In [1]:
```
import pandas as pd
import numpy as np
%matplotlib inline

from sklearn.metrics import mean_squared_log_error
from sklearn.ensemble import RandomForestRegressor
from lightgbm import LGBMRegressor

import warnings
warnings.filterwarnings('ignore')
```

Preparando os dados

Dados em UCI Repository (https://archive.ics.uci.edu/ml/datasets/Sales_Transactions_Dataset_Weekly).

este estudo é baseado no Workshop de Time-Series do curso do Mario Filho

In [2]:
```
data = pd.read_csv('Sales_Transactions_Dataset_Weekly.csv')
# para esquecer das colunas normalizadas
data = data.filter(regex=r'Product|W')
data.head()
```

Out[2]:

	Product_Code	W0	W1	W2	W3	W4	W5	W6	W7	W8	...	W42	W43	W44	W45	W46
0	P1	11	12	10	8	13	12	14	21	6	...	4	7	8	10	12
1	P2	7	6	3	2	7	1	6	3	3	...	2	4	5	1	1
2	P3	7	11	8	9	10	8	7	13	12	...	6	14	5	5	7
3	P4	12	8	13	5	9	6	9	13	13	...	9	10	3	4	6
4	P5	8	5	13	11	6	7	9	14	9	...	7	11	7	12	6

5 rows × 53 columns

Usando a função melt do pandas para deixar o dataframe em um formato melhor.

In [3]:
```
melt = data.melt(id_vars='Product_Code', var_name='Week', value_name=
'Sales')

# regex para pegar somente os números do código do produto
melt['Product_Code'] = melt['Product_Code'].str.extract('(\d+)', expa
nd=False).astype(int)
# regex para pegar somente os números da semana
melt['Week'] = melt['Week'].str.extract('(\d+)', expand=False).astype
(int)

# ordenando os valores por semana e código do produto
melt = melt.sort_values(['Week', 'Product_Code'])
# dimensões do dataframe
print(melt.shape)
melt.head()
```

```
(42172, 3)
```

Out[3]:

	Product_Code	Week	Sales
0	1	0	11
1	2	0	7
2	3	0	7
3	4	0	12
4	5	0	8

simples de variáveis simples

In [4]:
```
melt2 = melt.copy()
# o argumento default de shift é 1
# vendas da última semana por produto: pegando as vendas da última se
mana
melt2['Sales_Ultima_Semana'] = melt2.groupby(['Product_Code'])['Sale
s'].shift(1)
# vendas da última semana por produto: pegando a diferença das vendas
da última semana
melt2['Diff_Sales_Ultima_Semana'] = melt2.groupby(['Product_Code'])[
'Sales_Ultima_Semana'].diff()
# tirando os dados que contém nan
# tirando os valores faltantes. temos poucos features
melt2 = melt2.dropna()
melt2.head()
```

Out[4]:

	Product_Code	Week	Sales	Sales_Ultima_Semana	Diff_Sales_Ultima_Semana
1622	1	2	10	12.0	1.0
1623	2	2	3	6.0	-1.0
1624	3	2	8	11.0	4.0
1625	4	2	13	8.0	-4.0
1626	5	2	13	5.0	-3.0

In [ ]:

In [5]:
```
melt2['Week'].value_counts().sort_values()
```

Out[5]:
```
31    811
14    811
29    811
28    811
27    811
26    811
25    811
24    811
23    811
22    811
21    811
20    811
51    811
19    811
50    811
18    811
49    811
17    811
48    811
16    811
47    811
15    811
45    811
13    811
44    811
33    811
7     811
12    811
43    811
11    811
42    811
10    811
41    811
9     811
40    811
8     811
46    811
39    811
30    811
6     811
37    811
5     811
36    811
4     811
35    811
3     811
34    811
2     811
38    811
32    811
Name: Week, dtype: int64
```

Os valores de venda para cada semana são igualmente distribuídos!

Baseline e Validação: obtendo um resultado simples

In [6]:
```
# root mean squared log error metrics
def rmsle(ytrue, ypred):
    return np.sqrt(mean_squared_log_error(ytrue, ypred))
```

baseline simples usando o valor da semana a ser previsto como sendo o valor da semana anterior!

