ASA (Atractiveness Score Analysis)

May 24, 2022

1 Top Mobile Communication Companies in Georgia 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.

[1]:
```
from datetime import datetime, timedelta
nb_st = datetime.utcnow()
print(f"\nNotebook START time: {nb_st} UTC\n")
```

```
Notebook START time: 2022-05-23 22:05:24.270398 UTC
```

1.1 Index

[2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from IPython.display import display
sns.set_theme()
```

2 Data

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

2.1 Import the data

[3]:
```
def import_data_en(excel_path):
    df = pd.read_excel(excel_path).sort_values("Month",ascending=True).
 ↪reset_index(drop=True)
    # English version of 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 accordingly:
    df.rename({'Subscribers': 'CompanySubscribers'}, axis=1, inplace=True)
    return df
```

[4]:
```
# Import data from 'data/EN/all.xlsx', 'data/EN/legal_entities.xlsx' and 'data/
↪EN/natural_persons.xlsx' files:
all_df, legal_entities_df, natural_persons_df = import_data_en('data/EN/all.
↪xlsx'), import_data_en('data/EN/legal_entities.xlsx'), import_data_en('data/
↪EN/natural_persons.xlsx')
all_df.head()
```

[4]:

	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

2.2 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).

2.3 Interval of time covered by the given data

[5]:
```
start_month, end_month = all_df['Month'].min(), all_df['Month'].max()

print("\nGiven data covers the interval of time "
      f"from {start_month.month_name()} {start_month.year} "
      f"to {end_month.month_name()} {end_month.year} (inclusive).\n")
```

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

2.4 Mobile Companies operationg in Georgia

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

[6]:
```
display(all_df['Company'].value_counts().reset_index().rename({"Company":␣
↪"Active Months", "index": "Company"}, axis=1))
```

	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
```

[7]:
```
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')]
```

2.5 Date of merger of the Silknet and Geocell

[8]:
```
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):
    return df.
 ↪loc[(df['Month']==Geocell_last_month)&(df['Company']=='Silknet'),'CompanySubscribers'].
 ↪item()

def get_Silknet_Geocell_merger_subscribers(df):
    return df.
 ↪loc[(df['Month']==Silknet_Geocell_merger_month)&(df['Company']=='Silknet'),'CompanySubscrib
 ↪item()
```

```
print(f'\n{Silknet_Geocell_merger_month.month_name()}␣
 ↪{Silknet_Geocell_merger_month.year} is the date of Merger of the Silknet and␣
 ↪Geocell.\n')
```

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

2.6 Date of COVID-19 Start

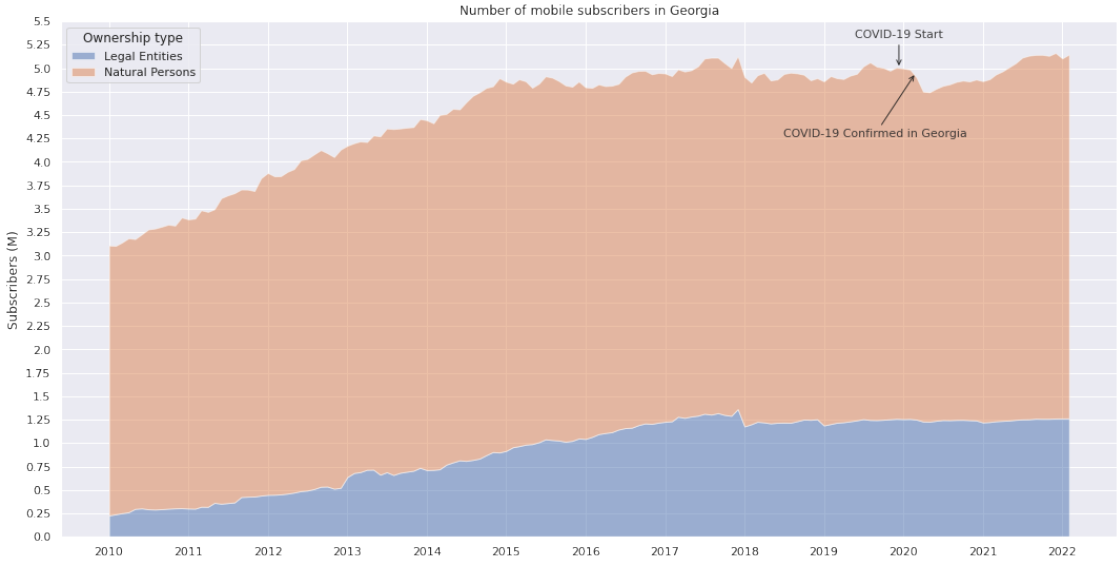
[9]:
```
# December 12, 2019:
# A cluster of patients in Wuhan, Hubei Providence, China begin to experience␣
 ↪shortness of breath and fever.
COVID19_start_date = pd.Timestamp(year=2019, month=12, day=12)

# February 26, 2020:
# Georgia oficially 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, date):
    observed_date_before = df.loc[(df['Month'] <= date), 'Month'].tail(1).
 ↪item()  # FIXME ignoring edge cases
    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\n -␣
 ↪{COVID19_start_date_Georgia:%B %d, %Y}: Georiga")
```

