In [1]:

```
import os
import numpy as np
import pandas as pd
import seaborn as sns
import xgboost as xgb
import matplotlib.pyplot as plt

from sklearn.metrics import r2_score
from sklearn.preprocessing import OrdinalEncoder
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import train_test_split, GridSearchCV
from mlxtend.feature_selection import SequentialFeatureSelector as sfs


sns.set()
%matplotlib inline
```

In [11]:

```
files = [file for file in os.listdir('data/') if file[-4:] == 'xlsx']

df = pd.DataFrame()

for file in files:
    df_temp = pd.read_excel(f'data/{file}', usecols="A, B, D, F, H, I, K, N")
    df = df.append(df_temp)
```

Преобразование данных

In [12]:

```
df.columns = [
    'date', 'patient_ID', 'sex', 'CODE_SERVER', 'COUNT_SERVER', 'PAYM',
    'MKB10', 'MKB10_1'
]
```

In [13]:

```
# Удаляем строки с пустыми диагнозами
df.dropna(subset=['MKB10', 'MKB10_1', 'sex'], inplace=True)
```

In [14]:

```
# Берем только числа из столбца "Кол-во услог"
df = df[df.COUNT_SERVER.apply(lambda x: x[0].isdigit())]
```

In [15]:

```
# Преобразуем типы
df.date = df.date.astype('datetime64[ns]')
df.patient_ID = df.patient_ID.astype(np.uint64)
df.sex = df.sex.astype(int)
df.COUNT_SERVER = df.COUNT_SERVER.astype(np.float32)
df.COUNT_SERVER = df.COUNT_SERVER.astype(np.uint16)
df.PAYM = df.PAYM.astype(np.float32)

df['month'] = df.date.dt.month
df['day'] = df.date.dt.day
```

In [16]:

```
# Кодируем категориальные данные в ранжированные данные
```

```
MKB10_enc = OrdinalEncoder()
df['MKB10_code'] = MKB10_enc.fit_transform(df[['MKB10']])

MKB10_1_enc = OrdinalEncoder()
df['MKB10_1_code'] = MKB10_1_enc.fit_transform(df[['MKB10_1']])

CODE_SERVER_enc = OrdinalEncoder()
df['CODE_SERVER_code'] = CODE_SERVER_enc.fit_transform(df[['CODE_SERVER'
                                                           ]].astype(str))
```

In [17]:

```
# Найти оригинальное значение диагноза
MKB10_enc.inverse_transform(df[['MKB10_code']])
MKB10_1_enc.inverse_transform(df[['MKB10_code']])
CODE_SERVER_enc.inverse_transform(df[['CODE_SERVER_code']])
```

Out[17]:

```
array([['1120001'],
       ['2080017'],
       ['2080075'],
       ...,
       ['1151003'],
       ['1001004'],
       ['1140005']], dtype=object)
```

In [18]:

```
df.drop(['date', 'MKB10', 'MKB10_1', 'CODE_SERVER'], inplace=True, axis=1)
```

In [19]:

```
df.describe()
```

Out[19]:

