Strategy Bonus

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Task:

Вот вам ещё одна задача на +1 (+2 за крутое исполнение) по прошлой лекции. Надо пойти на яндекс-маркет (или в подобное аналогичное место), выбрать какой-нибудь популярный товар (телефон, стиральная машина, да почти что угодно) и посмотреть разброс цен на него (за строго один и то же товар!). В идеале - выгрузить распределения цен по нескольким товарам и погонять анализом данных. А потом придумать стилизованную модель конкуренции, объясняющую это безобразие.

As the data for our analysis, we download the prices of different cereal brands traded in several European markets in the period from 2013 to 2021. The source:

https://data.europa.eu/data/datasets/cereal_prices?locale=en (https://data.europa.eu/data/datasets/cereal_prices?locale=en)

Code preparation

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
plt.style.use("fivethirtyeight")
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
path_file = "Cereals Prices.csv"
df_raw = pd.read_csv(path_file)
```

In [3]:
```
df_raw.head(5)
```

Out[3]:

	Sector Code	Member State Code	Product Group Name	Product Name	Market Name	Product Stage Name	Weight Unit Name	Week - Begin Date	Week - End Date	EU Price
0	NaN	CZ	Barley	Malting barley	Brno	Delivered to processor after one intermediary ...	Tonnes	2013-06-10 00:00:00.000000	2013-06-16 00:00:00.000000	€224.32
1	NaN	CZ	Barley	Malting barley	Brno	Delivered to processor after one intermediary ...	Tonnes	2013-06-17 00:00:00.000000	2013-06-23 00:00:00.000000	€216.72
2	NaN	CZ	Barley	Malting barley	Brno	Delivered to processor after one intermediary ...	Tonnes	2013-07-01 00:00:00.000000	2013-07-07 00:00:00.000000	€214.74
3	NaN	CZ	Barley	Malting barley	Brno	Delivered to processor after one intermediary ...	Tonnes	2013-07-15 00:00:00.000000	2013-07-21 00:00:00.000000	€194.35
4	NaN	CZ	Barley	Malting barley	Brno	Delivered to processor after one intermediary ...	Tonnes	2013-07-29 00:00:00.000000	2013-08-04 00:00:00.000000	€208.54

Transforming and cleaning the dataframe.

In [4]:
```
df = df_raw[['Product Name', 'Market Name', 'Product Group Name', 'EU Price', 'Week - Begin Date', 'Week
df['EU Price'] = df['EU Price'].apply(lambda x: float(x.replace('€','')))
df['Week - Begin Date'] = df['Week - Begin Date'].apply(pd.to_datetime)
df['Week - End Date'] = df['Week - End Date'].apply(pd.to_datetime)
df['month'] = pd.DatetimeIndex(df['Week - Begin Date']).month
df = df.sort_values(by="Week - Begin Date")
df.index = df['Week - Begin Date']
df = df.rename(columns={"EU Price": "Price"})
df.head(4)
```

Out[4]:

Week - Begin Date	Product Name	Market Name	Product Group Name	Price	Week - Begin Date	Week - End Date	month
2009-11-16	Feed barley	Burgas	Barley	92.03	2009-11-16	2009-11-22	11
2009-11-16	Milling wheat	Dobrich	Soft wheat	99.70	2009-11-16	2009-11-22	11
2009-11-16	Feed wheat	Dobrich	Soft wheat	92.03	2009-11-16	2009-11-22	11
2009-11-16	Maize	Pleven	Maize	94.59	2009-11-16	2009-11-22	11

First things first, in a chaotic manner, we conduct data analysis.

Data Analysis

Let's look at the frequency of entities for each market.

In [5]:
```
1 df[['Market Name']].value_counts()
```

Out[5]:
```
Market Name
Zachodni                      2954
Vilnius                       2117
Hamburg                       1950
Bologna                       1517
Naantali                      1284
Bratislava                    1279
Slaski                        1251
Lisboa                        1214
Rotterdam                     1177
Antwerpen                      992
Oltenia                        943
Rouen                          923
Dobrich                        898
Ljubljana                      880
Zagreb Depsilo                 858
Kujawsko-Mazurski              843
Wien                           797
UK Average                     796
Praha (Delivered)              721
Constanta                      693