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

3 Total number of subscribers

[10]:
```
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)
)
```

[11]:
```
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)
```

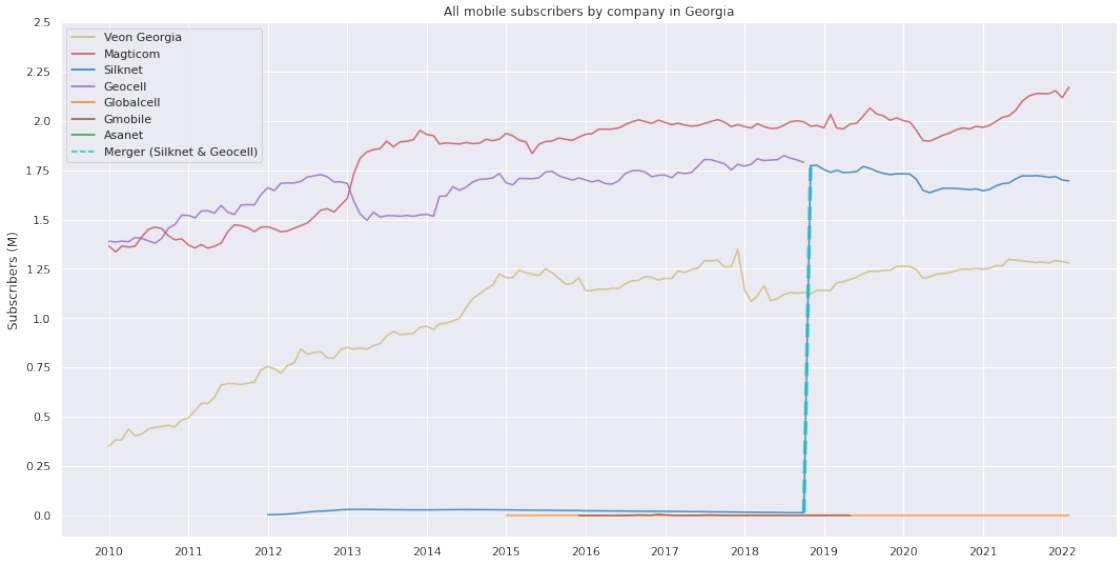


4 Number of subscribers by company

4.1 All subscribers

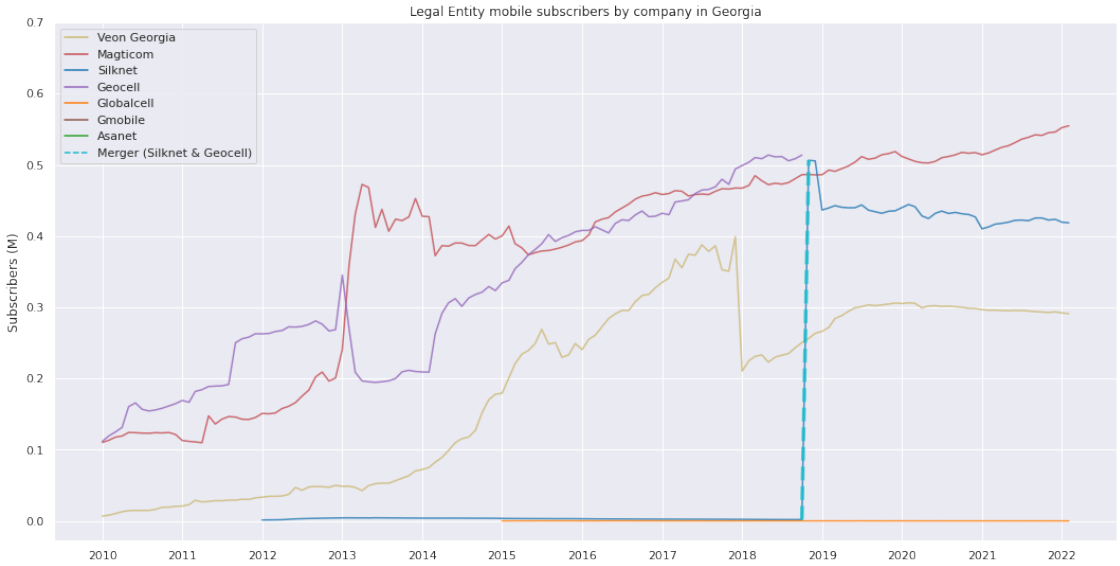
[12]:
```
def plot_number_of_subscribers_by_company(df, title, yticks_range=np.arange(0,2.
↪75,0.25)):
    companies = [company for company in company_name_list if company in␣
↪df['Company'].unique()]
    company_color_palette=[company_colors[company] for company in␣
↪company_name_list if company in 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")
```