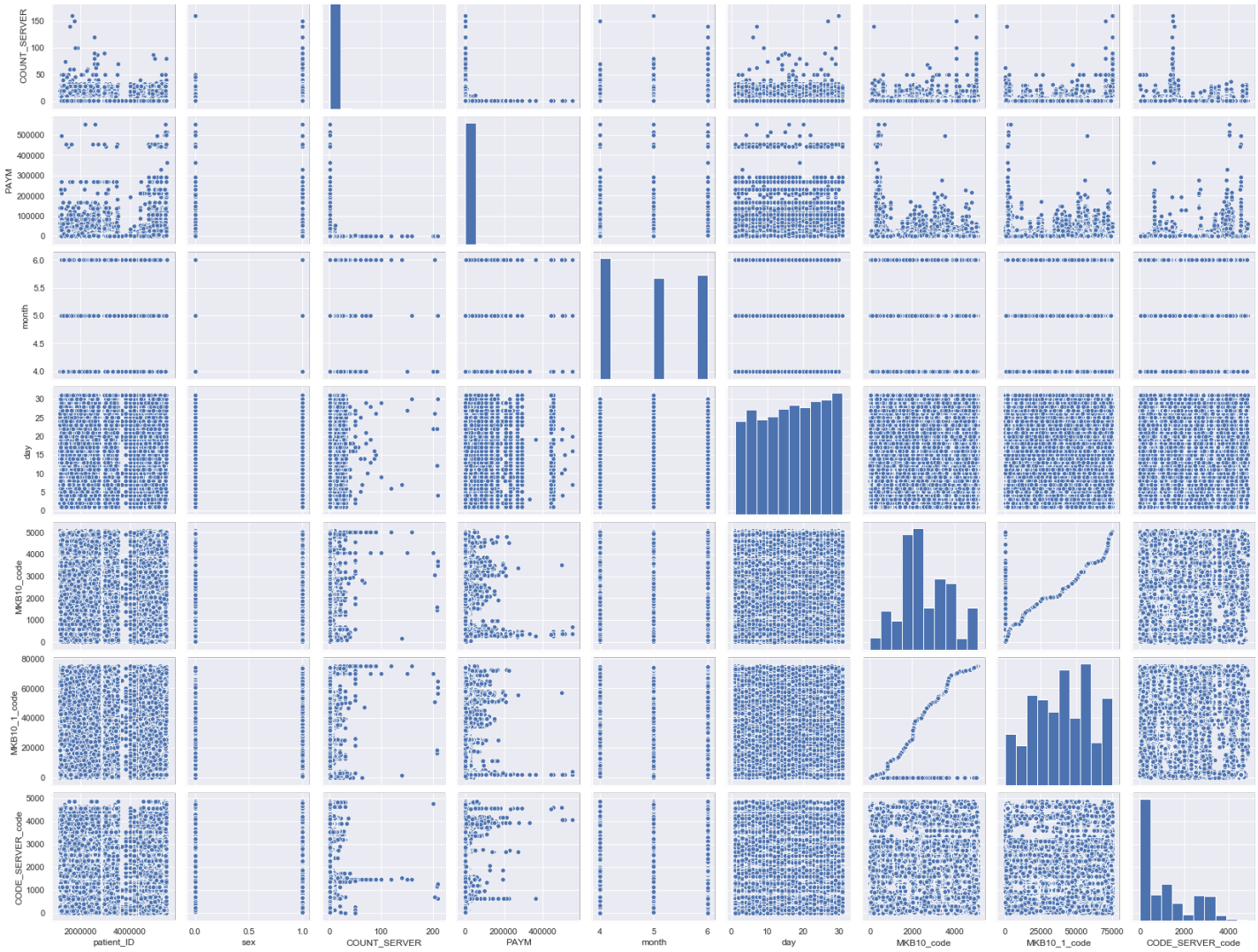
	patient_ID	sex	COUNT_SERVER	PAYM	month	day	MKB10_code	MKB10_1_cod
count	1.500659e+06	1.500659e+06	1.500659e+06	1.500659e+06	1.500659e+06	1.500659e+06	1.500659e+06	1.500659e+0
mean	3.294480e+06	6.401548e-01	1.193116e+00	2.048020e+03	4.946889e+00	1.615157e+01	2.550708e+03	3.996208e+0
std	1.369103e+06	4.799550e-01	1.783363e+00	9.844341e+03	8.287866e-01	8.712659e+00	1.134858e+03	2.021423e+0
min	1.150188e+06	0.000000e+00	1.000000e+00	0.000000e+00	4.000000e+00	1.000000e+00	0.000000e+00	0.000000e+0
25%	2.151779e+06	0.000000e+00	1.000000e+00	7.500000e+02	4.000000e+00	8.000000e+00	1.868000e+03	2.443500e+0
50%	3.053649e+06	1.000000e+00	1.000000e+00	1.411000e+03	5.000000e+00	1.700000e+01	2.252000e+03	3.912500e+0
75%	4.841609e+06	1.000000e+00	1.000000e+00	1.847000e+03	6.000000e+00	2.400000e+01	3.483000e+03	5.657000e+0
max	5.526715e+06	1.000000e+00	2.090000e+02	5.518200e+05	6.000000e+00	3.100000e+01	5.078000e+03	7.505000e+0

