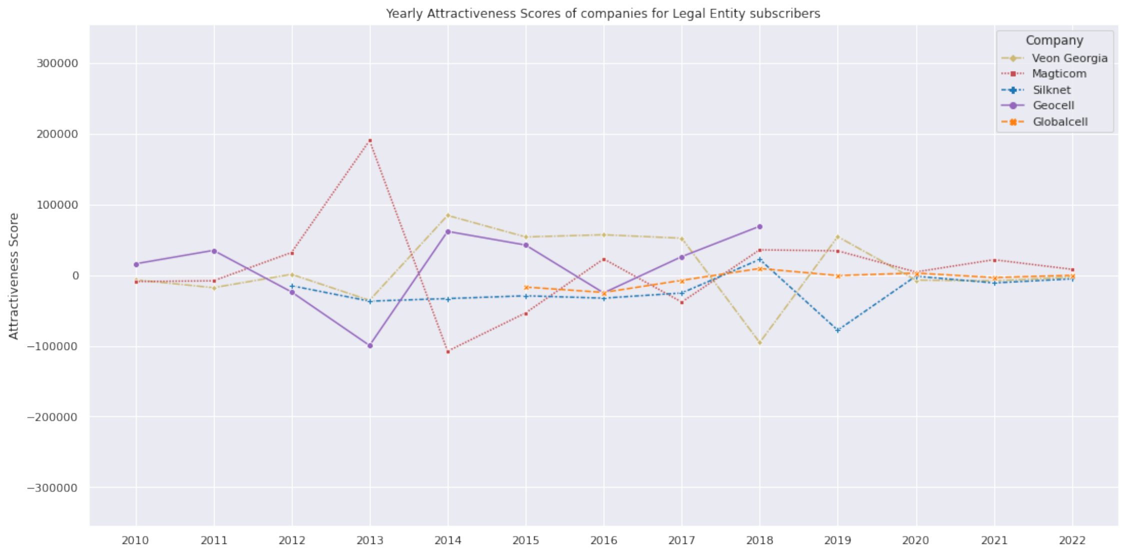


11.2 Yearly Scores for Legal Entity subscribers

```
[41]: title = ("Yearly Attractiveness Scores of companies "
               "for Legal Entity subscribers")
      print(f'\n{title}:\n')
      display(get_top_3_companies_per_year(legal_entities_df))
      plot_yearly_attractiveness_score_of_companies(legal_entities_df, title)
```

```
Yearly Attractiveness Scores of companies for Legal Entity subscribers:


            Company                                  AttractivenessScore  \
Place             1             2             3                        1
Year
2010        Geocell  Veon Georgia      Magticom             16015.083230
2011        Geocell      Magticom  Veon Georgia             35038.238082
2012       Magticom  Veon Georgia       Silknet             32021.290422
2013       Magticom  Veon Georgia       Silknet            190397.530087
2014   Veon Georgia       Geocell       Silknet             84478.617926
2015   Veon Georgia       Geocell    Globalcell             54016.464085
2016   Veon Georgia      Magticom    Globalcell             57131.163247
2017   Veon Georgia       Geocell    Globalcell             52236.986105
2018        Geocell      Magticom       Silknet             69153.218138
2019   Veon Georgia      Magticom    Globalcell             54436.124665
2020       Magticom    Globalcell       Silknet              4486.802501
2021       Magticom    Globalcell  Veon Georgia             21836.080569
2022       Magticom    Globalcell  Veon Georgia              8245.535916
```