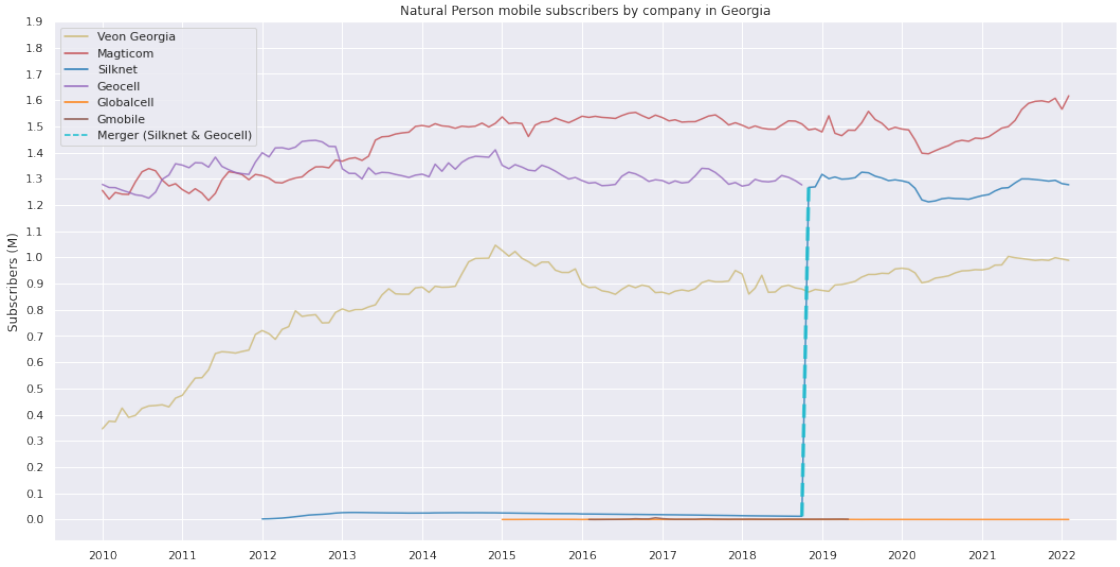
4.2 Legal Entity subscribers

[13]:
```
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))
```



4.3 Natural Person subscribers

[14]:
```
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))
```

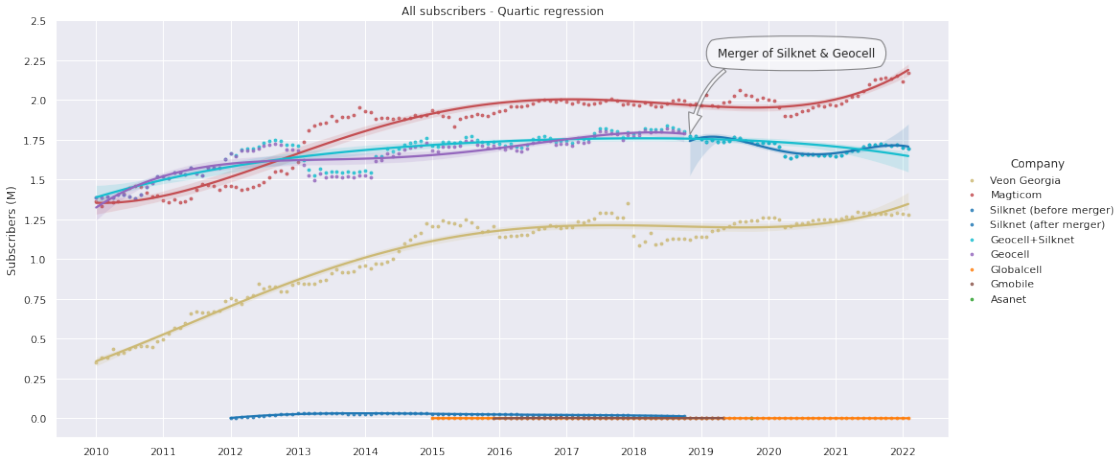


5 Trend of number of sybscribers by company

5.1 All subscribers trend

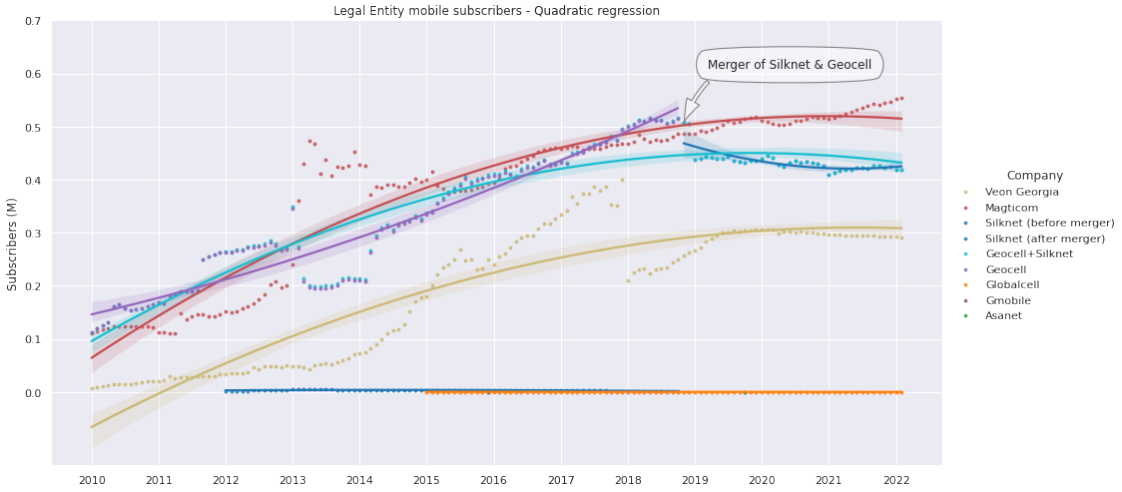
[15]:
```
def plot_trend_by_company_regression(subscribers_df, title, yticks_range=np.
↪arange(0,2.75,0.25), merger_v_offset=5.2e5, regression_order=4):
    companies = [company for company in company_name_list if company in␣
↪subscribers_df['Company'].unique()]
    company_color_palette=[company_colors[company] 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)
```