In [20]:

```
sns.pairplot(df)
```

Out[20]:

```
<seaborn.axisgrid.PairGrid at 0x1cc1bf4c2c8>
```



Отбор признаков

Построим линейную регруссию и выполним на ней прямой отбор признаков

In [21]:

```
X = df[[
    'patient_ID', 'sex', 'CODE_SERVER_code', 'COUNT_SERVER', 'month', 'day',
    'MKB10_code', 'MKB10_1_code'
]]
y = df[['PAYM']]

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, random_state=42
)
```

In [22]:

```
clf = LinearRegression(n_jobs=-1)

sfs1 = sfs(clf,
           k_features=4,
           forward=True,
           floating=False,
           verbose=2,
           scoring='r2',
           cv=5)
sfs1 = sfs1.fit(X_train, y_train.values.ravel())
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   8 out of   8 | elapsed:    2.1s finished
```

```
[2021-03-29 17:01:46] Features: 1/4 -- score: 0.01914469904122078[Parallel(n_jobs=1)]: Us
ing backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.4s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   7 out of   7 | elapsed:    3.3s finished

[2021-03-29 17:01:49] Features: 2/4 -- score: 0.024635270671548935[Parallel(n_jobs=1)]: U
sing backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.5s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   6 out of   6 | elapsed:    3.2s finished

[2021-03-29 17:01:52] Features: 3/4 -- score: 0.026712807705484322[Parallel(n_jobs=1)]: U
sing backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.5s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   5 out of   5 | elapsed:    3.0s finished

[2021-03-29 17:01:55] Features: 4/4 -- score: 0.02817074658443839
```

In [23]:

```
feat_cols = list(sfs1.k_feature_names_)
print(f'Самая лучшая модель отобрала признаки: {sfs1.k_feature_names_}')
```

```
Самая лучшая модель отобрала признаки: ('patient_ID', 'CODE_SERVER_code', 'COUNT_SERVER',
'MKB10_1_code')
```

In [24]:

```
X = df[feat_cols]
y = df[['PAYM']]

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, random_state=42
)
```

Посмотрим матрицу корреляций

In [25]:

```
corr = X.corr(method='spearman')
corr
```

Out[25]:

	patient_ID	CODE_SERVER_code	COUNT_SERVER	MKB10_1_code
patient_ID	1.000000	0.021443	0.001681	0.029470
CODE_SERVER_code	0.021443	1.000000	0.226840	-0.066849
COUNT_SERVER	0.001681	0.226840	1.000000	-0.004143
MKB10_1_code	0.029470	-0.066849	-0.004143	1.000000

In [26]:

```
sns.heatmap(corr)
```

Out[26]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1cc7f925888>
```

In [27]:

```
# Удалил все признаки, у которых корреляция больше 0.9
columns = np.full((corr.shape[0], ), True, dtype=bool)
for i in range(corr.shape[0]):
    for j in range(i + 1, corr.shape[0]):
        if corr.iloc[i, j] >= 0.9:
            if columns[j]:
                columns[j] = False
selected_columns = X.columns[columns]
X = X[selected_columns]
```

Выбор модели машиного обучения

In [28]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, random_state=42
)
```

In [29]:

```
models = [
    LinearRegression(n_jobs=-1),
    RandomForestRegressor(n_estimators=50, max_features='sqrt', n_jobs=-1),
    KNeighborsRegressor(n_neighbors=6, n_jobs=-1),
    xgb.XGBRegressor(),
]
```