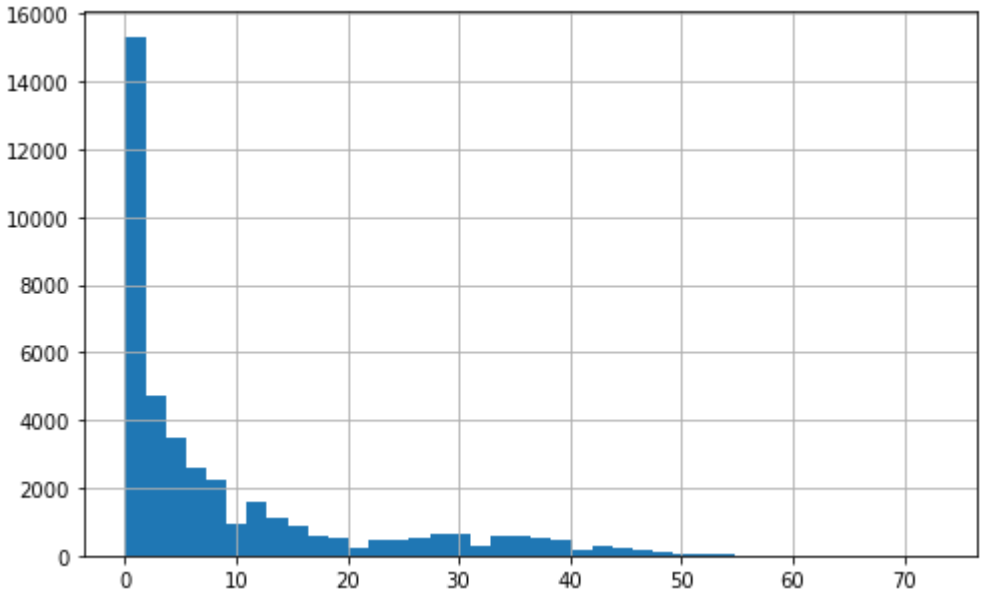
In [7]:
```
mean_error = []
for week in range(40,52):
    # treina nas semanas anteriores
    train = melt2[melt2['Week'] < week]
    # valida na semana atual
    val = melt2[melt2['Week'] == week]

    p = val['Sales_Ultima_Semana'].values

    error = rmsle(val['Sales'].values, p)
    print('Semana %d - Erro %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

```
Semana 40 - Erro 0.51952
Semana 41 - Erro 0.51691
Semana 42 - Erro 0.51026
Semana 43 - Erro 0.50792
Semana 44 - Erro 0.53409
Semana 45 - Erro 0.52347
Semana 46 - Erro 0.50018
Semana 47 - Erro 0.49138
Semana 48 - Erro 0.50585
Semana 49 - Erro 0.50547
Semana 50 - Erro 0.52220
Semana 51 - Erro 0.55242
Média Erro = 0.51581
```

In [8]:
```
# fazendo um histograma do número de vendas
```

In [9]:
```
melt2['Sales'].hist(bins=40, figsize=(8,5))
```

Out[9]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4006432ac8>
```



as vendas estão concentradas no intervalo 0-10

In [ ]:
```

```

Criando modelos interessantes!

In [10]:
```
melt4 = melt.copy()
melt4['Sales_Ultima_Semana'] = melt4.groupby(['Product_Code'])['Sale
s'].shift()
melt4['Media_movel_1'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana'].rolling(1).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana'] = melt4.groupby(['Product_Code'])[
'Sales_Ultima_Semana'].diff()
melt4['Sales_Ultima_Semana-1'] = melt4.groupby(['Product_Code'])['Sal
es'].shift(2)
melt4['Media_movel_2'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana-1'].rolling(2).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana-1'] = melt4.groupby(['Product_Code'])
['Sales_Ultima_Semana-1'].diff()
melt4['Sales_Ultima_Semana-2'] = melt4.groupby(['Product_Code'])['Sal
es'].shift(3)
melt4['Media_movel_3'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana-2'].rolling(3).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana-2'] = melt4.groupby(['Product_Code'])
['Sales_Ultima_Semana-2'].diff()
melt4 = melt4.dropna()
melt4.tail()
```

Out[10]:

	Product_Code	Week	Sales	Sales_Ultima_Semana	Media_movel_1	Diff_Sales_Ultima_S
42167	815	51	0	2.0	2.0	
42168	816	51	5	6.0	6.0	
42169	817	51	3	4.0	4.0	
42170	818	51	0	2.0	2.0	
42171	819	51	1	0.0	0.0	