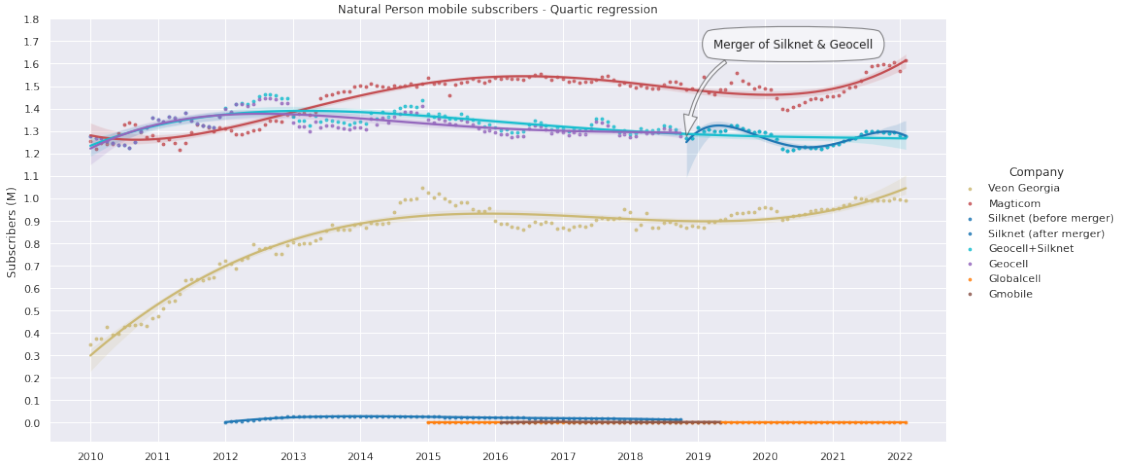
5.2 Legal Entity subscribers trend

[16]:
```
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)
```



5.3 Natural Person subscribers trend

[17]:
```
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)
```



6 Performance of Companies

[18]:
```
def get_total_subscribers_df(df):
    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):
    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  # extreme outlier & it is an effect of␣
 ↪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
```

[19]:
```
print("\nDescriptive statistics of monthly changes in number of All Subscribers:
↪\n")
with pd.option_context('display.float_format', '{:0.2f}'.format):
    ␣
↪display(compute_subscriber_and_market_features(all_df)[['MarketSubscribersDelta','CompanySu
↪describe())
```

```
Descriptive statistics of monthly changes in 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

[20]:
```
print("\nDescriptive statistics of monthly changes in 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'
↪describe())
```

```
Descriptive statistics of monthly changes in 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

[21]:
```
print("\nDescriptive statistics of monthly changes in 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
↪describe())
```

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

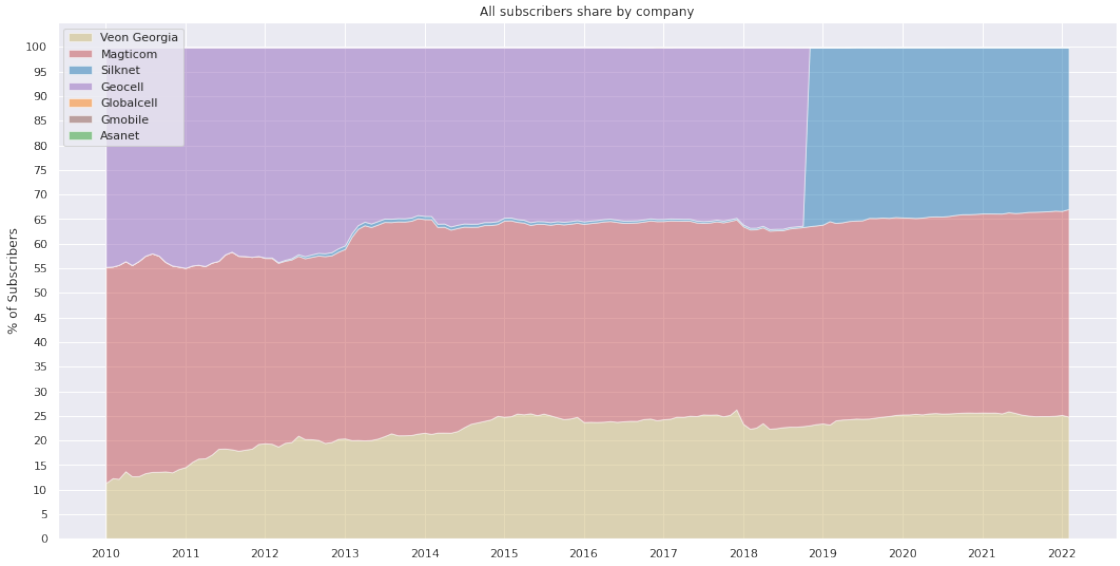
	MarketSubscribersDelta	CompanySubscribersDelta
count	646.00	646.00
mean	4840.02	1584.16
std	41158.06	16627.51
min	-132445.00	-84790.00
25%	-23975.50	-3381.00
50%	4341.00	-1.00
75%	32419.00	5354.75
max	127319.00	61788.00