In [30]:

```
TestModel = pd.DataFrame()
tmp = {}

for model in models:
    m = str(model)
    model.fit(X_train, y_train)

    tmp['Model'] = m[:m.index('(')]
    tmp['R^2_test'] = r2_score(y_test, model.predict(X_test))
    tmp['R^2_train'] = r2_score(y_train, model.predict(X_train))

    TestModel = TestModel.append([tmp])
```

```
C:\Program Files\Anaconda3\lib\site-packages\ipykernel_launcher.py:6: DataConversionWarni
ng: A column-vector y was passed when a 1d array was expected. Please change the shape of
y to (n_samples,), for example using ravel().
```

In [31]:

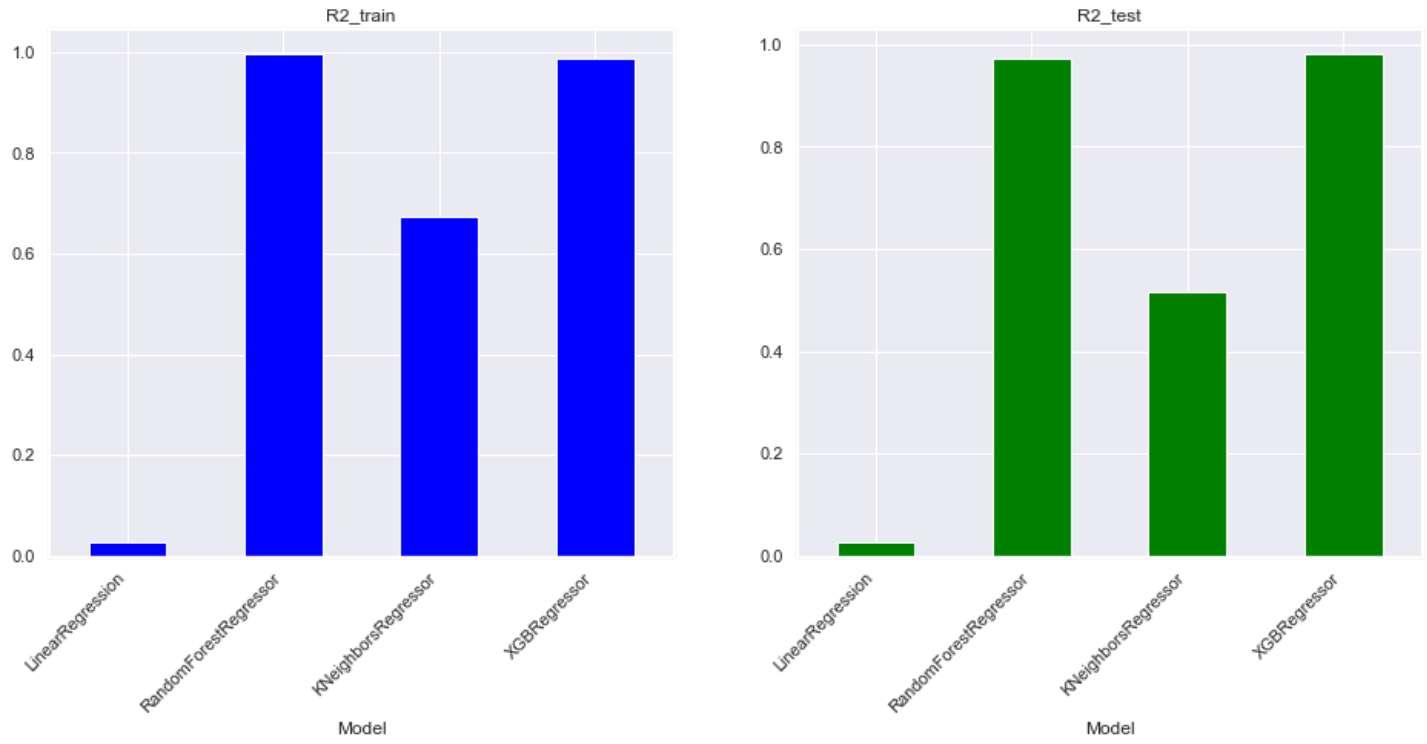
```
TestModel = TestModel.set_index(['Model'])
```