In [48]:
```
mean_error = []
for week in range(40,52):
    train = melt4[melt4['Week'] < week]
    val = melt4[melt4['Week'] == week]

    xtr, xts = train.drop(['Sales'], axis=1), val.drop(['Sales'], axi
s=1)
    ytr, yts = train['Sales'].values, val['Sales'].values

    mdl = RandomForestRegressor(n_estimators=1000, n_jobs=-1, random_
state=0)
    mdl.fit(xtr, ytr)

    p = mdl.predict(xts)

    error = rmsle(yts, p)
    print('Semana %d - Erro %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

```
Semana 40 - Erro 0.42007
Semana 41 - Erro 0.42680
Semana 42 - Erro 0.42025
Semana 43 - Erro 0.41694
Semana 44 - Erro 0.42772
Semana 45 - Erro 0.39780
Semana 46 - Erro 0.42112
Semana 47 - Erro 0.42974
Semana 48 - Erro 0.41538
Semana 49 - Erro 0.40337
Semana 50 - Erro 0.44168
Semana 51 - Erro 0.44709
Média Erro = 0.42233
```

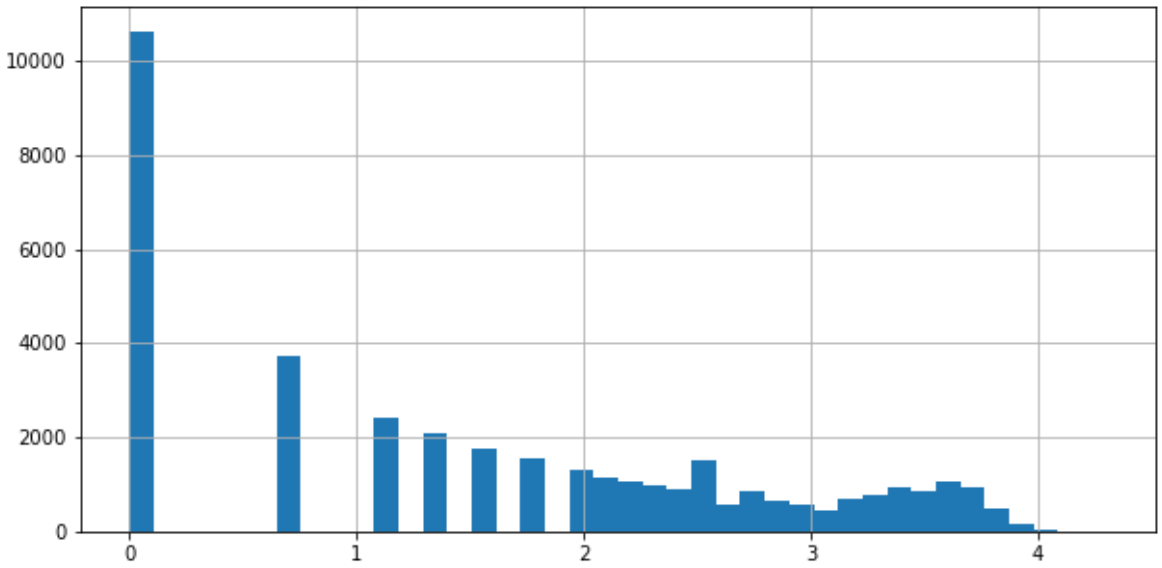
In [ ]:

Modificando a função otimizada (e distribuição do alvo)

temos valores mais uniformemente distribuídos

In [49]:
```
np.log1p(melt4['Sales']).hist(bins=40, figsize=(10,5))
```

Out[49]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fed08802ef0>
```



recalculando!