7 Share Of Subscribers by company

7.1 All subscribers share

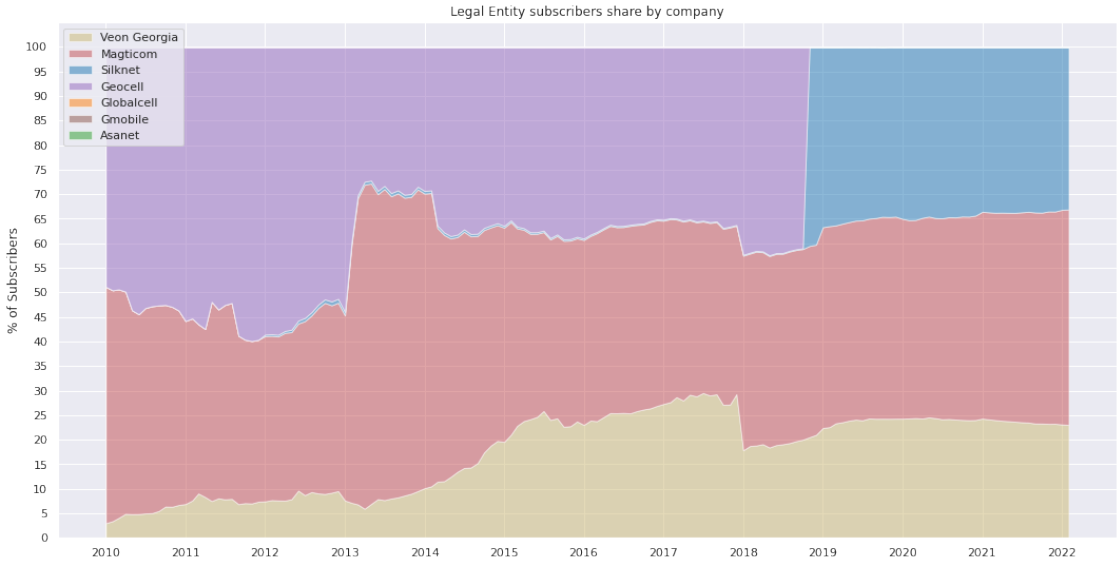
[22]:
```
def plot_market_share_of_companies(df, title):
    df = compute_subscriber_and_market_features(df)

    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")
```



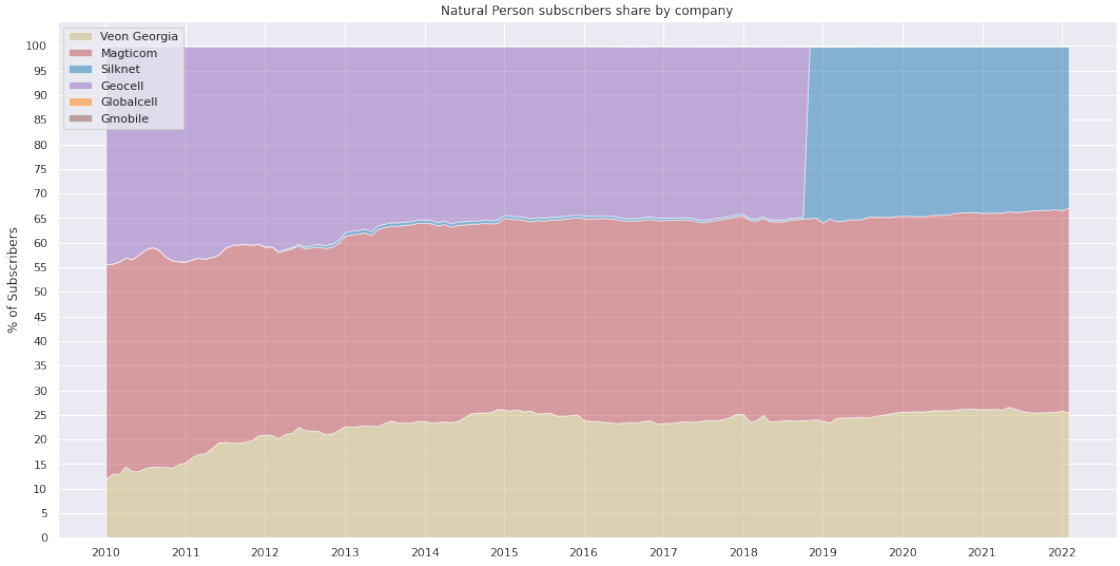
7.2 Legal Entity subscribers share

[23]:
```
plot_market_share_of_companies(legal_entities_df, "Legal Entity subscribers␣
 ↪share by company")
```



7.3 Natural Person subscribers share

[24]:
```
plot_market_share_of_companies(natural_persons_df, "Natural Person subscribers␣
↪share by company")
```



8 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.