Budapest                       692
Dublin/North East/Midlands     692
Creil                          624
Banat                          556
Pleven                         554
Riga                           525
Muntenia                       475
Burgas                         453
Burgos                         445
Seinäjoki                      443
Valladolid                     440
Wels                           407
Brussel - Bruxelles            387
Leon                           384
La Pallice                     372
Navarra                        364
Sevilla                        360
Jelgava                        351
East Coast                     330
Bordeaux                       314
Serres                         272
Södra Sverige                  268
Thessaloniki                   230
Eure-et-Loir                   187
Larnaca                        138
Brno                           136
Lemesos                        117
National average               112
Talli                           85
dtype: int64
```

As we can see, Zachodni is the most occurring market in the dataframe.

If we look at the summary table corresponding to each brand, we can see that Durum Wheat is the most expensive and most volatile cereal brand among all considered. The least expensive is Rye as its mean and median prices are the lowest. Although Barley had a moderate price, it saw the greatest increase in price over the period.

In [6]:
```
max_min = lambda x: (x[-1] - x[0])/x[0]
max_min.__name__ = 'growth'
df.groupby('Product Group Name').agg({"Price": [np.min, np.max, np.mean, np.median, np.std, max_min] }).
```

Out[6]:

	Price					
	amin	amax	mean	median	std	growth
Product Group Name						
Barley	75.19	330.00	165.62	164.00	31.01	2.37
Durum wheat	188.00	545.00	270.04	250.00	71.51	1.12
Maize	94.59	294.00	169.31	165.88	31.75	1.79
Oats	71.47	300.00	147.42	140.00	32.56	1.19
Rye	51.10	281.00	143.60	137.41	29.44	0.74
Soft wheat	72.74	332.00	173.86	170.00	29.35	1.23
Triticale	196.89	261.53	228.31	224.76	25.67	0.33

From the next table, we observe not all the brands are presented in all markets. For example, Oats are available only in Antwerpen, Hamburg, Seinäjoki, Vilnius and Zachodni.

In [7]:
```
counts = pd.crosstab(df['Product Group Name'], df['Market Name']).T
counts
```

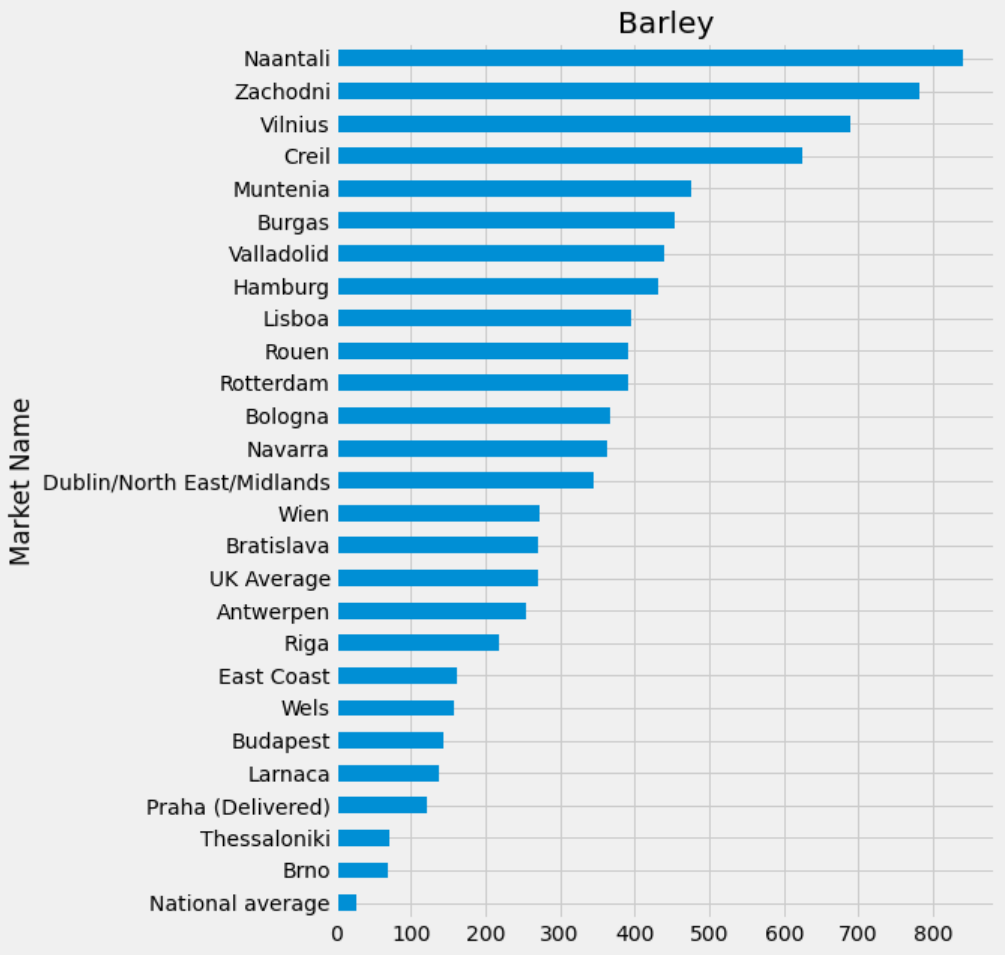
Out[7]:

Market Name	Barley	Durum wheat	Maize	Oats	Rye	Soft wheat	Triticale
Antwerpen	254	0	0	236	0	502	0
Banat	0	0	0	0	0	556	0
Bologna	368	374	402	0	0	373	0
Bordeaux	0	0	314	0	0	0	0
Bratislava	271	0	299	0	0	709	0
Brno	69	0	67	0	0	0	0
Brussel - Bruxelles	0	0	387	0	0	0	0
Budapest	144	0	267	0	0	281	0
Burgas	453	0	0	0	0	0	0
Burgos	0	0	0	0	0	445	0
Constanta	0	0	348	0	0	345	0
Creil	624	0	0	0	0	0	0
Dobrich	0	0	0	0	0	898	0
Dublin/North East/Midlands	345	0	0	0	0	347	0
East Coast	162	0	0	0	0	168	0
Eure-et-Loir	0	0	0	0	0	187	0
Hamburg	432	0	148	96	412	862	0
Jelgava	0	0	0	0	0	351	0
Kujawsko-Mazurski	0	0	0	0	0	843	0
La Pallice	0	0	0	0	0	372	0
Larnaca	138	0	0	0	0	0	0
Lemesos	0	117	0	0	0	0	0
Leon	0	0	384	0	0	0	0
Lisboa	396	0	414	0	0	404	0
Ljubljana	0	0	437	0	0	443	0
Muntenia	475	0	0	0	0	0	0
Naantali	840	0	0	0	0	444	0
National average	28	0	14	0	28	28	14
Navarra	364	0	0	0	0	0	0
Oltenia	0	0	520	0	0	423	0
Pleven	0	0	554	0	0	0	0
Praha (Delivered)	122	0	0	0	0	599	0
Riga	218	0	0	0	0	307	0
Rotterdam	392	0	393	0	0	392	0
Rouen	392	0	0	0	0	531	0
Seinäjoki	0	0	0	443	0	0	0
Serres	0	0	272	0	0	0	0
Sevilla	0	360	0	0	0	0	0
Slaski	0	0	407	0	0	844	0
Södra Sverige	0	0	0	0	0	268	0
Talli	0	0	0	0	0	85	0
Thessaloniki	71	76	0	0	0	83	0
UK Average	270	0	0	0	0	526	0
Valladolid	440	0	0	0	0	0	0
Vilnius	689	0	0	308	219	901	0
Wels	157	0	0	0	0	250	0
Wien	272	0	216	0	0	309	0
Zachodni	782	0	416	111	800	845	0

Product Group Name	Barley	Durum wheat	Maize	Oats	Rye	Soft wheat	Triticale
Market Name							
Zagreb Depsilo	0	0	434	0	0	424	0

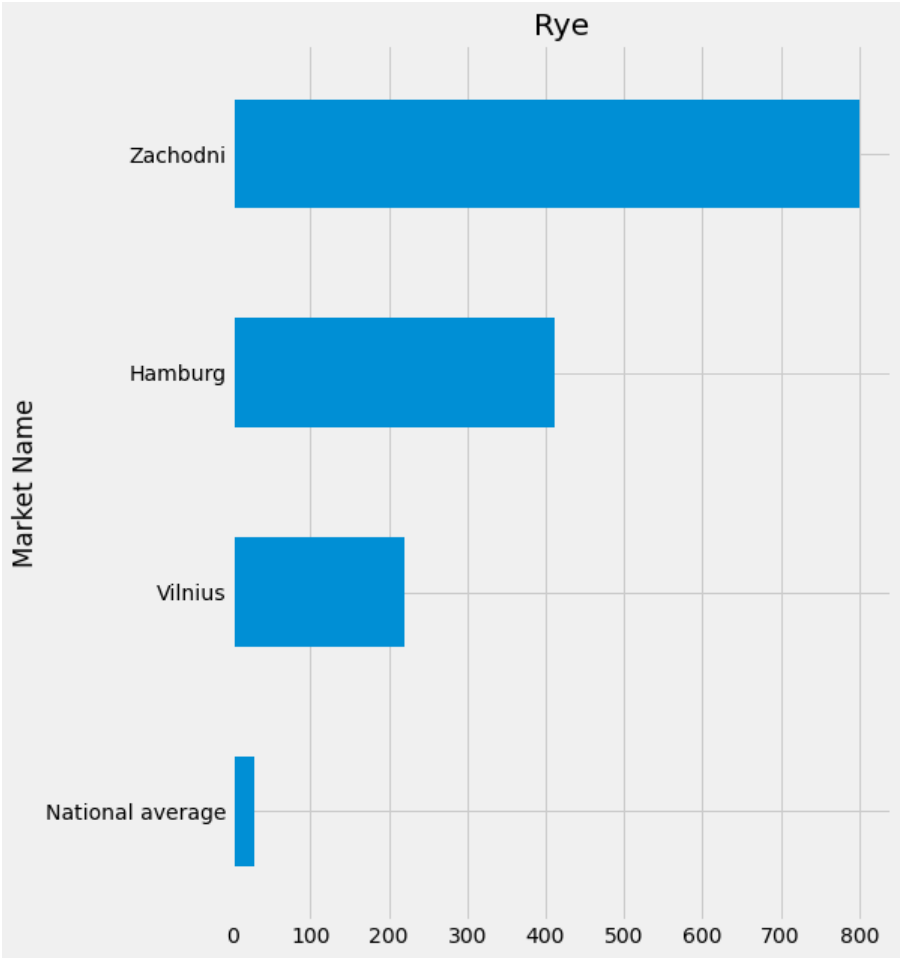
In [8]:

```
1 plt.rcParams["figure.figsize"] = (7,10)
2 counts.Barley[counts.Barley > 0].sort_values().plot(kind='barh');
3 plt.title("Barley");
4 plt.plot();
```



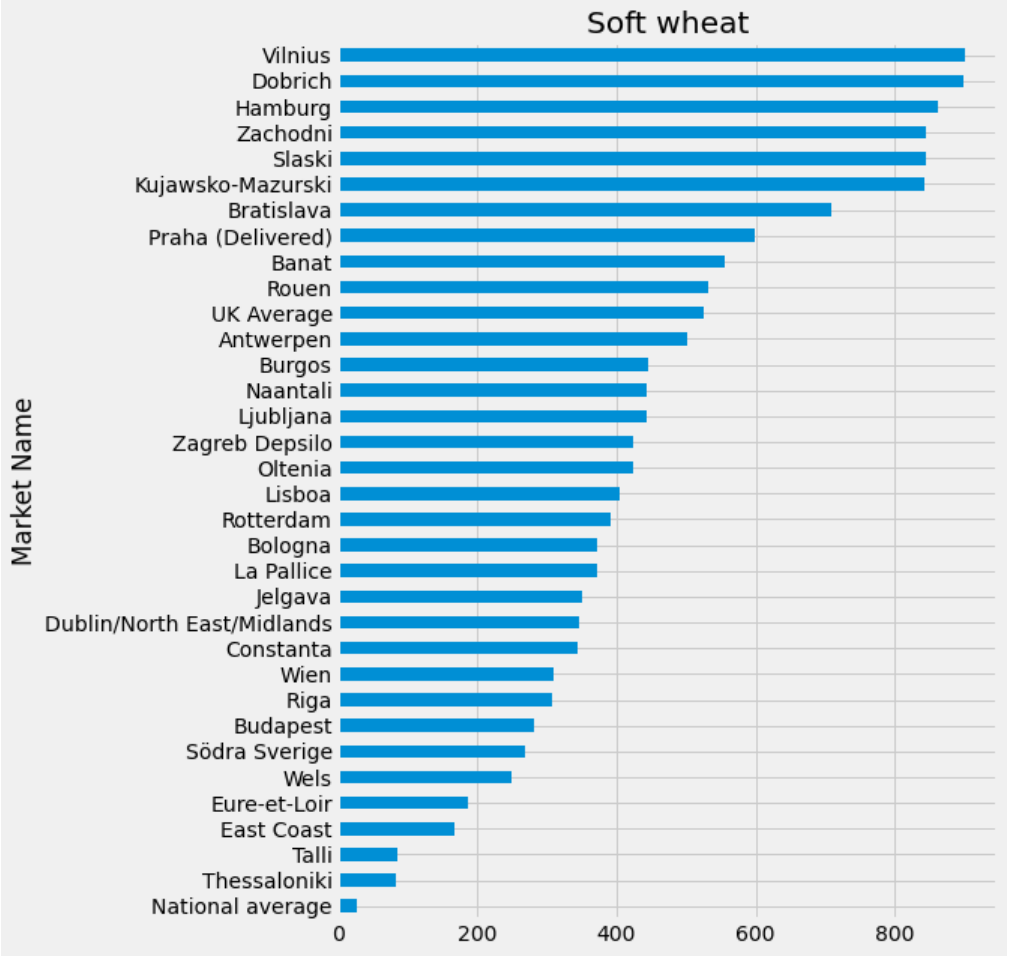
In [9]:

```
plt.rcParams["figure.figsize"] = (7,10)
counts.Rye[counts.Rye > 0].sort_values().plot(kind='barh');
plt.title("Rye");
plt.plot();
```



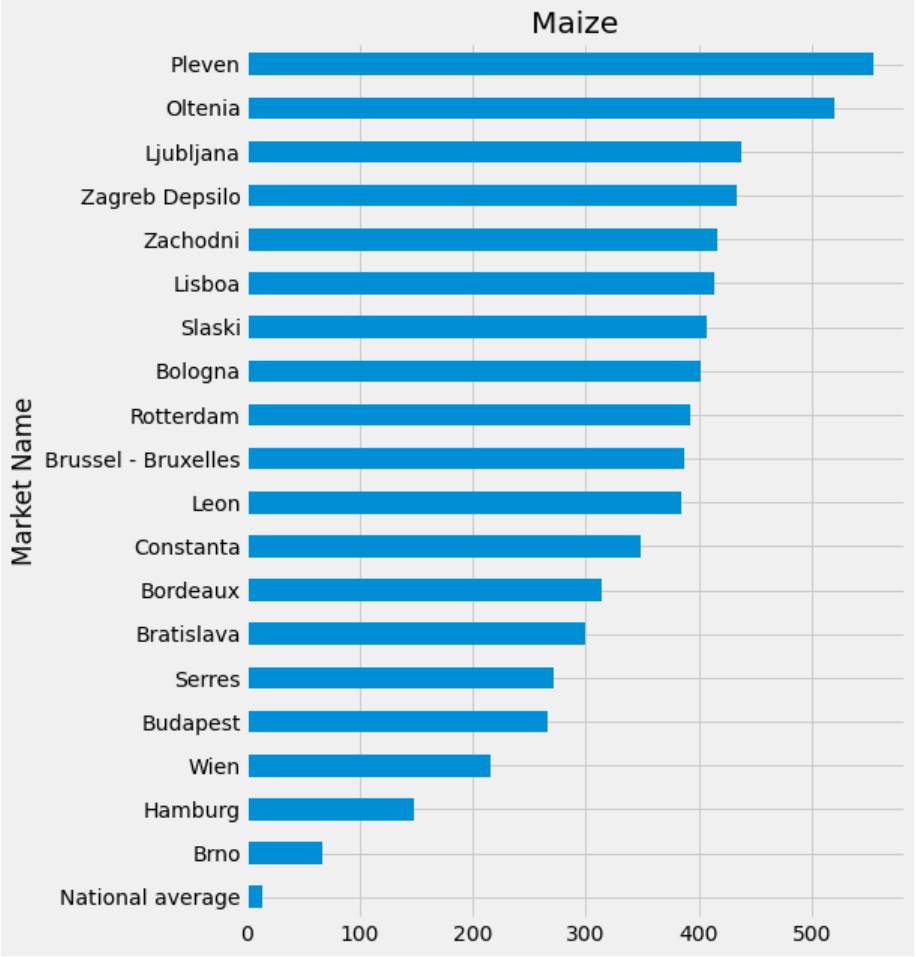
In [10]:

```
plt.rcParams["figure.figsize"] = (7,10)
counts['Soft wheat'][counts['Soft wheat'] > 0].sort_values().plot(kind='barh');
plt.title("Soft wheat");
plt.plot();
```



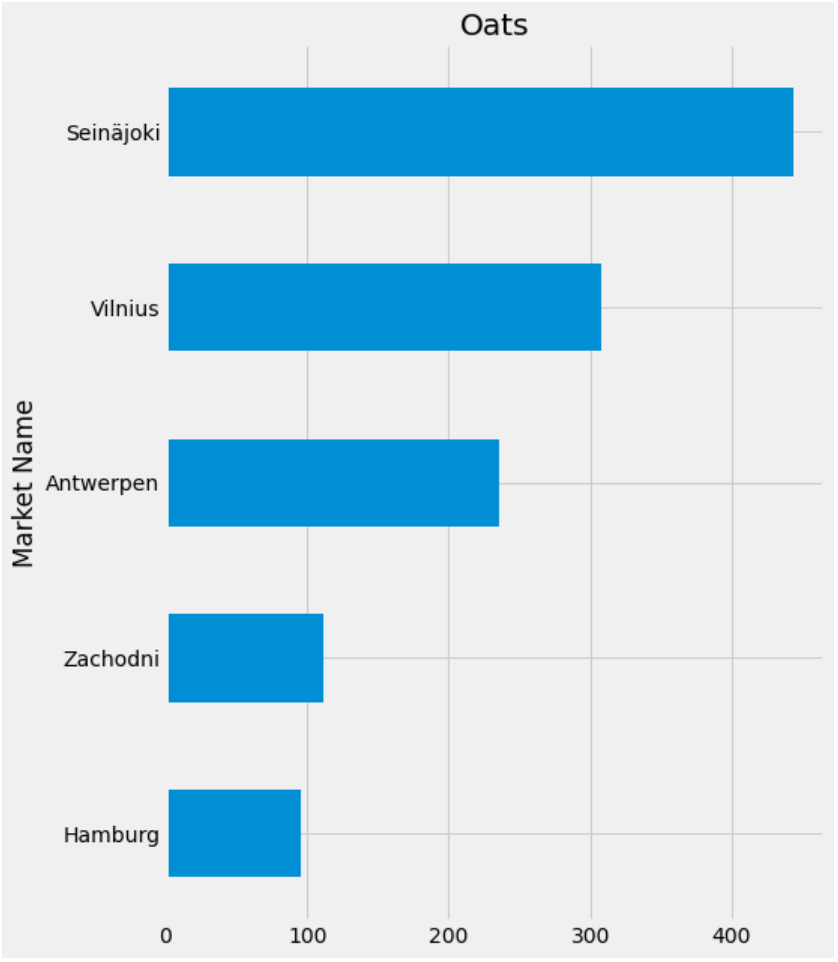
In [11]:

```
plt.rcParams["figure.figsize"] = (7,10)
counts.Maize[counts.Maize > 0].sort_values().plot(kind='barh');
plt.title("Maize");
plt.plot();
```



In [12]:

```
plt.rcParams["figure.figsize"] = (7,10)
counts.Oats[counts.Oats > 0].sort_values().plot(kind='barh');
plt.title("Oats");
plt.plot();
```



The following table shows the mean price for different brands and different markets. Interestingly, each brand placed various prices in each market it operates, but all brands tried to have a similar price within one market (e.g. Budapest market). Is setting a much higher price than competitors leads to market loss?

In [13]:

```
means = pd.crosstab(df['Product Group Name'], df['Market Name'], values=df.Price,  aggfunc='mean',
                    margins=True, margins_name="Total").replace(np.nan, 0).round(0).T
means
```

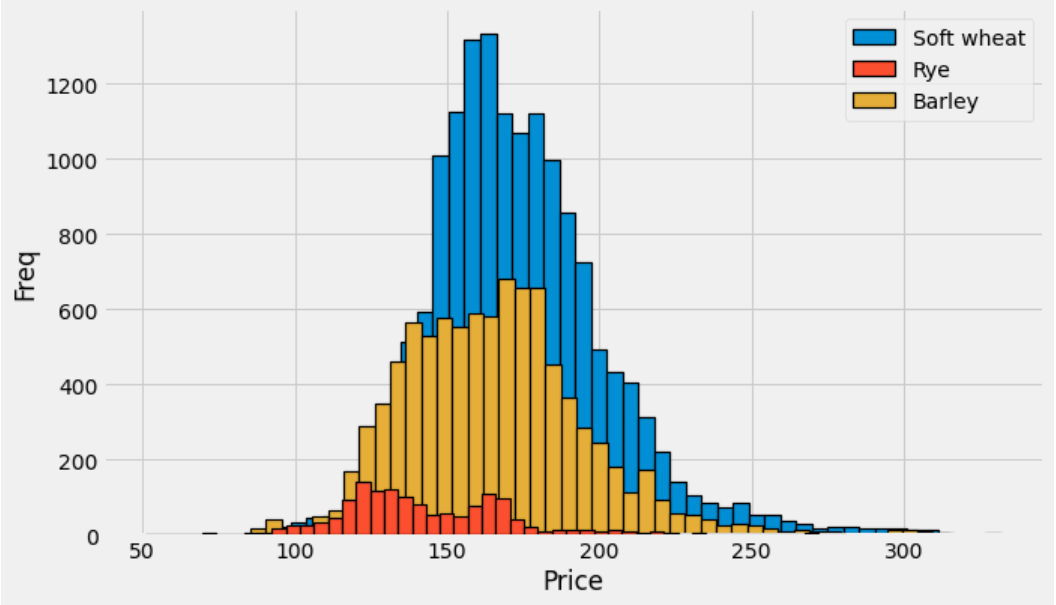
Out[13]:

Product Group Name	Barley	Durum wheat	Maize	Oats	Rye	Soft wheat	Triticale	Total
Market Name								
Antwerpen	168.0	0.0	0.0	177.0	0.0	179.0	0.0	175.0
Banat	0.0	0.0	0.0	0.0	0.0	165.0	0.0	165.0
Bologna	190.0	274.0	189.0	0.0	0.0	202.0	0.0	213.0
Bordeaux	0.0	0.0	170.0	0.0	0.0	0.0	0.0	170.0
Bratislava	128.0	0.0	143.0	0.0	0.0	150.0	0.0	144.0
Brno	177.0	0.0	152.0	0.0	0.0	0.0	0.0	165.0
Brussel - Bruxelles	0.0	0.0	192.0	0.0	0.0	0.0	0.0	192.0
Budapest	143.0	0.0	157.0	0.0	0.0	150.0	0.0	151.0
Burgas	151.0	0.0	0.0	0.0	0.0	0.0	0.0	151.0
Burgos	0.0	0.0	0.0	0.0	0.0	186.0	0.0	186.0
Constanta	0.0	0.0	176.0	0.0	0.0	185.0	0.0	181.0
Creil	179.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0
Dobrich	0.0	0.0	0.0	0.0	0.0	171.0	0.0	171.0
Dublin/North East/Midlands	183.0	0.0	0.0	0.0	0.0	194.0	0.0	188.0
East Coast	150.0	0.0	0.0	0.0	0.0	161.0	0.0	155.0
Eure-et-Loir	0.0	0.0	0.0	0.0	0.0	157.0	0.0	157.0
Hamburg	172.0	0.0	191.0	186.0	170.0	190.0	0.0	182.0
Jelgava	0.0	0.0	0.0	0.0	0.0	149.0	0.0	149.0
Kujawsko-Mazurski	0.0	0.0	0.0	0.0	0.0	170.0	0.0	170.0
La Pallice	0.0	0.0	0.0	0.0	0.0	189.0	0.0	189.0
Larnaca	201.0	0.0	0.0	0.0	0.0	0.0	0.0	201.0
Lemesos	0.0	288.0	0.0	0.0	0.0	0.0	0.0	288.0
Leon	0.0	0.0	187.0	0.0	0.0	0.0	0.0	187.0
Lisboa	193.0	0.0	191.0	0.0	0.0	202.0	0.0	195.0
Ljubljana	0.0	0.0	165.0	0.0	0.0	190.0	0.0	177.0
Muntenia	155.0	0.0	0.0	0.0	0.0	0.0	0.0	155.0
Naantali	152.0	0.0	0.0	0.0	0.0	171.0	0.0	159.0
National average	226.0	0.0	219.0	0.0	210.0	255.0	228.0	229.0
Navarra	184.0	0.0	0.0	0.0	0.0	0.0	0.0	184.0
Oltenia	0.0	0.0	155.0	0.0	0.0	157.0	0.0	156.0
Pleven	0.0	0.0	157.0	0.0	0.0	0.0	0.0	157.0
Praha (Delivered)	136.0	0.0	0.0	0.0	0.0	165.0	0.0	160.0
Riga	144.0	0.0	0.0	0.0	0.0	175.0	0.0	162.0
Rotterdam	180.0	0.0	188.0	0.0	0.0	191.0	0.0	187.0
Rouen	172.0	0.0	0.0	0.0	0.0	186.0	0.0	180.0
Seinäjoki	0.0	0.0	0.0	145.0	0.0	0.0	0.0	145.0
Serres	0.0	0.0	164.0	0.0	0.0	0.0	0.0	164.0
Sevilla	0.0	264.0	0.0	0.0	0.0	0.0	0.0	264.0
Slaski	0.0	0.0	158.0	0.0	0.0	167.0	0.0	164.0
Södra Sverige	0.0	0.0	0.0	0.0	0.0	184.0	0.0	184.0
Talli	0.0	0.0	0.0	0.0	0.0	164.0	0.0	164.0
Thessaloniki	175.0	249.0	0.0	0.0	0.0	175.0	0.0	200.0
UK Average	144.0	0.0	0.0	0.0	0.0	169.0	0.0	160.0
Valladolid	178.0	0.0	0.0	0.0	0.0	0.0	0.0	178.0
Vilnius	159.0	0.0	0.0	124.0	117.0	165.0	0.0	152.0
Wels	155.0	0.0	0.0	0.0	0.0	170.0	0.0	165.0
Wien	146.0	0.0	160.0	0.0	0.0	168.0	0.0	158.0
Zachodni	165.0	0.0	164.0	127.0	135.0	174.0	0.0	158.0

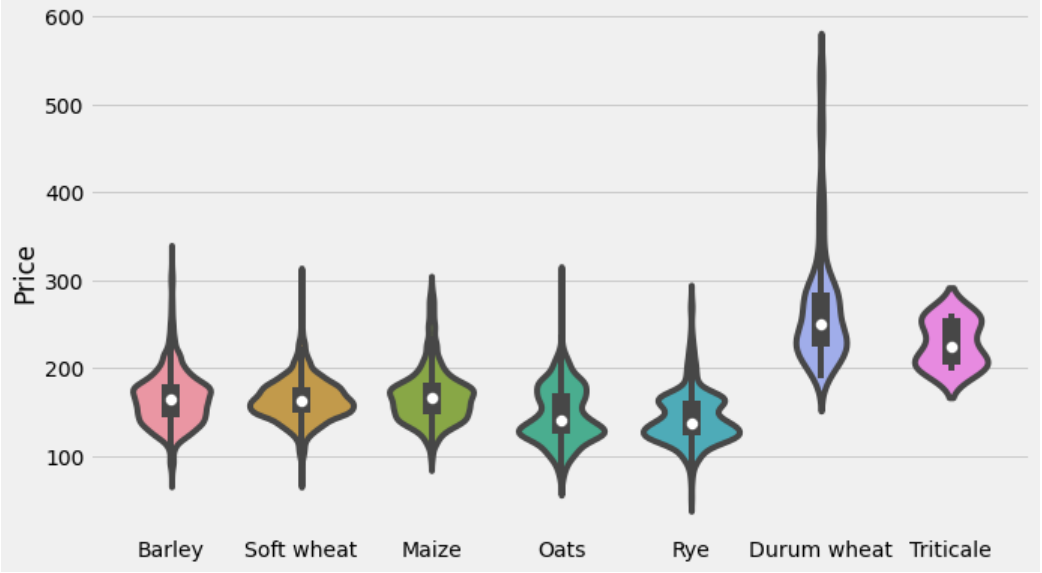
Product Group Name	Barley	Durum wheat	Maize	Oats	Rye	Soft wheat	Triticale	Total
Market Name								
Zagreb Depsilo	0.0	0.0	152.0	0.0	0.0	166.0	0.0	159.0
Total	166.0	270.0	169.0	147.0	144.0	174.0	228.0	171.0

From the following two plots, we start suspecting that the prices for each cereal product fluctuated around its mean throughout the whole period.

In [14]:
```
plt.rcParams["figure.figsize"] = (10,6)
df[df['Product Group Name'] == 'Soft wheat'].Price.hist(edgecolor='black', linewidth=1.2, alpha=1, bins=
df[df['Product Group Name'] == 'Rye'].Price.hist(edgecolor='black', linewidth=1.2, alpha=1, bins=50, zor
df[df['Product Group Name'] == 'Barley'].Price.hist(edgecolor='black', linewidth=1.2, alpha=1, bins=50)
plt.legend(['Soft wheat', 'Rye', 'Barley'])
plt.xlabel('Price')
plt.ylabel('Freq')
plt.plot();
```



In [15]:
```
vildf = pd.DataFrame()
for brand in df['Product Group Name'].unique():
    vildf[brand] = pd.Series(df[df['Product Group Name'] == brand]['Price'].values)
sns.violinplot(data=vildf)
plt.ylabel("Price")
plt.plot();
```

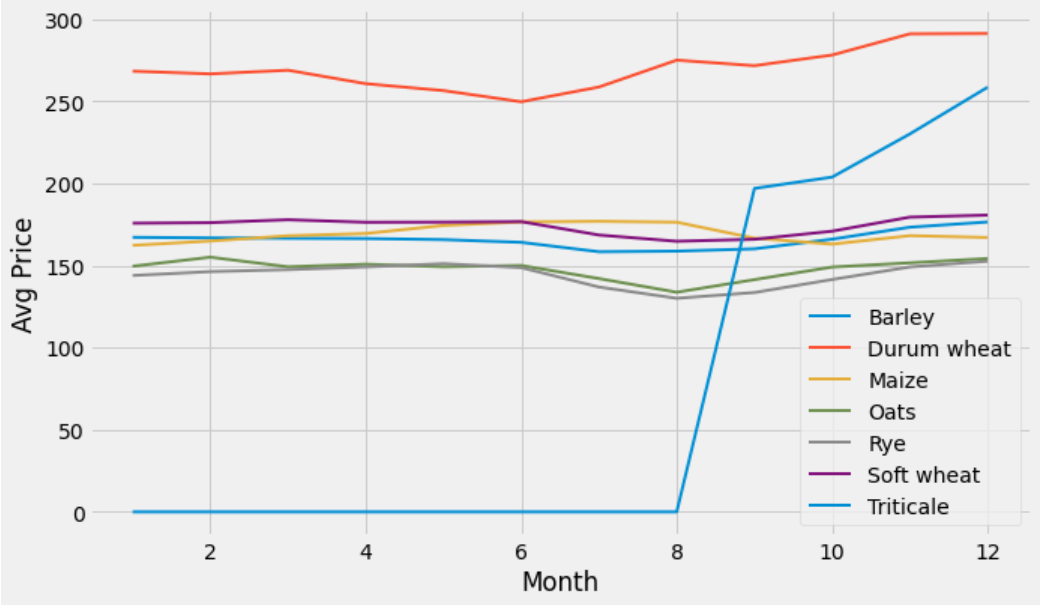


We move further, and now we want to study the presence of seasonality in our data.

The plot below illustrates the mean price of each brand in each month. All in all, the price seems not to depend on the month of sales. The same can be said about total sales.

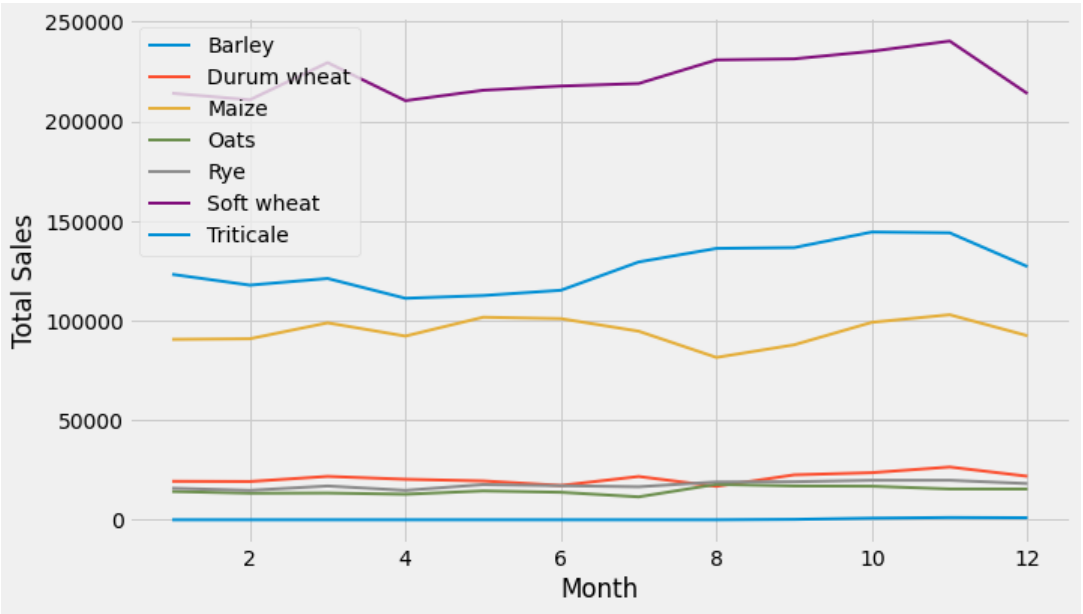
In [16]:

```
plt.rcParams["figure.figsize"] = (10,6)
tab = pd.crosstab(df['month'], df['Product Group Name'], values=df.Price,  aggfunc='mean').round(2).repl
for col in tab.columns:
    tab[col].plot(lw=2)
plt.legend(tab.columns)
plt.xlabel("Month")
plt.ylabel("Avg Price")
plt.show();
```



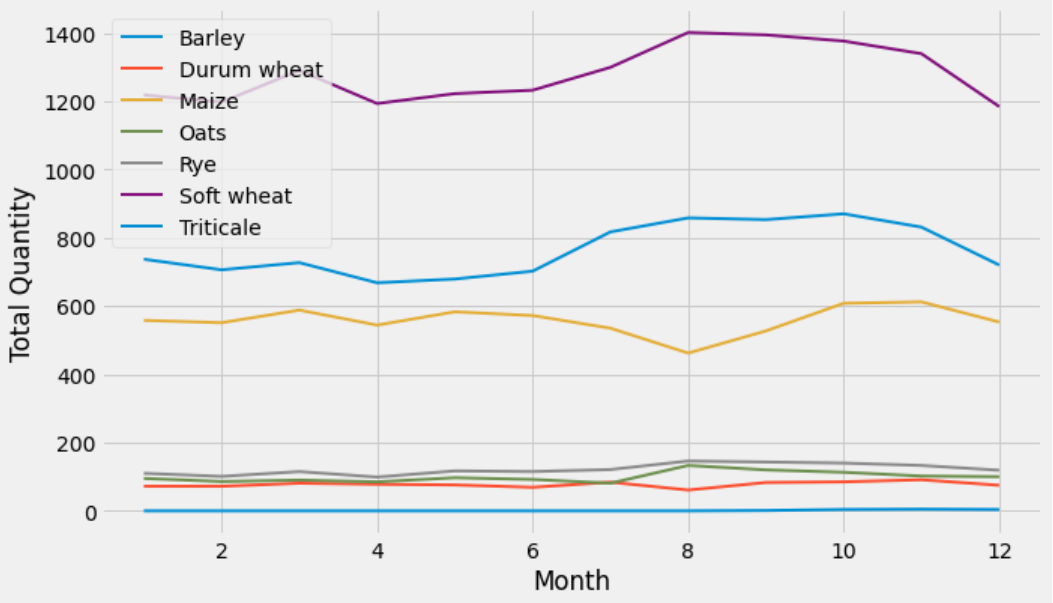
In [17]:

```
plt.rcParams["figure.figsize"] = (10,6)
tab = pd.crosstab(df['month'], df['Product Group Name'], values=df.Price,  aggfunc='sum').round(2).repla
for col in tab.columns:
    tab[col].plot(lw=2)
plt.legend(tab.columns)
plt.xlabel("Month")
plt.ylabel("Total Sales")
plt.show();
```



In [18]:

```
plt.rcParams["figure.figsize"] = (10,6)
tab = pd.crosstab(df['month'], df['Product Group Name'], values=df.Price,  aggfunc='count').round(2).rep
for col in tab.columns:
    tab[col].plot(lw=2)
plt.legend(tab.columns)
plt.xlabel("Month")
plt.ylabel("Total Quantity")
plt.show();
```



Consider Vilnius market

In [19]:

```
df_vil = df[df['Market Name']=='Vilnius']
df_vil.head(4)
```

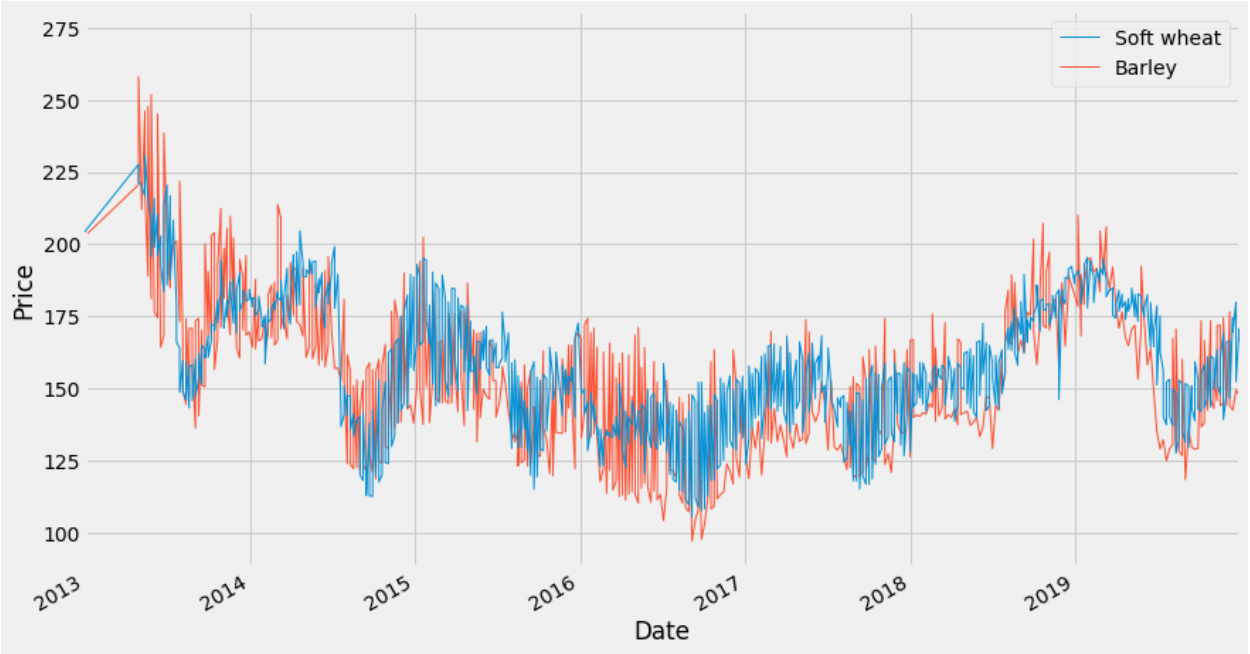
Out[19]:

Week - Begin Date	Product Name	Market Name	Product Group Name	Price	Week - Begin Date	Week - End Date	month
2012-10-01	Malting barley	Vilnius	Barley	214.66	2012-10-01	2012-10-07	10
2012-10-01	Feed oats	Vilnius	Oats	128.66	2012-10-01	2012-10-07	10
2012-10-01	Feed barley	Vilnius	Barley	189.19	2012-10-01	2012-10-07	10
2012-10-01	Feed rye	Vilnius	Rye	158.09	2012-10-01	2012-10-07	10

In [20]:
```
plt.rcParams["figure.figsize"] = (13,8)
df_vil[df_vil['Product Group Name'] == 'Soft wheat'].Price.plot(lw=1, zorder=10);
df_vil[df_vil['Product Group Name'] == 'Barley'].Price.plot(lw=1);


plt.legend(['Soft wheat',  'Barley', ])
plt.xlim('2013-01-01', '2019-12-30')
plt.xlabel("Date")
plt.ylabel("Price")
plt.plot();

```



As we can see, the price changes are almost the same for the two brands. Is one of the firms afraid of setting the price higher than competitors' price?

We can consider many various cases, however, the Zachodni market seems one of the most interesting. Let study the price fluctuations within this market.

In [21]:
```
df[df['Market Name']=='Zachodni']['Product Group Name'].value_counts()
```

Out[21]:
```
Soft wheat    845
Rye           800
Barley        782
Maize         416
Oats          111
Name: Product Group Name, dtype: int64
```

In [22]:
```
df_zach = df[df['Market Name']=='Zachodni'] #### Zachodni
df_zach.head(4)
```

Out[22]:

Week - Begin Date	Product Name	Market Name	Product Group Name	Price	Week - Begin Date	Week - End Date	month
2013-05-27	Milling wheat	Zachodni	Soft wheat	210.35	2013-05-27	2013-06-02	5
2013-05-27	Feed barley	Zachodni	Barley	182.69	2013-05-27	2013-06-02	5
2013-05-27	Feed rye	Zachodni	Rye	160.02	2013-05-27	2013-06-02	5
2013-05-27	Feed oats	Zachodni	Oats	138.75	2013-05-27	2013-06-02	5

In [23]:
```
df_zach.groupby('Product Group Name').agg({"Price": [np.min, np.max, np.mean, np.median, np.std, max_min
```

Out[23]:

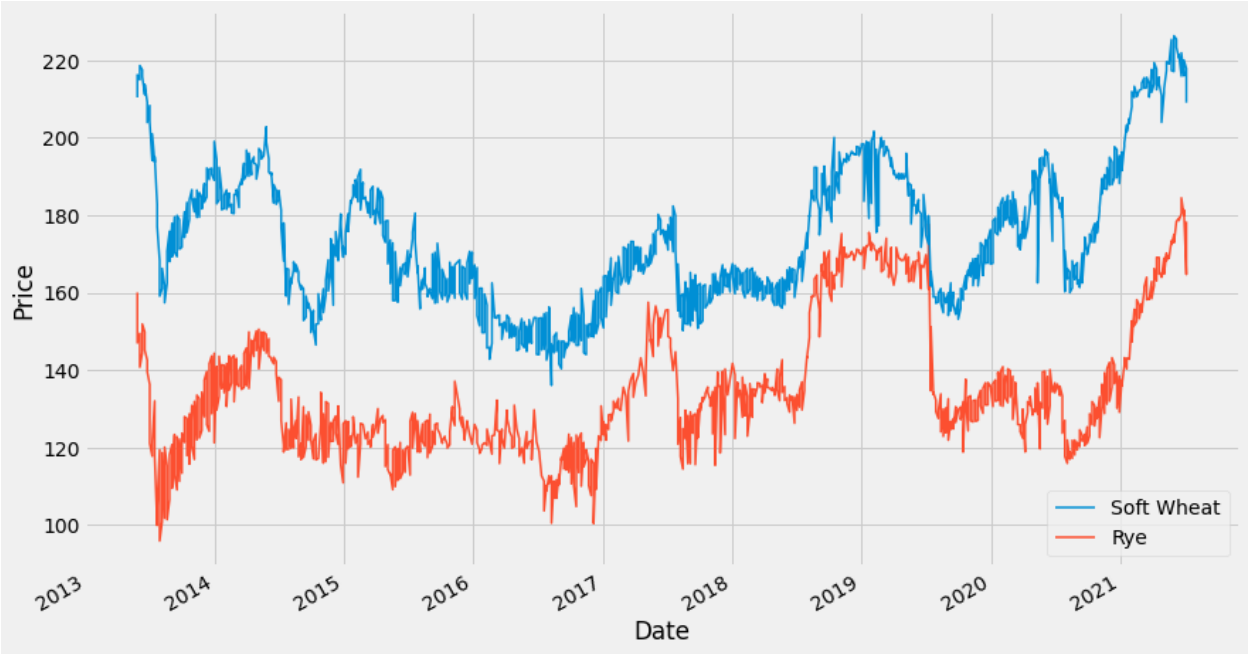
	Price					
	amin	amax	mean	median	std	growth
Product Group Name						
Barley	116.54	232.53	164.56	162.46	21.56	-0.06
Maize	128.26	234.93	163.91	161.16	19.35	0.12
Oats	84.04	192.27	127.04	123.97	23.98	0.02
Rye	95.92	184.43	135.08	130.87	17.55	0.11
Soft wheat	136.07	226.24	174.32	171.06	18.12	-0.01

Here we show three interesting dependencies for our model.

In [24]:
```
plt.rcParams["figure.figsize"] = (13,8)
df_zach[df_zach['Product Group Name'] == 'Soft wheat'].Price.plot(lw=1.5, zorder=10);
df_zach[df_zach['Product Group Name'] == 'Rye'].Price.plot(lw=1.5);

plt.legend(['Soft Wheat',  'Rye'])
plt.xlabel("Date")
plt.ylabel("Price")
plt.plot();

```



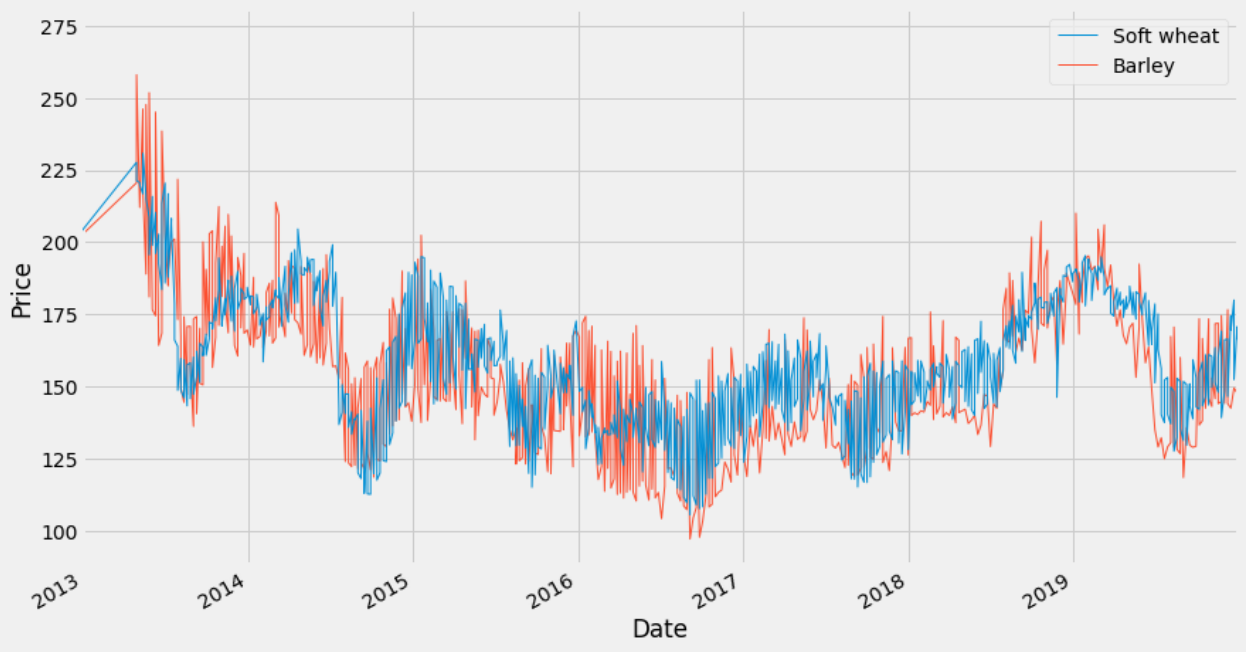
Modeling

Case 1 - Soft wheat vs Barley in Vilnius

In [25]:

```
plt.rcParams["figure.figsize"] = (13,8)
df_vil[df_vil['Product Group Name'] == 'Soft wheat'].Price.plot(lw=1, zorder=10);
df_vil[df_vil['Product Group Name'] == 'Barley'].Price.plot(lw=1);


plt.legend(['Soft wheat',  'Barley', ])
plt.xlim('2013-01-01', '2019-12-30')
plt.xlabel("Date")
plt.ylabel("Price")
plt.plot();
```



Consider the price changes in the Vilnius market. Here, Soft Wheat and Barley are the strongest players. Although there are fewer points for Soft Wheat, we can easily see that the prices fluctuated similarly and were approximately the same. We may assume that both firms produce similar goods and consumers in Vilnius do not differentiate the product. However, we assume that consumers have preference memory, so they are **slightly** more inclined to buy the good they purchased before unless it is much more expensive than the alternative. At each timestep t, Soft Wheat and Barley choose the prices and if one firm sets extremely high prices, it loses the whole market. Most of these assumptions are satisfied by the Bertrand model.

Bertrand model assumes some costs of the unit production c. The firm having lower marginal costs pushes the opponent from the market. Since both firms have been operating in the Vilnius market and producing non-zero quantities, we conclude that the firms had similar costs of production.

Now, we need to somehow explain the change in prices over time. This phenomenon will be explained by the fluctuating cost of grains during different years and times of the year. During a fertile period, we expected that the costs are lower, so we see a drop in the price of Soft Wheat and Barley. If the period is not fertile, this is reflected in the marginal costs.

In other words, we model the price choice by a repeated game where the costs are defined by the nature. Each round represents a modified Bertrand competition where minor product differentiation is based on the previous purchases, which explains some slight differences in price at some periods.

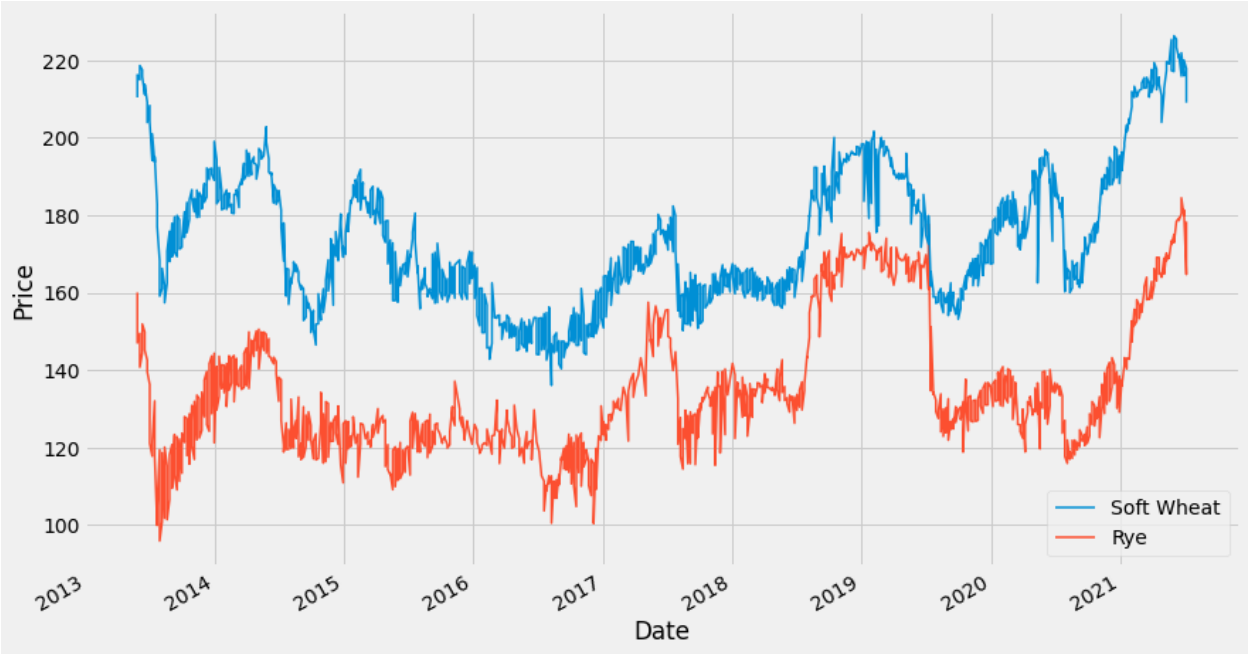
$$price_t = MC_t + \gamma_t \text{ where } \gamma_t^i \text{ is the margin tolerated by the i-th customer who have previously consumed the good}$$

$$MC_t = MC + \epsilon_t \text{ where } \epsilon_t \text{ is defined by the nature}$$

Case 2 - Soft wheat vs Rye in Zachodni

In [26]:
```
plt.rcParams["figure.figsize"] = (13,8)
df_zach[df_zach['Product Group Name'] == 'Soft wheat'].Price.plot(lw=1.5, zorder=10);
df_zach[df_zach['Product Group Name'] == 'Rye'].Price.plot(lw=1.5);

plt.legend(['Soft Wheat',  'Rye'])
plt.xlabel("Date")
plt.ylabel("Price")
plt.plot();
```



In [27]:
```
diff = df_zach[df_zach['Product Group Name'] == 'Soft wheat'].Price - df_zach[df_zach['Product Group Nam
np.mean(diff)
```

Out[27]: 39.67362327909887

Another case we consider is the Soft Wheat and Rye competition in the Zachodni market. Here, we, unfortunately, are not able to use the simplest Bertrand model as Soft Wheat visibly sets a much higher price throughout the whole period. However, the main observation we can make here is the fact that the shape of Rye's price time series almost completely replicates Soft Wheat's but it is lower by around 40 euro.

We understand that Soft Wheat production is treated as of higher quality by the Zachodni consumers. Though changing, people are more satisfied by the Soft Wheat unless its price does not exceed Rye's by 40 euro on average.

We may try to apply a Hotelling model here and modify it to our case.

Let describe the consumer's utility when purchasing Soft Wheat

$$U(SoftWheat)(p_S, p_R) = [S_{max} - d \cdot p_S - g(p_S - p_R)] * I(p_S - p_R < 40)$$

where S_{max} is the maximal level of satisfaction from consuming SW, g is some increasing function of the difference between Soft Wheat's price and Rye's price. If the price difference is too high then it does not make the individual happy to consume SW. Assume that d is a constant and the increase of price by a euro usually decreases the utility by d.

Here, we apply the assumption of the simplified version of the Hotelling model, where we assume that all customers cannot avoid consuming.

Do the same for Rye

$$U(Rye)(p_S, p_R) = [\tilde{S}_{max} - \tilde{d} \cdot p_R]$$

In [27]:
```
1
```

In [27]:
```
1
```