In [51]:
```
mean_error = []
for week in range(40,52):
    train = melt4[melt4['Week'] < week]
    val = melt4[melt4['Week'] == week]

    xtr, xts = train.drop(['Sales'], axis=1), val.drop(['Sales'], axi
s=1)
    ytr, yts = train['Sales'].values, val['Sales'].values

    mdl = RandomForestRegressor(n_estimators=1000, n_jobs=-1, random_
state=0)
    mdl.fit(xtr, np.log1p(ytr))

    p = np.expm1(mdl.predict(xts))

    error = rmsle(yts, p)
    print('Week %d - Error %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

```
Week 40 - Error 0.40767
Week 41 - Error 0.40515
Week 42 - Error 0.40197
Week 43 - Error 0.39968
Week 44 - Error 0.41825
Week 45 - Error 0.38842
Week 46 - Error 0.41281
Week 47 - Error 0.39931
Week 48 - Error 0.40716
Week 49 - Error 0.40968
Week 50 - Error 0.43622
Week 51 - Error 0.46366
Média Erro = 0.41250
```

engraçado, piorou muito nos últimas semanas!!!

Um modelo mais sofisticado

In [58]:
```
mean_error = []
for week in range(40,52):
    train = melt4[melt4['Week'] < week]
    val = melt4[melt4['Week'] == week]

    xtr, xts = train.drop(['Sales'], axis=1), val.drop(['Sales'], axi
s=1)
    ytr, yts = train['Sales'].values, val['Sales'].values

    mdl = LGBMRegressor(n_estimators=1000, learning_rate=0.01)
    mdl.fit(xtr, np.log1p(ytr))

    p = np.expm1(mdl.predict(xts))

    error = rmsle(yts, p)
    print('Semana %d - Erro %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

```
Semana 40 - Erro 0.40073
Semana 41 - Erro 0.38563
Semana 42 - Erro 0.38627
Semana 43 - Erro 0.38782
Semana 44 - Erro 0.40600
Semana 45 - Erro 0.37642
Semana 46 - Erro 0.39674
Semana 47 - Erro 0.38189
Semana 48 - Erro 0.39265
Semana 49 - Erro 0.39501
Semana 50 - Erro 0.41345
Semana 51 - Erro 0.44514
Média Erro = 0.39731
```

colocando o target como sqrt(x)

In [11]:
```
mean_error = []
for week in range(40,52):
    train = melt4[melt4['Week'] < week]
    val = melt4[melt4['Week'] == week]

    xtr, xts = train.drop(['Sales'], axis=1), val.drop(['Sales'], axi
s=1)
    ytr, yts = train['Sales'].values, val['Sales'].values

    mdl = LGBMRegressor(n_estimators=1000, learning_rate=0.01)
    mdl.fit(xtr, np.sqrt(ytr))

    p = (mdl.predict(xts))**2

    error = rmsle(yts, p)
    print('Semana %d - Erro %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

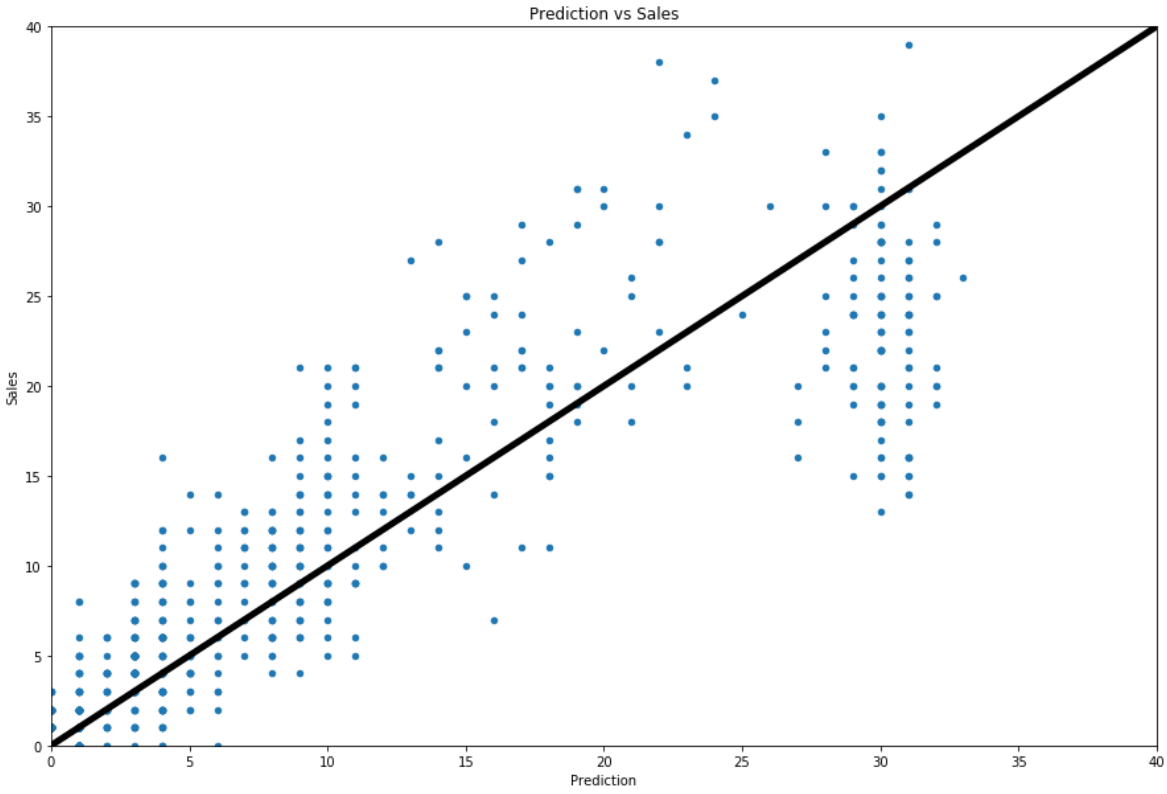
```
Semana 40 - Erro 0.41173
Semana 41 - Erro 0.38888
Semana 42 - Erro 0.39358
Semana 43 - Erro 0.39307
Semana 44 - Erro 0.41669
Semana 45 - Erro 0.38529
Semana 46 - Erro 0.40727
Semana 47 - Erro 0.37940
Semana 48 - Erro 0.39922
Semana 49 - Erro 0.40028
Semana 50 - Erro 0.41889
Semana 51 - Erro 0.44841
Média Erro = 0.40356
```

log para o target é melhor!

In [ ]:
```
```

In [94]:
```
import matplotlib.pyplot as plt
val.loc[:, 'Prediction'] = np.round(p)
val.plot.scatter(x='Prediction', y='Sales', figsize=(15,10), title='P
rediction vs Sales',
                 ylim=(0,40), xlim=(0,40))

xx=[0,10,20,30,40]
yy=[0,10,20,30,40]
plt.plot(xx,yy,linewidth=5,color='black')
```

Out[94]: [<matplotlib.lines.Line2D at 0x7fed066904a8>]



o modelo está errando mais para vendas de 20 unidades.

In [85]:
```
sel.shape
```

Out[85]: (257,)

In [39]:
```
df_aux=melt.groupby(['Week'])['Sales'].sum()
```

In [43]:
```
#df_aux
```

In [32]:
```
melt.shape[0]
```

Out[32]: 42172

In [36]:
```
melt['Week'][0]
```

Out[36]:
```
0
```

In [44]:
```
df_aux=melt.groupby(['Week'])['Sales'].sum()
list_week=[]
for i in range(melt.shape[0]):
    week=melt['Week'][i]
    list_week.append(df_aux[week])
```

In [46]:
```
#list_week
```

In [ ]:

In [ ]:

In [54]:
```
melt4 = melt.copy()
melt4['Sales_Ultima_Semana'] = melt4.groupby(['Product_Code'])['Sale
s'].shift()
melt4['Media_movel_1'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana'].rolling(1).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana'] = melt4.groupby(['Product_Code'])[
'Sales_Ultima_Semana'].diff()

#melt4['SalesperWeek']=melt4.groupby(['Week'])['Sales'].shift()
#melt4['PerweekMedia_movel_1'] = melt4.groupby(['Product_Code'])['Sal
esperWeek'].rolling(2).mean().reset_index(level=0, drop=True)
#melt4['Perweek_Diff_Sales_Ultima_Semana'] = melt4.groupby(['Product_
Code'])['SalesperWeek'].diff()
df_aux=melt.groupby(['Week'])['Sales'].sum()
list_week=[]
for i in range(melt.shape[0]):
    week=melt['Week'][i]
    list_week.append(df_aux[week])
melt4['weekallsales']=list_week

melt4['weekallsales'] = melt4.groupby(['Week'])['weekallsales'].shift
()
melt4['Media_movel_weeksales'] = melt4.groupby(['Week'])['weekallsale
s'].rolling(2).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_weekallsales'] = melt4.groupby(['Week'])['weekallsa
les'].diff()


melt4['Sales_Ultima_Semana-1'] = melt4.groupby(['Product_Code'])['Sal
es'].shift(2)
melt4['Media_movel_2'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana-1'].rolling(2).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana-1'] = melt4.groupby(['Product_Code'])
['Sales_Ultima_Semana-1'].diff()