[25]:
```
def compute_attractiveness_score(df):
    return compute_subscriber_and_market_features(df).assign(
        AttractivenessScore = lambda df:df['CompanySubscribersDelta'] - (0.
 ↪5*(df['CompanySubscribersShareOld'] + df['CompanySubscribersShare']) *␣
 ↪df['MarketSubscribersDelta'])
    )
```

9 Monthly Attractiveness Scores of Companies

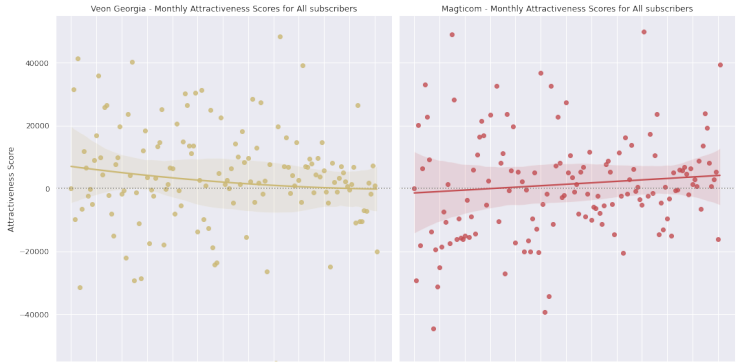
9.1 Monthly Scores for All subscribers

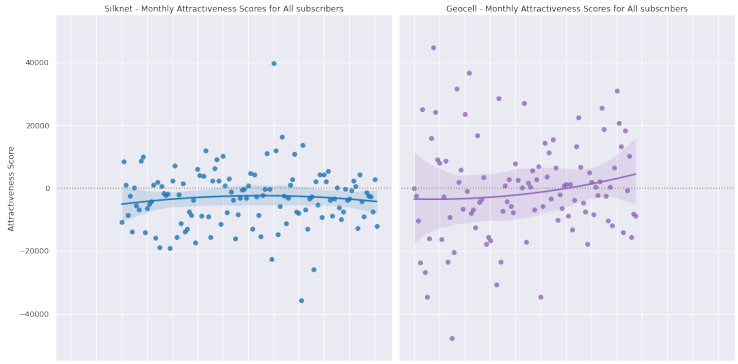
[26]:
```
display(compute_attractiveness_score(all_df)['AttractivenessScore'].describe())
```

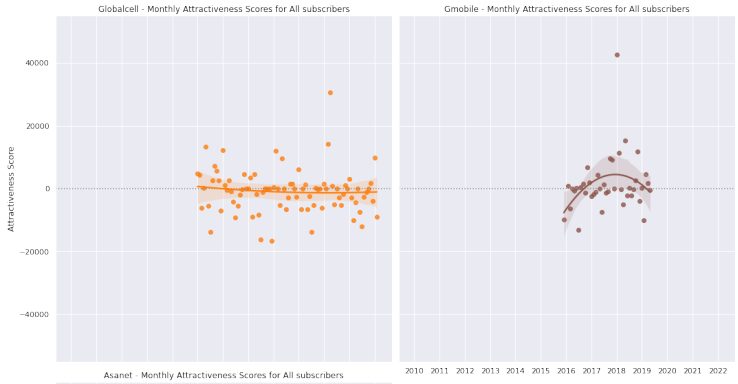
```
count       648.000000
mean         90.636727
std       18255.137182
min     -176201.147065
25%       -7301.075624
50%         -20.258358
75%        6489.583900
max      120434.423264
Name: AttractivenessScore, dtype: float64
```

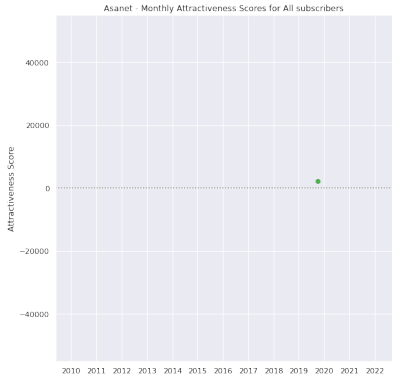
[27]:
```
def plot_attractiveness_score_of_companies(df, title):
    df = df.assign(MonthNum=lambda df:df['Month'].astype(int),Year=lambda df:[x.
 ↪year for x in df['Month']])
    df = compute_attractiveness_score(df)

    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]
```