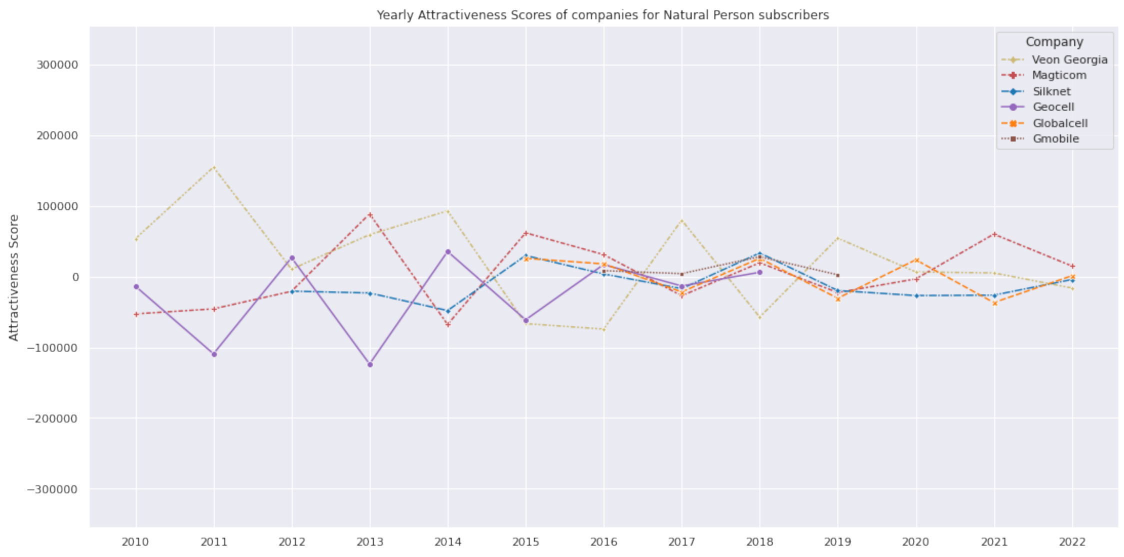
```
Place             2             3
Year
2010   -6592.335644  -9024.622081
2011   -8047.902630 -17747.657414
2012    1166.772836 -15008.081363
2013  -35643.258459 -36776.163718
2014   61890.963138 -33149.647736
2015   42567.025239 -16856.577701
2016   22945.576221 -24482.703995
2017   26132.037937  -7363.107595
2018   35778.728272  22243.376309
2019   34341.129394   -560.286020
2020    2923.260004  -1441.009696
2021   -3386.336872  -8133.935355
2022    -247.091267  -2759.755264
```



11.3 Yearly Scores for Natural Person subscribers

```
[42]: title = ("Yearly Attractiveness Scores of companies "
               "for Natural Person subscribers")
      print(f'\n{title}:\n')
      display(get_top_3_companies_per_year(legal_entities_df))
      plot_yearly_attractiveness_score_of_companies(natural_persons_df, title)
```

```
Yearly Attractiveness Scores of companies for Natural Person subscribers:


            Company                                AttractivenessScore  \
Place             1             2             3                    1
Year
2010        Geocell  Veon Georgia      Magticom         16015.083230
2011        Geocell      Magticom  Veon Georgia         35038.238082
2012       Magticom  Veon Georgia       Silknet         32021.290422
2013       Magticom  Veon Georgia       Silknet        190397.530087
2014   Veon Georgia       Geocell       Silknet         84478.617926
2015   Veon Georgia       Geocell    Globalcell         54016.464085
2016   Veon Georgia      Magticom    Globalcell         57131.163247
2017   Veon Georgia       Geocell    Globalcell         52236.986105
2018        Geocell      Magticom       Silknet         69153.218138
2019   Veon Georgia      Magticom    Globalcell         54436.124665
2020       Magticom    Globalcell       Silknet          4486.802501
2021       Magticom    Globalcell  Veon Georgia         21836.080569
2022       Magticom    Globalcell  Veon Georgia          8245.535916


Place             2             3
Year
2010   -6592.335644  -9024.622081
2011   -8047.902630 -17747.657414
2012    1166.772836 -15008.081363
2013  -35643.258459 -36776.163718
2014   61890.963138 -33149.647736
2015   42567.025239 -16856.577701
2016   22945.576221 -24482.703995
2017   26132.037937  -7363.107595
2018   35778.728272  22243.376309
2019   34341.129394   -560.286020
2020    2923.260004  -1441.009696
2021   -3386.336872  -8133.935355
2022    -247.091267  -2759.755264
```