#melt4['SalesperWeek_2']=melt4.groupby(['Week'])['Sales'].shift(2)
#melt4['PerweekMedia_movel_2'] = melt4.groupby(['Product_Code'])['Sal
esperWeek'].rolling(4).mean().reset_index(level=0, drop=True)
#melt4['Perweek_Diff_Sales_Ultima_Semana_2'] = melt4.groupby(['Produc
t_Code'])['SalesperWeek'].diff()


melt4['weekallsales_2'] = melt4.groupby(['Week'])['weekallsales'].shi
ft(2)
melt4['Media_movel_weeksales_2'] = melt4.groupby(['Week'])['weekallsa
les'].rolling(4).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_weekallsales_2'] = melt4.groupby(['Week'])['weekall
sales'].diff(2)


melt4['Sales_Ultima_Semana-2'] = melt4.groupby(['Product_Code'])['Sal
es'].shift(3)
melt4['Media_movel_3'] = melt4.groupby(['Product_Code'])['Sales_Ultim
a_Semana-2'].rolling(3).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_Ultima_Semana-2'] = melt4.groupby(['Product_Code'])
['Sales_Ultima_Semana-2'].diff()
```

```
melt4['weekallsales_3'] = melt4.groupby(['Week'])['weekallsales'].shi
ft(3)
melt4['Media_movel_weeksales_3'] = melt4.groupby(['Week'])['weekallsa
les'].rolling(8).mean().reset_index(level=0, drop=True)
melt4['Diff_Sales_weekallsales_3'] = melt4.groupby(['Week'])['weekall
sales'].diff(3)



melt4 = melt4.dropna()
melt4.tail()


#melt4['SalesperWeek_3']=melt4.groupby(['Week'])['Sales'].shift(3)
#melt4['PerweekMedia_movel_3'] = melt4.groupby(['Product_Code'])['Sal
esperWeek'].rolling(6).mean().reset_index(level=0, drop=True)
#melt4['Perweek_Diff_Sales_Ultima_Semana_3'] = melt4.groupby(['Produc
t_Code'])['SalesperWeek'].diff()
```

Out[54]:

	Product_Code	Week	Sales	Sales_Ultima_Semana	Media_movel_1	Diff_Sales_Ultima_S
42167	815	51	0	2.0	2.0	
42168	816	51	5	6.0	6.0	
42169	817	51	3	4.0	4.0	
42170	818	51	0	2.0	2.0	
42171	819	51	1	0.0	0.0	

5 rows × 21 columns

In [60]:
```
mean_error = []
for week in range(40,52):
    train = melt4[melt4['Week'] < week]
    val = melt4[melt4['Week'] == week]

    xtr, xts = train.drop(['Sales'], axis=1), val.drop(['Sales'], axi
s=1)
    ytr, yts = train['Sales'].values, val['Sales'].values

    mdl = LGBMRegressor(n_estimators=1000, learning_rate=0.01)
    mdl.fit(xtr, np.log1p(ytr))

    p = np.expm1(mdl.predict(xts))

    error = rmsle(yts, p)
    print('Semana %d - Erro %.5f' % (week, error))
    mean_error.append(error)
print('Média Erro = %.5f' % np.mean(mean_error))
```

```
Semana 40 - Erro 0.40137
Semana 41 - Erro 0.38608
Semana 42 - Erro 0.38729
Semana 43 - Erro 0.38751
Semana 44 - Erro 0.40707
Semana 45 - Erro 0.37430
Semana 46 - Erro 0.39651
Semana 47 - Erro 0.38039
Semana 48 - Erro 0.39163
Semana 49 - Erro 0.39334
Semana 50 - Erro 0.41228
Semana 51 - Erro 0.43789
Média Erro = 0.39631
```

In [ ]:

In [61]:
```
melt
```

Out[61]:

	Product_Code	Week	Sales
0	1	0	11
1	2	0	7
2	3	0	7
3	4	0	12
4	5	0	8
...	...	...	...
42167	815	51	0
42168	816	51	5
42169	817	51	3
42170	818	51	0
42171	819	51	1

42172 rows × 3 columns

In [ ]:
```

```