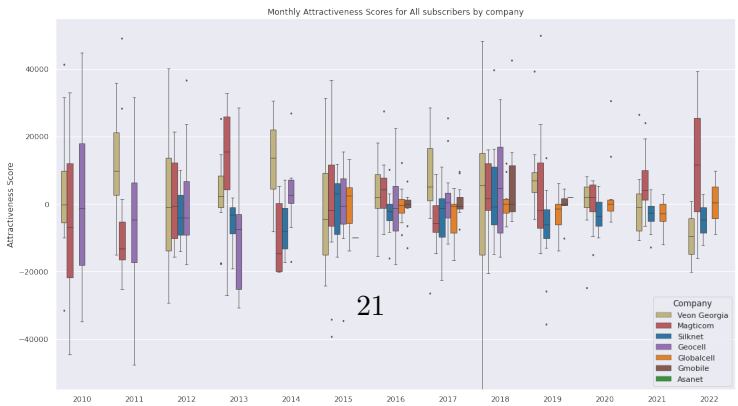
```
    grid = sns.FacetGrid(df, col="Company", hue="Company", col_order=companies,␣
 ↪hue_order=companies, palette=company_color_palette,
                         col_wrap=2, height=7.5)
    grid.refline(y=0, linestyle=":")  # Draw a horizontal line at zero
    grid.map(sns.regplot, 'MonthNum', 'AttractivenessScore', 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)
    )
    grid.fig.tight_layout(w_pad=1)
    grid.figure.add_axes([0.075, -0.27, 0.915, 0.25])  # Add additional axis to␣
 ↪plot boxplot in the end
    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
Attractiveness Score
40000
20000
0
−20000
−40000


Silknet - Monthly Attractiveness Scores for All subscribers
Geocell - Monthly Attractiveness Scores for All subscribers
Attractiveness Score
40000
20000
0
−20000
−40000


Globalcell - Monthly Attractiveness Scores for All subscribers
Gmobile - 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


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

9.2 Monthly Scores for Legal Entity subscribers

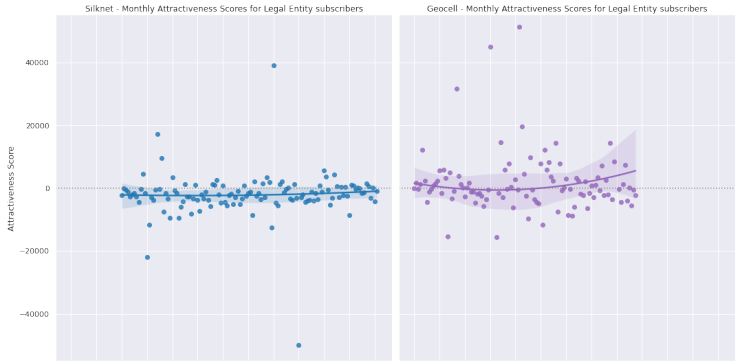
[28]:
```
display(compute_attractiveness_score(legal_entities_df)['AttractivenessScore'].
↪describe())
```

```
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
```

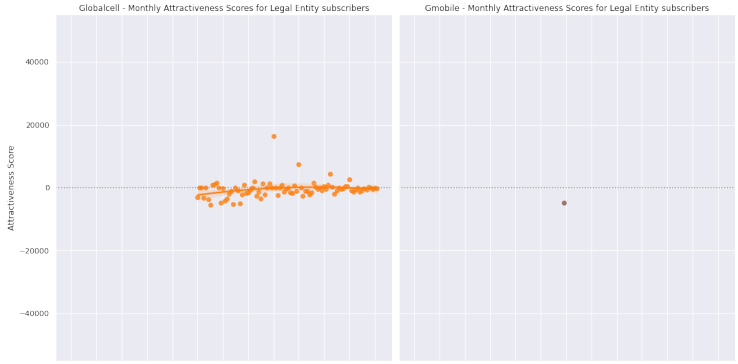
[29]:
```
plot_attractiveness_score_of_companies(legal_entities_df, "Monthly␣
↪Attractiveness Scores for Legal Entity subscribers")
```


Veon Georgia - Monthly Attractiveness Scores for Legal Entity subscribers
Attractiveness Score
40000
20000
0
−20000
−40000

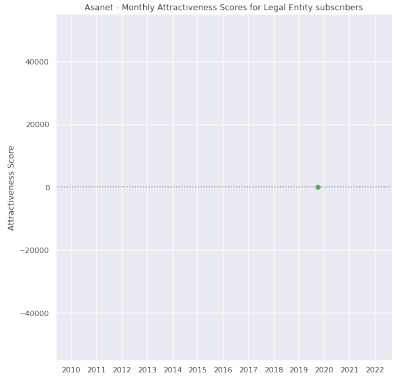
Magticom - Monthly Attractiveness Scores for Legal Entity subscribers

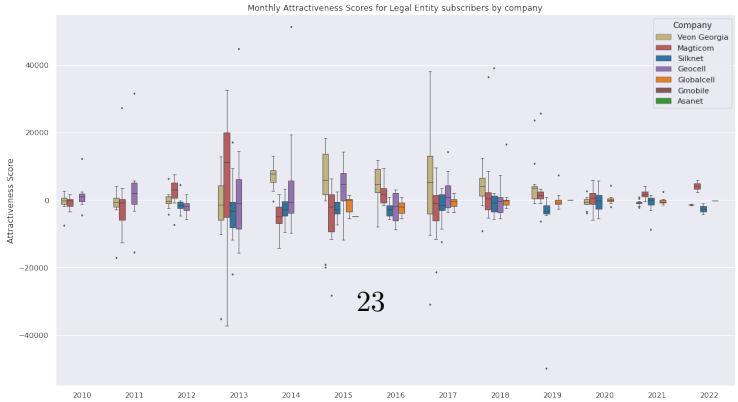

Silknet - Monthly Attractiveness Scores for Legal Entity subscribers
Attractiveness Score
40000
20000
0
−20000
−40000

Geocell - Monthly Attractiveness Scores for Legal Entity subscribers


Globalcell - Monthly Attractiveness Scores for Legal Entity subscribers
Attractiveness Score
40000
20000
0
−20000
−40000

Gmobile - Monthly Attractiveness Scores for Legal Entity subscribers
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022


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

9.3 Monthly Scores for Natural Person subscribers

[30]:
```
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
```

[31]:
```
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
Company
Veon Georgia
Magticom
Silknet
Geocell
Globalcell
Gmobile