12 Top Companies by Attractiveness Score

[43]:
```python
def get_top_companies_per_year(df: pd.DataFrame, name: str) -> pd.DataFrame:
    return (get_top_3_companies_per_year(df)
            .loc[:,[('Company',1)]].T.reset_index(drop=True).T
            .rename({0:name}, axis=1))


def extract_available_months(df: pd.DataFrame) -> pd.DataFrame:
    return (df
            .assign(
                MonthName=lambda df: [x.month_name() for x in df['Month']],
                Year=lambda df: [x.year for x in df['Month']],
            )
            .groupby('Year')
            .apply(lambda df: pd.DataFrame({
                "Months": [
                    ' - '.join((lambda m: [m[0], m[-1]] if len(m) > 1 else m)(
                        df['MonthName'].unique()
                    ))
                ]
            })).reset_index()
           ).set_index('Year').filter(['Months'])


print("\nTop Mobile Communication Companies in Georgia "
      "by Attractiveness Score per year:\n")
top_companies_df = get_top_companies_per_year(all_df,
                                              "For All subscribers").join(
    get_top_companies_per_year(legal_entities_df,
                               "For Legal Entity subscribers")
).join(
    get_top_companies_per_year(natural_persons_df,
                               "For Natural Person subscribers")
).join(
    extract_available_months(all_df)
).reset_index().set_index(['Months', 'Year'])
display(top_companies_df)

for category in ('For All subscribers', 'For Legal Entity subscribers',
                 'For Natural Person subscribers'):
    print(f'{category} during the '
          f'{top_companies_df.loc["January - December"].index.min()}'
          f' - {top_companies_df.loc["January - December"].index.max()} years '
          'the following companies held the yearly top spot:')

    for company,count in top_companies_df.loc['January - December',
                                              category
                                             ].value_counts().iteritems():
        company = '"{}"'.format(company)
        print(f' - {company:<16} {count:} {"times" if count > 1 else "time"}.')
    print()
```

```
Top Mobile Communication Companies in Georgia by Attractiveness Score per year:

                        For All subscribers For Legal Entity subscribers  \
Months             Year
January - December 2010        Veon Georgia                      Geocell
                   2011        Veon Georgia                      Geocell
                   2012            Magticom                     Magticom
                   2013            Magticom                     Magticom
                   2014        Veon Georgia                 Veon Georgia
                   2015            Magticom                 Veon Georgia
                   2016            Magticom                 Veon Georgia
                   2017        Veon Georgia                 Veon Georgia
                   2018            Magticom                      Geocell
                   2019        Veon Georgia                 Veon Georgia
                   2020          Globalcell                     Magticom
                   2021            Magticom                     Magticom
January - February 2022            Magticom                     Magticom

                        For Natural Person subscribers
Months             Year
January - December 2010                   Veon Georgia
```

```
                    2011                     Veon Georgia
                    2012                          Geocell
                    2013                         Magticom
                    2014                     Veon Georgia
                    2015                         Magticom
                    2016                         Magticom
                    2017                     Veon Georgia
                    2018                          Silknet
                    2019                     Veon Georgia
                    2020                       Globalcell
                    2021                         Magticom
January - February 2022                         Magticom
For All subscribers during the 2010 - 2021 years the following companies held
the yearly top spot:
 - "Magticom"       6 times.
 - "Veon Georgia"   5 times.
 - "Globalcell"     1 time.

For Legal Entity subscribers during the 2010 - 2021 years the following
companies held the yearly top spot:
 - "Veon Georgia"   5 times.
 - "Magticom"       4 times.
 - "Geocell"        3 times.

For Natural Person subscribers during the 2010 - 2021 years the following
companies held the yearly top spot:
 - "Veon Georgia"   5 times.
 - "Magticom"       4 times.
 - "Geocell"        1 time.
 - "Silknet"        1 time.
 - "Globalcell"     1 time.
```

[44]:
```python
def get_full_years(df: pd.DataFrame) -> pd.DataFrame:
    df = extract_available_months(df)
    return (df
            .loc[df['Months']=='January - December']
            .reset_index()['Year']
            .sort_values(ascending=False)
            .reset_index(drop=True))
```

[45]:
```python
def get_321_df(df: pd.DataFrame, full_years: pd.Series) -> pd.DataFrame:
    df = df.loc[full_years, "Company"].melt(ignore_index=False).reset_index()
    df['Score'] = -1 * (df['Place'] - 4)
    return df
```

[46]:
```
full_years = get_full_years(all_df)
all_321_df = get_321_df(all_top3_df, full_years)

width_123 = 8
height_123 = 3

ncols = 3
nrows = len(full_years) - 1 + ncols
nrows = np.ceil(nrows / ncols).astype(int)


fig = plt.figure(figsize=(ncols*width_123, nrows*height_123))


def plot_123(ax: plt.Axes, year: int):
    width = 0.35  # the width of the bars
    x = np.arange(len([1]))
    first_place, second_place, third_place = [
        all_321_df.loc[(all_321_df['Year']==year)&(all_321_df['Place']==i),
                       'value'].item()
        for i in (1, 2, 3)
    ]

    rects1 = ax.bar(x - (width/2), [3], width, label=first_place,
                    color=company_colors[first_place])
    rects2 = ax.bar(x + (width/2), [2], width, label=second_place,
                    color=company_colors[second_place])
    rects3 = ax.bar(x - (width/2) -width, [1], width, label=third_place,
                    color=company_colors[third_place])
    ax.annotate(
        first_place,
        xy=(0-(width/2),3.25),
        fontsize=14, fontweight='bold',
        va="center", ha="center", alpha=0.85,
        color=company_colors[first_place]
    )
    ax.annotate(
        second_place,
        xy=(0+(width/2),2.25),
        fontsize=14, fontweight='bold',
        va="center", ha="center", alpha=0.85,
        color=company_colors[second_place]
    )
    ax.annotate(
        third_place,
        xy=(-0-(width/2)-width,1.25),
        fontsize=14, fontweight='bold',
        va="center", ha="center", alpha=0.85,
        color=company_colors[third_place]
    )
    ax.annotate(
        "1",
        xy=(0-(width/2),1.65),
        fontsize=36, fontweight='bold',
        va="center", ha="center", alpha=0.85, color='w'
    )
    ax.annotate(
        "2",
        xy=(0+(width/2),1.05),
        fontsize=36, fontweight='bold',
        va="center", ha="center", alpha=0.85, color='w'
    )
    ax.annotate(
        "3",
        xy=(-0-(width/2)-width,0.45),
        fontsize=36, fontweight='bold',
        va="center", ha="center", alpha=0.85, color='w'
    )

    ax.set_yticks([0,3.7])
    ax.set_xticks([-2*width-0.75*width,0,1*width+0.75*width])
    ax.set_axis_off()
    ax.set_title(f'{year}', fontdict={
        "weight": "bold",
        "size": 24,
        "color": "#444444",
    })


ax = fig.add_subplot(nrows,1,1)
plot_123(ax, full_years[0].item())

for idx,year in full_years[1:].iteritems():
    ax = fig.add_subplot(nrows, ncols, idx+ncols)
    plot_123(ax, year)

fig.tight_layout(h_pad=4)



##
# Instead of displaying here save the plot as `ranking.png` image file
# in order to display in the beggining of this notebook.
# FIXME: This approach may require 2x run of notebook to update the map
```

```
##
fig.savefig("ranking.png")


# plt.show()


plt.close(fig)
```

[47]:
```
print(f"\n ** Total Elapsed time: {datetime.utcnow() - nb_st} ** \n")
print(f"Notebook END time: {datetime.utcnow()} UTC\n")
```

```

 ** Total Elapsed time: 0:00:16.262610 **

Notebook END time: 2022-07-02 18:51:42.959128 UTC
```

[48]:
```
%%capture
%mkdir OGP_classic
```

[49]:
```
%%capture
%%file "OGP_classic/conf.json"
{
  "base_template": "classic",
  "preprocessors": {
    "500-metadata": {
      "type": "nbconvert.preprocessors.ClearMetadataPreprocessor",
      "enabled": true,
      "clear_notebook_metadata": true,
      "clear_cell_metadata": true
    },
    "900-files": {
      "type": "nbconvert.preprocessors.ExtractOutputPreprocessor",
      "enabled": true
    }
  }
}
```

[50]:
```
%%capture
%%file "OGP_classic/index.html.j2"
{%- extends 'classic/index.html.j2' -%}
{%- block html_head -%}

{#  OGP attributes for shareability #}
<meta property="og:url"          content="https://sentinel-1.github.io/
 ↪mobile_subscribers_Georgia/" />
<meta property="og:type"         content="article" />
```

```
<meta property="og:title"        content="Ranking of Mobile Network Operators␣
 ↪in Georgia" />
<meta property="og:description"  content="Which companies are preffered by␣
 ↪mobile subscribers in Georgia?" />
<meta property="og:image"        content="https://raw.githubusercontent.com/
 ↪sentinel-1/mobile_subscribers_Georgia/master/images/ASA_Mobile_123.png" />
<meta property="og:image:alt"    content="ASA Mobile Companies Ranking 123␣
 ↪logo" />
<meta property="og:image:type"   content="image/png" />
<meta property="og:image:width"  content="1200" />
<meta property="og:image:height" content="628" />

<meta property="article:published_time" content="2022-05-23T22:33:25+00:00" />
<meta property="article:modified_time"  content="{{ resources.
 ↪iso8610_datetime_now }}" />
<meta property="article:publisher"      content="https://sentinel-1.github.io" /
 ↪>
<meta property="article:author"         content="https://github.com/sentinel-1"␣
 ↪/>
<meta property="article:section"        content="datascience" />
<meta property="article:tag"            content="datascience" />
<meta property="article:tag"            content="Python" />
<meta property="article:tag"            content="data" />
<meta property="article:tag"            content="analytics" />
<meta property="article:tag"            content="datavisualization" />
<meta property="article:tag"            content="bigdataunit" />
<meta property="article:tag"            content="visualization" />
<meta property="article:tag"            content="mobilesubscribers" />
<meta property="article:tag"            content="mobilecompanies" />
<meta property="article:tag"            content="ranking" />
<meta property="article:tag"            content="telecomunication" />


<link rel="icon" type="image/x-icon" href="../favicon.ico">

{{ super() }}

{%- endblock html_head -%}


{% block body_header %}
<body>

<div class="container">
  <nav class="navbar navbar-default">
    <div class="container-fluid">
```

```
      <ul class="nav nav-pills  navbar-left">
        <li role="presentation">
          <a href="/">
            <svg xmlns="http://www.w3.org/2000/svg"
                 viewBox="0 0 576 512" width="1em">
              <path
                fill="#999999"
d="M 288,0 574,288 511,288 511,511 352,511 352,352 223,352 223,511 62,511␣
 ↪64,288 0,288 Z"
              />
            </svg> Home
          </a>
        </li>
      </ul>
      <ul class="nav nav-pills  navbar-right">
        <li role="presentation" class="active">
          <a href="/mobile_subscribers_Georgia/">□ English </a>
        </li>
        <li role="presentation">
          <a href="/mobile_subscribers_Georgia/ka/">□     </a>
        </li>
      </ul>
    </div>
  </nav>
</div>



  <div tabindex="-1" id="notebook" class="border-box-sizing">
    <div class="container" id="notebook-container">
{% endblock body_header %}

{% block body_footer %}
    </div>
  </div>
  <footer>
    <div class="container"
         style="display:flex; flex-direction: row; justify-content: center;␣
 ↪align-items: center;">
      <p style="margin: 3.7em auto;"> © 2022
        <a href="https://github.com/sentinel-1" target="_blank">Sentinel-1</a>
      </p>
      <!-- TOP.GE ASYNC COUNTER CODE -->
      <div id="top-ge-counter-container" data-site-id="116052"
           style="margin-right: 3.7em;float: right;"></div>
      <script async src="//counter.top.ge/counter.js"></script>
      <!-- / END OF TOP.GE COUNTER CODE -->
      <!-- ANALYTICS.LAGOGAL.COM -->
      <div id="analytics-lagogal-com-access" data-site-id="20221"
           style="margin: 0;padding: 0;"></div>
      <script async src="//analytics.lagogal.com/access.js"></script>
      <!-- / END OF ANALYTICS.LAGOGAL.COM -->
     </div>
  </footer>
</body>
{% endblock body_footer %}
```