In [32]:

```
fig, axes = plt.subplots(ncols=2, figsize=(16, 7))

TestModel['R^2_train'].plot(ax=axes[0], kind='bar', title='R2_train', color='blue')
```

```
TestModel['R^2_test'].plot(ax=axes[1], kind='bar', title='R2_test', color='green')
fig.autofmt_xdate(rotation=45)
```



Построение модели и обучение

In [33]:

```
modelXGB = xgb.XGBRegressor()
```

Выбор гиперпараметров модели

In [34]:

```
reg_cv = GridSearchCV(modelXGB, {
    "colsample_bytree": [1.0],
    "min_child_weight": [1.0, 1.2],
    'max_depth': [3, 4, 6],
    'n_estimators': [30, 100]
},
                      verbose=1,
                      n_jobs=-1)
```

In [35]:

```
reg_cv.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 12 candidates, totalling 60 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=-1)]: Done  38 tasks      | elapsed:  3.7min
[Parallel(n_jobs=-1)]: Done  60 out of  60 | elapsed:  6.6min finished
```

Out[35]:

```
GridSearchCV(cv=None, error_score=nan,
             estimator=XGBRegressor(base_score=None, booster=None,
                                    colsample_bylevel=None,
                                    colsample_bynode=None,
                                    colsample_bytree=None, gamma=None,
                                    gpu_id=None, importance_type='gain',
                                    interaction_constraints=None,
                                    learning_rate=None, max_delta_step=None,
                                    max_depth=None, min_child_weight=None,
                                    missing=nan, monotone_constraints=None,
```

```
                                    n_est...
                                    random_state=None, reg_alpha=None,
                                    reg_lambda=None, scale_pos_weight=None,
                                    subsample=None, tree_method=None,
                                    validate_parameters=None, verbosity=None),
             iid='deprecated', n_jobs=-1,
             param_grid={'colsample_bytree': [1.0], 'max_depth': [3, 4, 6],
                         'min_child_weight': [1.0, 1.2],
                         'n_estimators': [30, 100]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=1)
```

In [36]:

```
gbm = xgb.XGBRegressor(**reg_cv.best_params_)
gbm.fit(X_train, y_train)
```

Out[36]:

```
XGBRegressor(base_score=0.5, booster='gbtree', colsample_bylevel=1,
             colsample_bynode=1, colsample_bytree=1.0, gamma=0, gpu_id=-1,
             importance_type='gain', interaction_constraints='',
             learning_rate=0.300000012, max_delta_step=0, max_depth=6,
             min_child_weight=1.2, missing=nan, monotone_constraints='()',
             n_estimators=100, n_jobs=6, num_parallel_tree=1,
             objective='reg:squarederror', random_state=0, reg_alpha=0,
             reg_lambda=1, scale_pos_weight=1, subsample=1, tree_method='exact',
             validate_parameters=1, verbosity=None)
```

In [38]:

```
print(f'Точность на тестовом наборе: {r2_score(y_test, gbm.predict(X_test))}')
print(f'Точность на тренировочном наборе: {r2_score(y_train, gbm.predict(X_train))}')
```

```
Точность на тестовом наборе: 0.9803634359417404
Точность на тренировочном наборе: 0.9861941758522282
```

In [39]:

```
y_pred = gbm.predict(X_test)
```

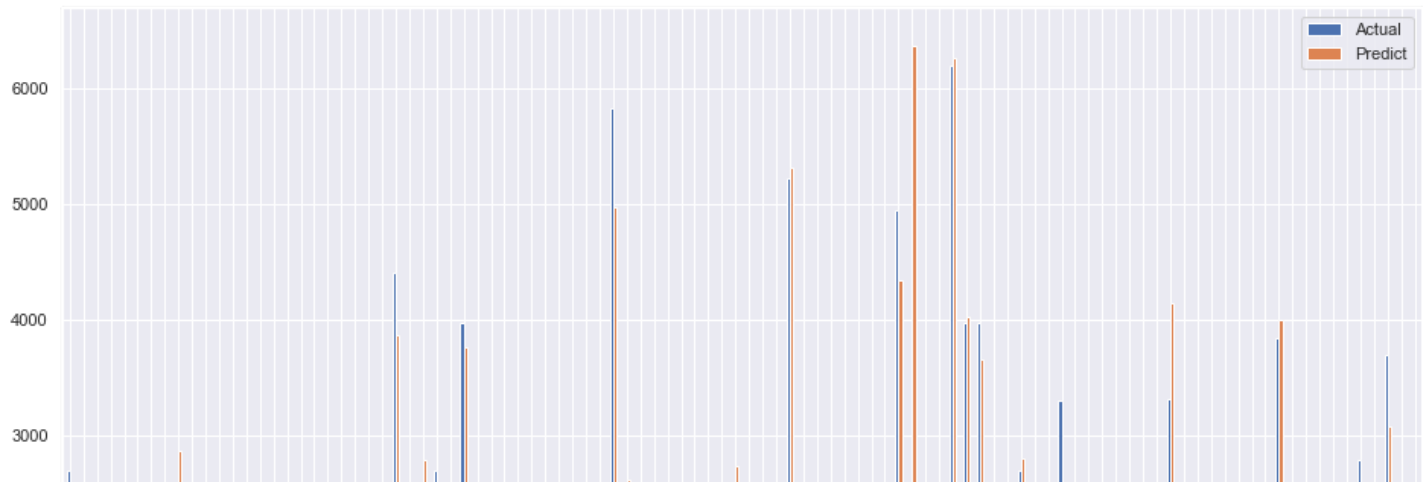
Отобразим первые **100** испытаний

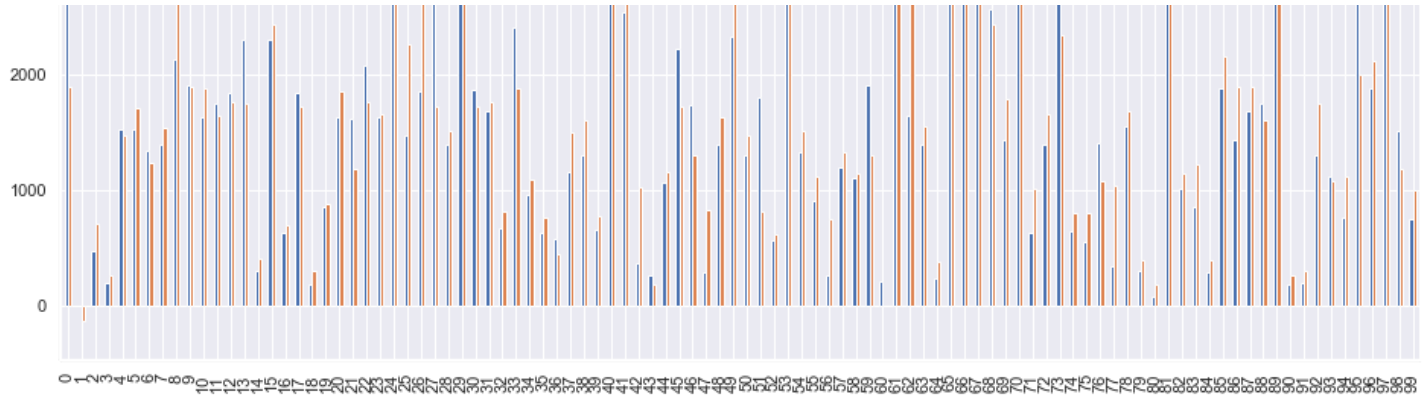
In [40]:

```
df_plots = pd.DataFrame({'Actual': np.array(y_test[:100].values.ravel()),
                         'Predict': np.array(y_pred[:100])})
```

In [41]:

```
df_plots.plot(kind='bar',figsize=(16,10))
plt.grid(which='major', linestyle='-', linewidth='1')
plt.grid(which='minor', linestyle=':', linewidth='1')#, color='black')
plt.show()
```





Предсказанное значение

In [42]:

```
y_pred.sum()
```

Out[42]:

```
1225021300.0
```