10 Yearly Attractiveness Scores of Companies

10.1 Yearly Scores for All subscribers

[32]:
```
def get_top_3_companies_per_year(df):
    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)
          .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, title):
    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)


title = "Yearly Attractiveness Scores of companies for All subscribers"
print(f'\n{title}:\n')
display(get_top_3_companies_per_year(all_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	Asanet	Magticom	100520.205002	
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	2197.154207	1197.475701
2020	4339.903478	3196.041334
2021	-3725.224280	-36470.176832

```
2022      854.293360  -9328.489339
```

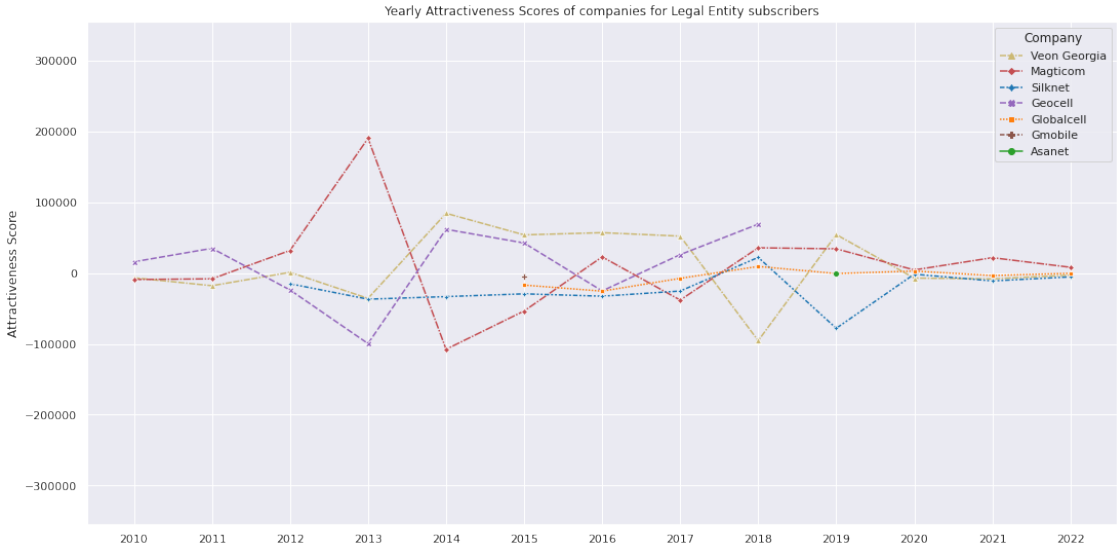
10.2 Yearly Scores for Legal Entity subscribers

[33]:
```
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	Gmobile	54016.232382
2016	Veon Georgia	Magticom	Geocell	57131.393478
2017	Veon Georgia	Geocell	Globalcell	52236.986105
2018	Geocell	Magticom	Silknet	69153.218138
2019	Veon Georgia	Magticom	Asanet	54390.024447
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   42566.644955  -4849.277917
2016   22946.183006 -25146.310677
2017   26132.037937  -7363.107595
2018   35778.728272  22243.376309
2019   34327.040916     -0.456368
2020    2923.260004  -1441.009696
2021   -3386.336872  -8133.935355
2022    -247.091267  -2759.755264
```



10.3 Yearly Scores for Natural Person subscribers

[34]:
```
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	Gmobile	54016.232382
2016	Veon Georgia	Magticom	Geocell	57131.393478
2017	Veon Georgia	Geocell	Globalcell	52236.986105
2018	Geocell	Magticom	Silknet	69153.218138
2019	Veon Georgia	Magticom	Asanet	54390.024447
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	42566.644955	-4849.277917
2016	22946.183006	-25146.310677
2017	26132.037937	-7363.107595
2018	35778.728272	22243.376309
2019	34327.040916	-0.456368
2020	2923.260004	-1441.009696
2021	-3386.336872	-8133.935355
2022	-247.091267	-2759.755264

11 Top Companies by Attractiveness Score

[35]:
```
def get_top_companies_per_year(df, name):
    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):
    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 months:[months[0],months[-1]] if␣
 ↪len(months) > 1 else months)(
                        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 {top_companies_df.loc["January - December"].
 ↪index.min()}'
          f' - {top_companies_df.loc["January - December"].index.max()} years '
          f'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.
```

[36]:
```
print(f"\n ** Total Elapsed time: {datetime.utcnow() - nb_st} ** \n")
print(f"Notebook END time: {datetime.utcnow()} UTC\n")
```

```
 ** Total Elapsed time: 0:00:16.136020 **

Notebook END time: 2022-05-23 22:05:40.406569 UTC
```

This notebook is originally published under the Apache License (Version 2.0) at the following GitHub repository: sentinel-1/mobile_subscribers_Georgia

For the issues, feedback or suggestions regarding the original notebook (if any) feel free to open an issue at the corresponding Issues page of the repository

[ ]: