Importação de Bibliotecas básicas para compreensão dos dados

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from datetime import datetime
!pip install pmdarima

%matplotlib inline
```

```
Requirement already satisfied: pmdarima in /usr/local/lib/python3.6/dist-packag
es (1.8.0)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.6/dist-package
s (from pmdarima) (1.24.3)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/py
thon3.6/dist-packages (from pmdarima) (51.3.3)
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.6/dist-p
ackages (from pmdarima) (1.19.5)
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.1.5)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.0.0)
Requirement already satisfied: statsmodels!=0.12.0,>=0.11 in /usr/local/lib/pyt
hon3.6/dist-packages (from pmdarima) (0.12.1)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.4.1)
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.6/d
ist-packages (from pmdarima) (0.22.2.post1)
Requirement already satisfied: Cython<0.29.18,>=0.29 in /usr/local/lib/python3.
6/dist-packages (from pmdarima) (0.29.17)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.6/dist-pa
ckages (from pandas>=0.19->pmdarima) (2018.9)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python
3.6/dist-packages (from pandas>=0.19->pmdarima) (2.8.1)
Requirement already satisfied: patsy>=0.5 in /usr/local/lib/python3.6/dist-pack
ages (from statsmodels!=0.12.0,>=0.11->pmdarima) (0.5.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.6/dist-packag
es (from python-dateutil>=2.7.3->pandas>=0.19->pmdarima) (1.15.0)
```

In [2]:
```
import warnings
warnings.filterwarnings("ignore")
```

Base de Dados total, após extração do site da Receita Federal.

Fonte: https://www.gov.br/receitafederal/pt-br/acesso-a-informacao/dados-abertos/receitadata/arrecadacao/arrecadacao-por-estado (https://www.gov.br/receitafederal/pt-br/acesso-a-informacao/dados-abertos/receitadata/arrecadacao/arrecadacao-por-estado)

In [3]:
```
receita_estados = pd.read_excel('Arrecadacao_Federal_2.xlsx', index_col = 'PERIOD
```

In [4]:
```
receita_estados.head()
```

Out[4]:

PERIODO	AC	AL	AM	AP	BA	CE	D
2004-01-01	8196055.0	44664273.0	9819616.0	232926443.0	398719822.0	205806616.0	2.564871e+(
2004-02-01	6880044.0	29343728.0	198376255.0	6290900.0	317779982.0	149876852.0	2.128429e+(
2004-03-01	6644264.0	29646976.0	321840650.0	7000692.0	451389711.0	168632051.0	2.608416e+(
2004-04-01	7932322.0	39141205.0	265230821.0	6980236.0	414844245.0	212638649.0	2.229929e+(
2004-05-01	7408996.0	30907727.0	420825736.0	10347917.0	443559112.0	169051965.0	2.139627e+(

In [5]:
```
receita_estados.info()
```

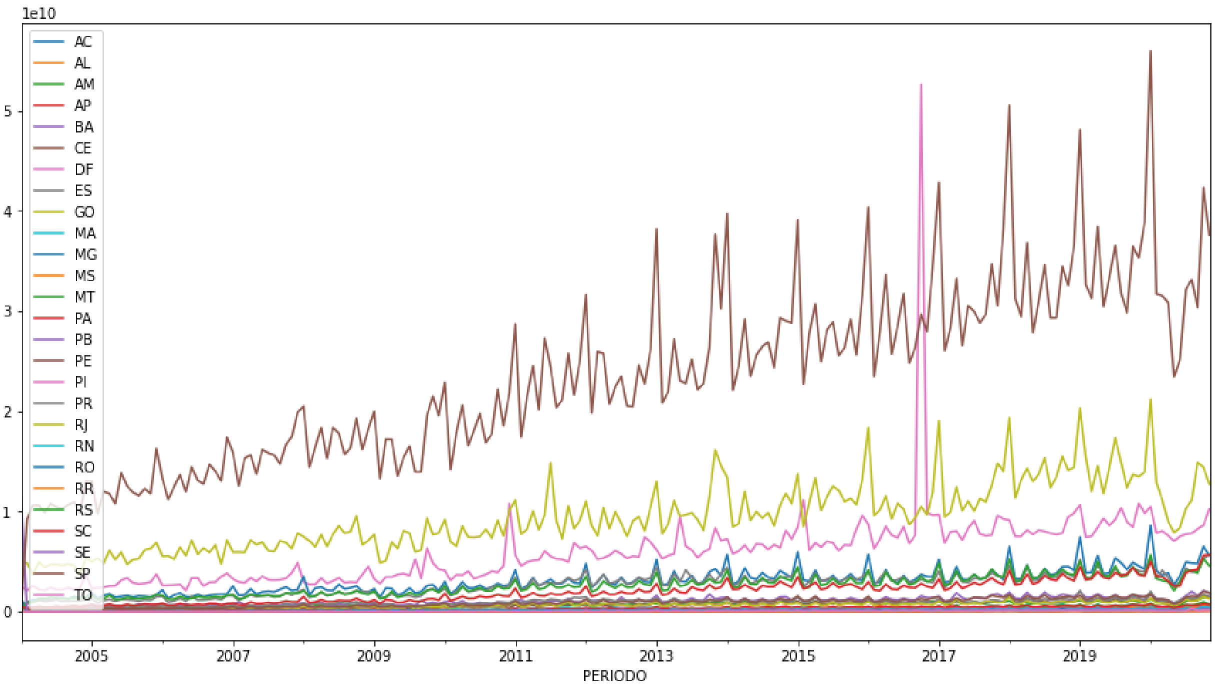
```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 203 entries, 2004-01-01 to 2020-11-01
Data columns (total 27 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   AC      203 non-null    float64
 1   AL      203 non-null    float64
 2   AM      203 non-null    float64
 3   AP      203 non-null    float64
 4   BA      203 non-null    float64
 5   CE      203 non-null    float64
 6   DF      203 non-null    float64
 7   ES      203 non-null    float64
 8   GO      203 non-null    float64
 9   MA      203 non-null    float64
 10  MG      203 non-null    float64
 11  MS      203 non-null    float64
 12  MT      203 non-null    float64
 13  PA      203 non-null    float64
 14  PB      203 non-null    float64
 15  PE      203 non-null    float64
 16  PI      203 non-null    float64
 17  PR      203 non-null    float64
 18  RJ      203 non-null    float64
 19  RN      203 non-null    float64
 20  RO      203 non-null    float64
 21  RR      203 non-null    float64
 22  RS      203 non-null    float64
 23  SC      203 non-null    float64
 24  SE      203 non-null    float64
 25  SP      203 non-null    float64
 26  TO      203 non-null    float64
dtypes: float64(27)
memory usage: 44.4 KB
```

In [6]:
```
estados = [x for x in receita_estados]
```

- Os dados acima nos mostram mês a mês a **Arrecadação das receitas federais por Unidade da Federação (preços correntes)**.

- Neste primeiro momento vamos plotar todos estes dados, para vizualiarmos de maneira melhor, e tirar algumas conclusões

In [7]:
```
receita_estados.plot(figsize = (15,8));
```



1. A partir do gráfico é possível observar grande predominio na arrecadação de alguns Estados, e outros se encontram relativamente próximos.
2. Vamos identificar os 4 estados que mais arrecadam os Tributos Federais.

In [8]:
```
soma = {}

for i in receita_estados:
  soma[i] = receita_estados[i].sum()
```

In [9]:
```
soma
```

Out[9]:
```
{'AC': 6519065904.32,
 'AL': 25611308238.13,
 'AM': 145306559353.73,
 'AP': 7401618244.169999,
 'BA': 219304153688.5,
 'CE': 134385650102.81999,
 'DF': 1204153278917.6802,
 'ES': 192186362317.03998,
 'GO': 128178722948.55,
 'MA': 60617362394.909996,
 'MG': 611877972452.15,
 'MS': 46190336276.97,
 'MT': 63371127150.9,
 'PA': 69359484437.2,
 'PB': 39654825599.95,
 'PE': 185747460766.2,
 'PI': 23987445306.6,
 'PR': 539914727132.63,
 'RJ': 1913446053560.31,
 'RN': 38185236177.14,
 'RO': 21583875066.1,
 'RR': 6601220766.21,
 'RS': 526350866268.24,
 'SC': 403134502629.94,
 'SE': 37744261828.46,
 'SP': 4736256195034.48,
 'TO': 13507203821.48}
```

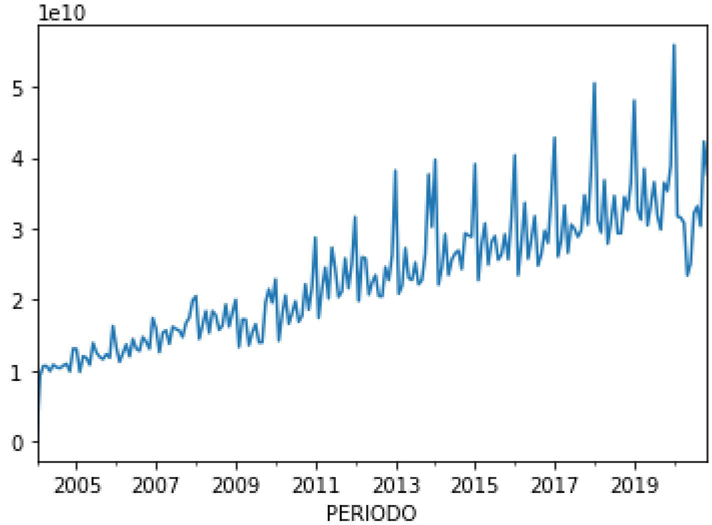
In [10]:
```
soma_pd = pd.DataFrame.from_dict(soma, orient='index', columns=['Soma'])
```

In [11]:
```
soma_pd.sort_values(by='Soma', ascending=False).head(5)
```

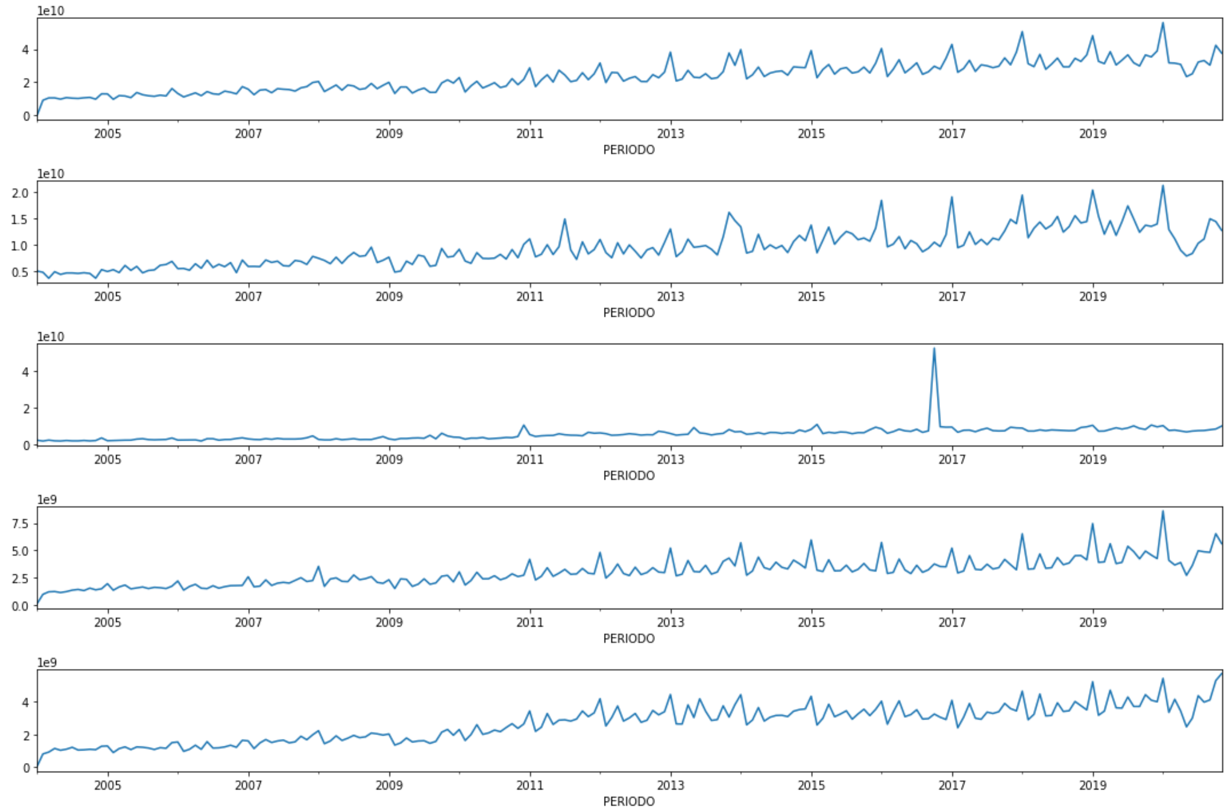
Out[11]:

	Soma
SP	4.736256e+12
RJ	1.913446e+12
DF	1.204153e+12
MG	6.118780e+11
PR	5.399147e+11

In [12]:
```
receita_estados['SP'].plot();
```



In [13]:
```
fig, (ax1,ax2,ax3, ax4, ax5) = plt.subplots(5,1, figsize=(15,10))
receita_estados['SP'].plot(ax=ax1)
receita_estados['RJ'].plot(ax=ax2)
receita_estados['DF'].plot(ax=ax3)
receita_estados['MG'].plot(ax=ax4)
receita_estados['PR'].plot(ax=ax5)
plt.tight_layout()
```



- É possível observar uma tendência de aumento da receita tributária federal em praticamente todos estados observados.
- Como forma de simplificar os estudos, analisaremos a tendência Geral (soma da receita de todos os estados), para isso criaremos uma coluna com a soma de todos os Estados
- Analisaremos também o Estado de São Paulo, para conferir se a tendência geral se repete para um estado específico

In [14]:
```
receita_estados['total'] = receita_estados[estados].sum(axis=1)
```

In [15]:
```
receita_estados.head()
```

Out[15]:

PERIODO	AC	AL	AM	AP	BA	CE	D
2004-01-01	8196055.0	44664273.0	9819616.0	232926443.0	398719822.0	205806616.0	2.564871e+(
2004-02-01	6880044.0	29343728.0	198376255.0	6290900.0	317779982.0	149876852.0	2.128429e+(
2004-03-01	6644264.0	29646976.0	321840650.0	7000692.0	451389711.0	168632051.0	2.608416e+(
2004-04-01	7932322.0	39141205.0	265230821.0	6980236.0	414844245.0	212638649.0	2.229929e+(
2004-05-01	7408996.0	30907727.0	420825736.0	10347917.0	443559112.0	169051965.0	2.139627e+(

In [16]:
```
# Fazer uma cópia do dataframe para trabalhar

df = receita_estados.copy()
```

In [17]:
```
df = df/1000000                         # representar os valores em milhões de R$
df.index.freq = 'MS'                    # month start frequency - frequência mensal

# https://pandas.pydata.org/pandas-docs/stable/user_guide/timeseries.html#offset-
```

In [18]:
```
df.head()
```

Out[18]:

PERIODO	AC	AL	AM	AP	BA	CE	DF	
2004-01-01	8.196055	44.664273	9.819616	232.926443	398.719822	205.806616	2564.870978	267.9
2004-02-01	6.880044	29.343728	198.376255	6.290900	317.779982	149.876852	2128.428567	243.6
2004-03-01	6.644264	29.646976	321.840650	7.000692	451.389711	168.632051	2608.416177	304.(
2004-04-01	7.932322	39.141205	265.230821	6.980236	414.844245	212.638649	2229.928611	325.1
2004-05-01	7.408996	30.907727	420.825736	10.347917	443.559112	169.051965	2139.626719	350.(

In [19]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 203 entries, 2004-01-01 to 2020-11-01
Freq: MS
Data columns (total 28 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   AC      203 non-null    float64
 1   AL      203 non-null    float64
 2   AM      203 non-null    float64
 3   AP      203 non-null    float64
 4   BA      203 non-null    float64
 5   CE      203 non-null    float64
 6   DF      203 non-null    float64
 7   ES      203 non-null    float64
 8   GO      203 non-null    float64
 9   MA      203 non-null    float64
 10  MG      203 non-null    float64
 11  MS      203 non-null    float64
 12  MT      203 non-null    float64
 13  PA      203 non-null    float64
 14  PB      203 non-null    float64
 15  PE      203 non-null    float64
 16  PI      203 non-null    float64
 17  PR      203 non-null    float64
 18  RJ      203 non-null    float64
 19  RN      203 non-null    float64
 20  RO      203 non-null    float64
 21  RR      203 non-null    float64
 22  RS      203 non-null    float64
 23  SC      203 non-null    float64
 24  SE      203 non-null    float64
 25  SP      203 non-null    float64
 26  TO      203 non-null    float64
 27  total   203 non-null    float64
dtypes: float64(28)
memory usage: 46.0 KB
```

In [20]:
```
df.index
```

Out[20]:
```
DatetimeIndex(['2004-01-01', '2004-02-01', '2004-03-01', '2004-04-01',
               '2004-05-01', '2004-06-01', '2004-07-01', '2004-08-01',
               '2004-09-01', '2004-10-01',
               ...
               '2020-02-01', '2020-03-01', '2020-04-01', '2020-05-01',
               '2020-06-01', '2020-07-01', '2020-08-01', '2020-09-01',
               '2020-10-01', '2020-11-01'],
              dtype='datetime64[ns]', name='PERIODO', length=203, freq='MS')
```

In [21]:
```
df.tail()
```

Out[21]:

PERIODO	AC	AL	AM	AP	BA	CE	DF
2020-07-01	61.076365	242.598772	1067.244564	73.673689	1606.239983	1275.386502	7748.009769
2020-08-01	67.174636	240.360865	1284.699181	71.439498	2025.418303	1124.203634	7836.318896
2020-09-01	62.600098	233.863879	1154.111553	66.779225	1595.798321	1184.131617	8254.097099
2020-10-01	76.414279	303.041327	1448.325017	76.810235	2134.431851	1656.806063	8648.919115
2020-11-01	80.344635	279.494217	1511.740383	86.350712	1875.636834	1490.175851	10238.914898

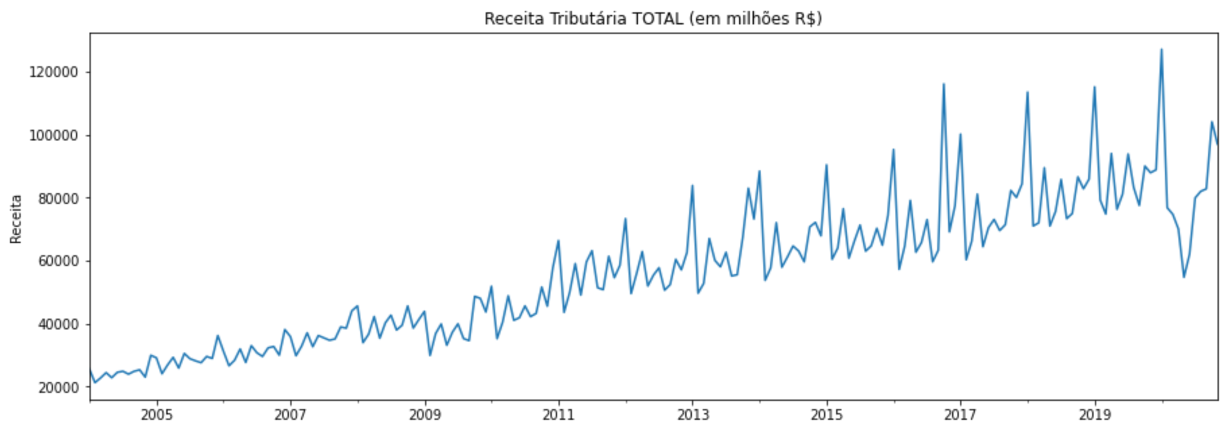
In [22]:
```
df.describe()
```

Out[22]:

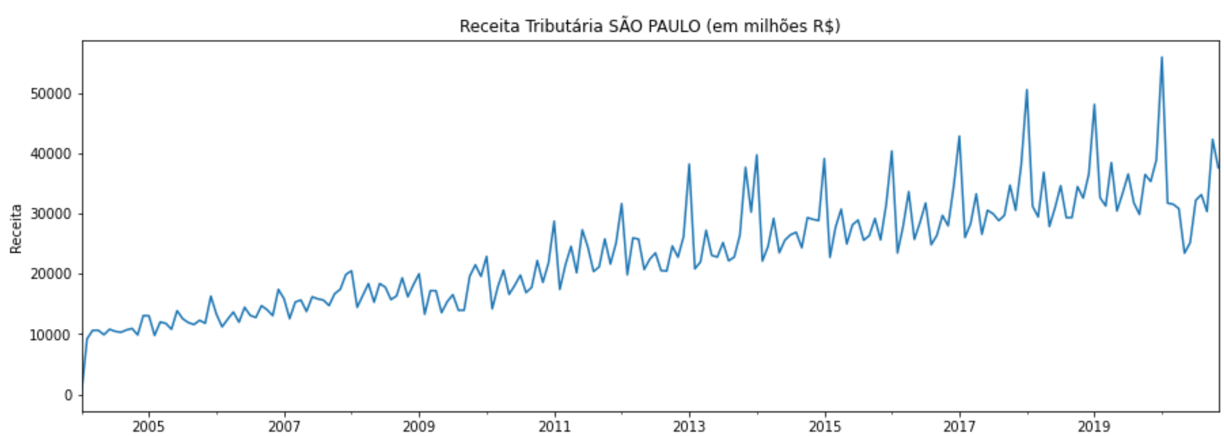
	AC	AL	AM	AP	BA	CE	DF
count	203.000000	203.000000	203.000000	203.000000	203.000000	203.000000	203.000000
mean	32.113625	126.164080	715.795859	36.461174	1080.316028	661.998276	5931.789551
std	17.798326	66.653824	260.238457	24.674666	388.676844	340.625405	4085.858470
min	6.644264	26.471482	9.819616	6.290900	317.779982	149.876852	2128.428567
25%	16.760748	66.404321	503.957670	16.967802	781.101148	356.093104	3361.509695
50%	31.939407	124.893794	743.460788	36.233122	1071.751468	651.293986	5796.539094
75%	45.515044	176.291153	897.843084	48.133151	1358.721987	902.549589	7658.122798
max	100.073573	303.041327	1511.740383	232.926443	2134.431851	1759.208303	52581.764685

Plotar os Dados

In [23]:
```
title='Receita Tributária TOTAL (em milhões R$)'
ylabel='Receita'
xlabel=''

ax = df['total'].plot(figsize=(15,5),title=title);
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```

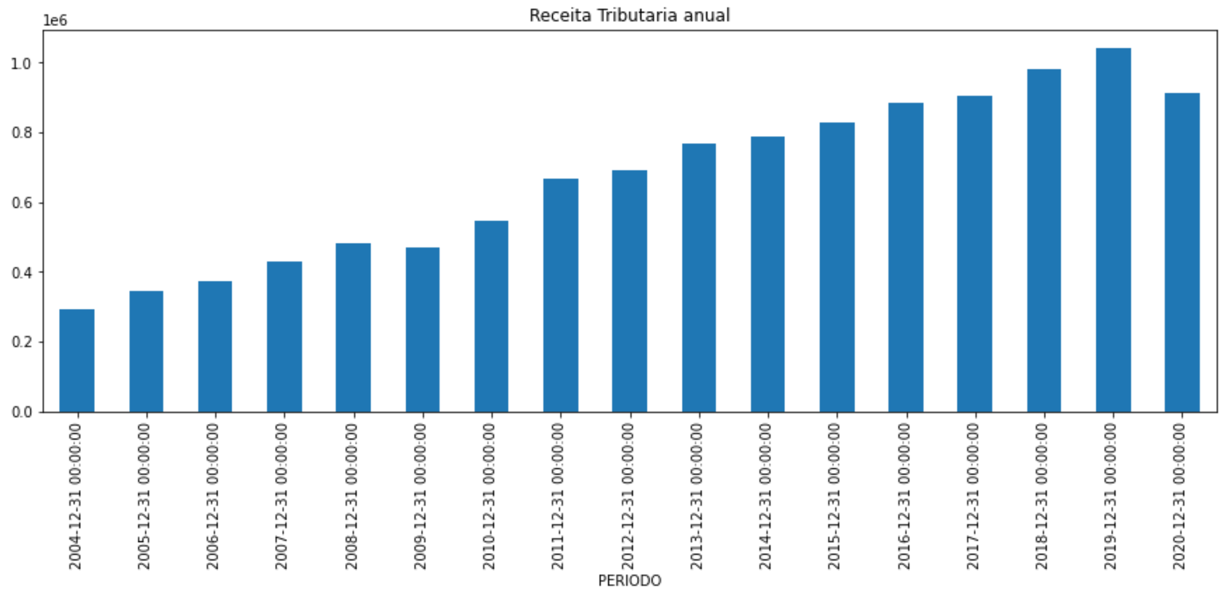


In [24]:
```
title='Receita Tributária SÃO PAULO (em milhões R$)'
ylabel='Receita'
xlabel=''

ax = df['SP'].plot(figsize=(15,5),title=title);
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



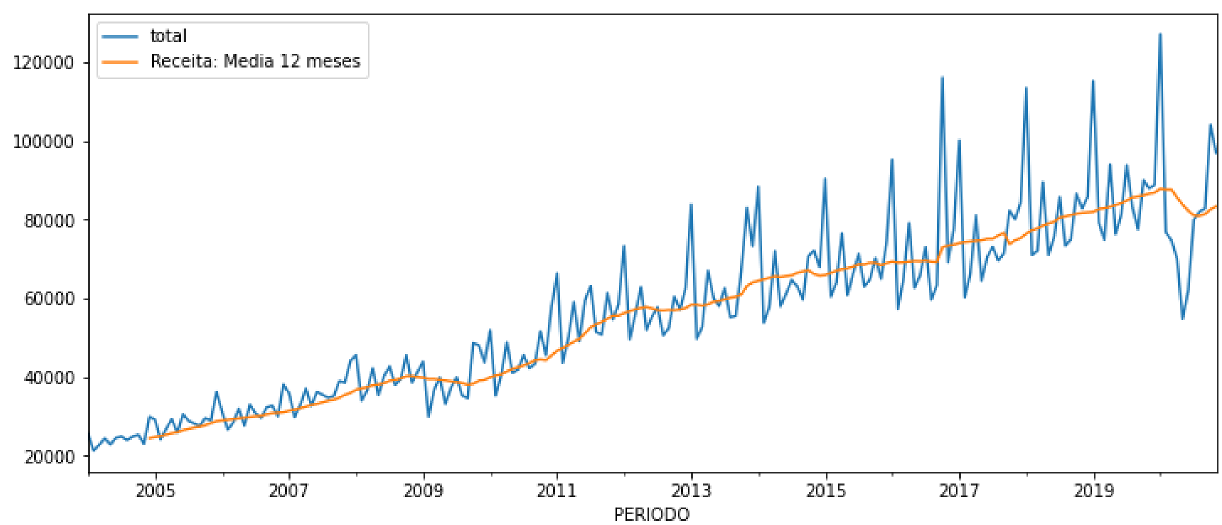
- É possível observar grande semelhança nos gráficos de São Paulo e no gráfico Geral.
- Possívelmente, pelo fato de que a Arrecadação de São Paulo representa grande parcela da Arrecadação Total do País.

In [25]:
```
# Variação por ano
df['total'].resample('A').sum().plot.bar(figsize = (15,5),x = df.index, title='Re
```



- **Será inserida uma média de 12 meses, para observar tendência**

In [26]:
```
df['Receita: Media 12 meses'] = df['total'].rolling(window=12).mean()
df[['total','Receita: Media 12 meses']].plot(figsize=(12,5)).autoscale(axis='x',t
```



Utilizando Statsmodels para obter tendência

O filtro Hodrick-Prescott (https://en.wikipedia.org/wiki/Hodrick%E2%80%93Prescott_filter) separa uma série temporal y_t em uma componente de tendência τ_t e uma componente cíclica c_t

$y_t = \tau_t + c_t$

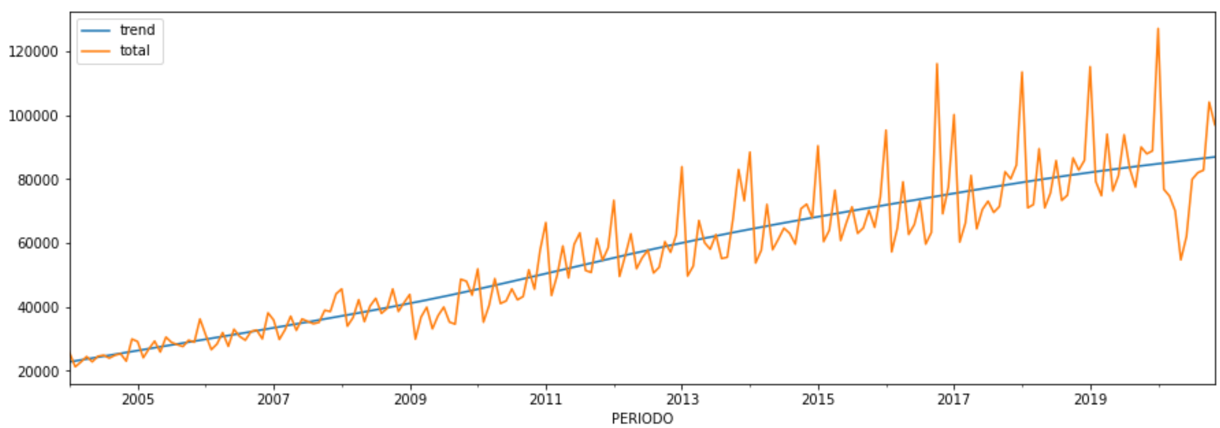
Conforme a fonte:
https://www.statsmodels.org/stable/generated/statsmodels.tsa.filters.hp_filter.hpfilter.html (https://www.statsmodels.org/stable/generated/statsmodels.tsa.filters.hp_filter.hpfilter.html)

O valor **lamb** a ser utilizado deve ser **129600** para dados mensais.

In [27]:
```
from statsmodels.tsa.filters.hp_filter import hpfilter

# Separando as variáveis
rec_cycle, rec_trend = hpfilter(df['total'], lamb=129600)
```

In [28]:
```
df['trend'] = rec_trend
```

In [29]:
```
df[['trend','total']].plot(figsize = (15,5)).autoscale(axis='x',tight=True);
```

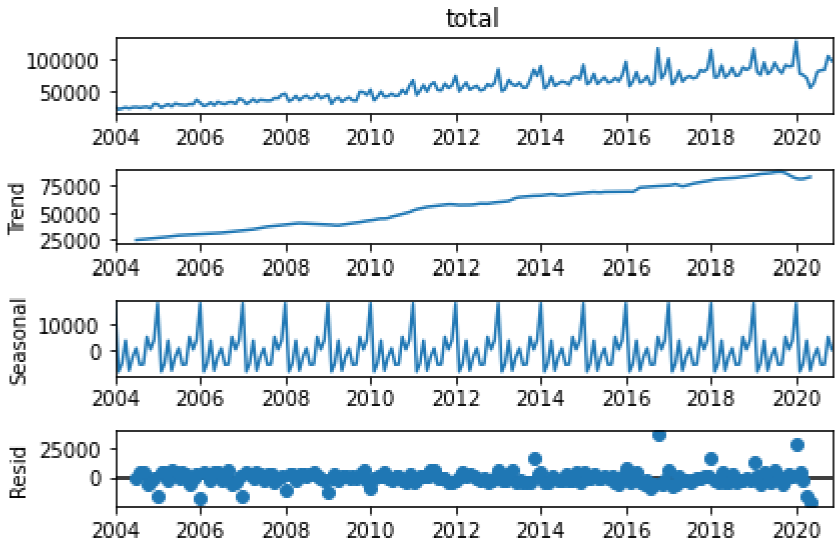


ETS

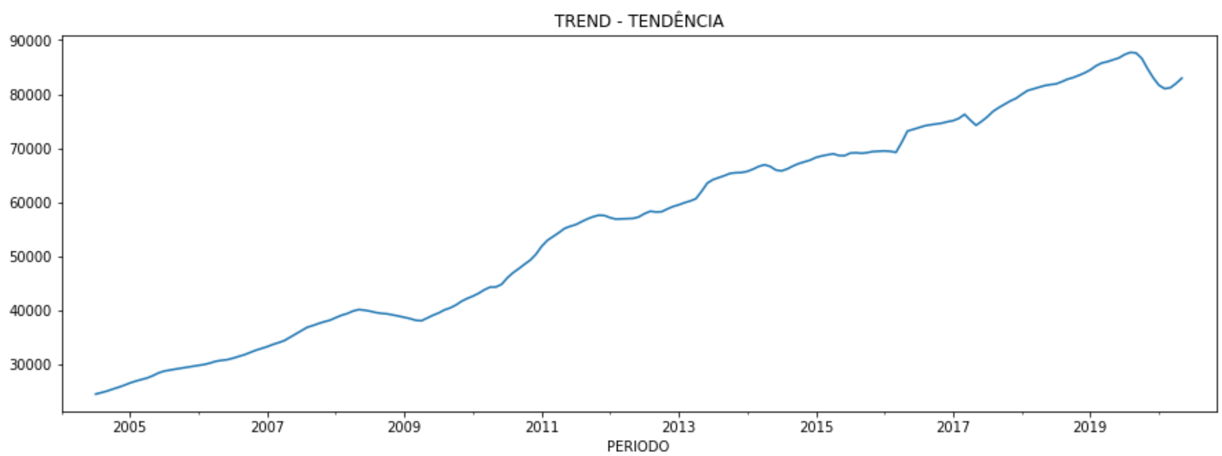
Error / Trend / Seasonality Models

A decomposição (https://en.wikipedia.org/wiki/Decomposition_of_time_series) de uma série temporal tenta isolar componentes insividuais como *erro*, *tendência*, and *sazonalidade* (ETS).

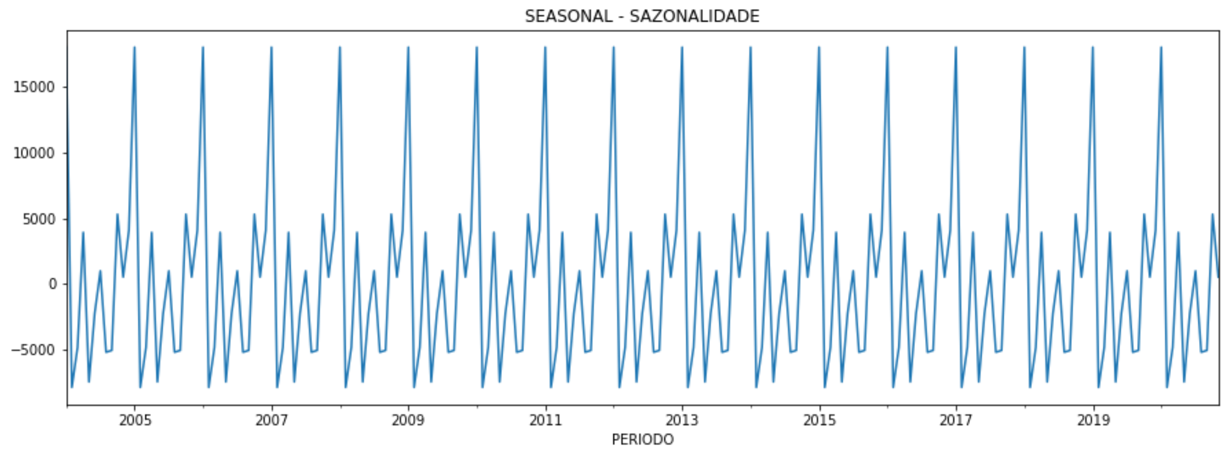
In [30]:
```
from statsmodels.tsa.seasonal import seasonal_decompose

resultado = seasonal_decompose(df['total'], model='add')
resultado.plot();
```



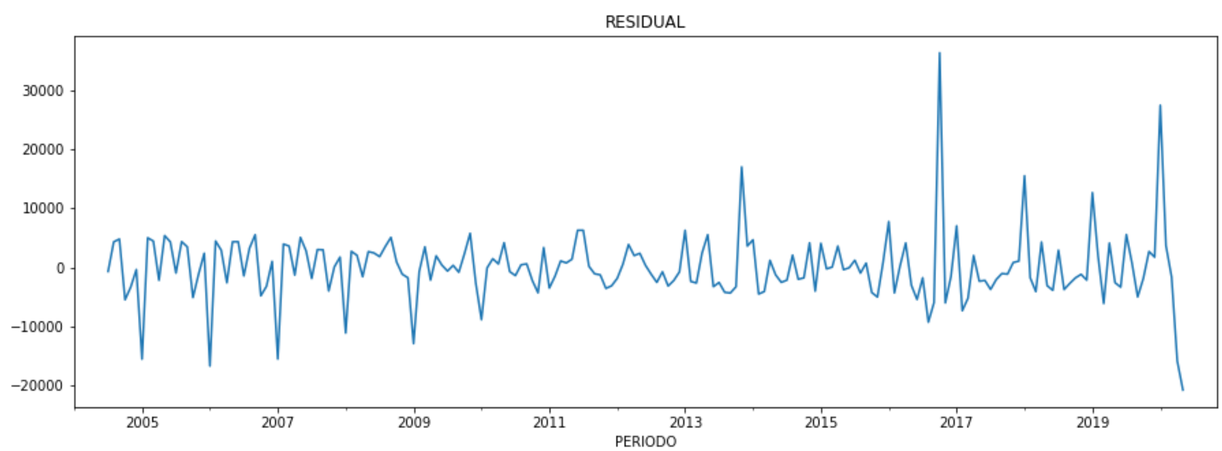
In [31]:
```
resultado.trend.plot(title='TREND - TENDÊNCIA', figsize=(15,5));
```



In [32]:
```python
resultado.seasonal.plot(title='SEASONAL - SAZONALIDADE', figsize=(15,5));
```



In [33]:
```python
resultado.resid.plot(title='RESIDUAL', figsize=(15,5));
```



Holt-Winters Methods

- *Fonte:* [*https://otexts.com/fpp2/holt-winters.html (https://otexts.com/fpp2/holt-winters.html)*](https://otexts.com/fpp2/holt-winters.html)
- Método Holt-Winters lida com casos de sazonalidade.
- Possui três equações:
  - uma para ajuste de nível
  - outra para ajuste do crescimento
  - outra para sazonalidade

Divisão dos dados

In [34]:
```
train = df.loc[:'2016-12-01']
test = df.loc['2017-01-01':]
```

In [35]:
```
from statsmodels.tsa.holtwinters import ExponentialSmoothing

fitted_model = ExponentialSmoothing(train['total'],trend='add',seasonal='add',sea
```

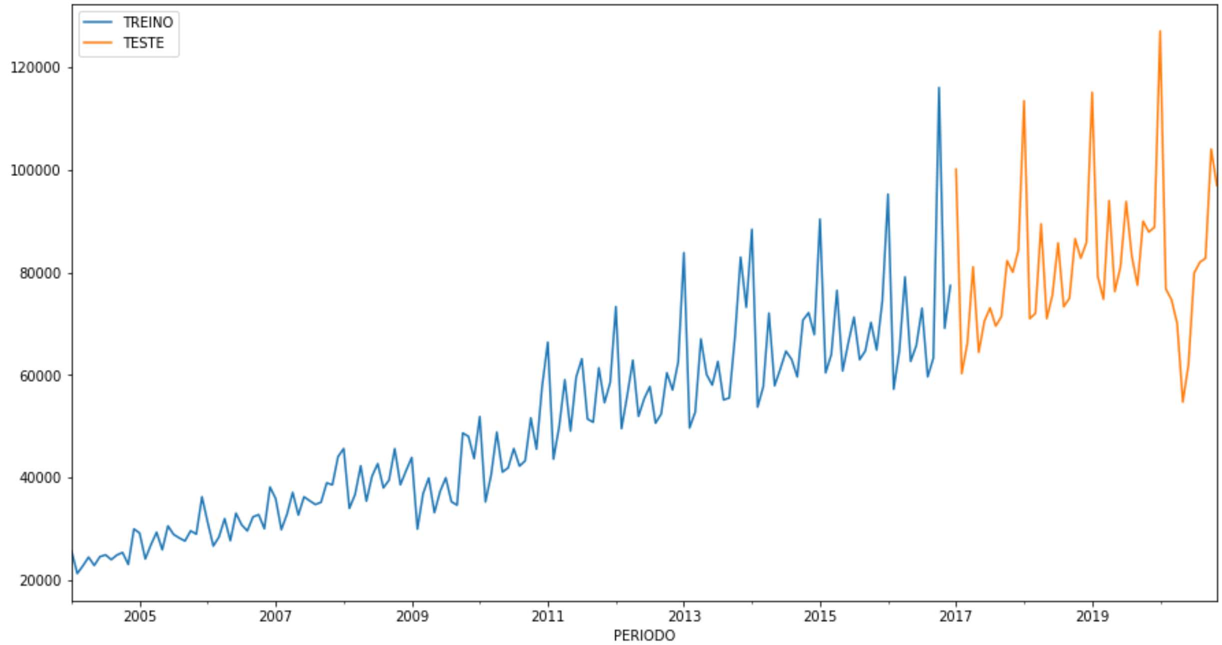
```
/usr/local/lib/python3.6/dist-packages/statsmodels/tsa/holtwinters/model.py:92
2: ConvergenceWarning: Optimization failed to converge. Check mle_retvals.
  ConvergenceWarning,
```

In [36]:
```
test_predictions = fitted_model.forecast(47).rename('Previsão - Holt-Winters')
```

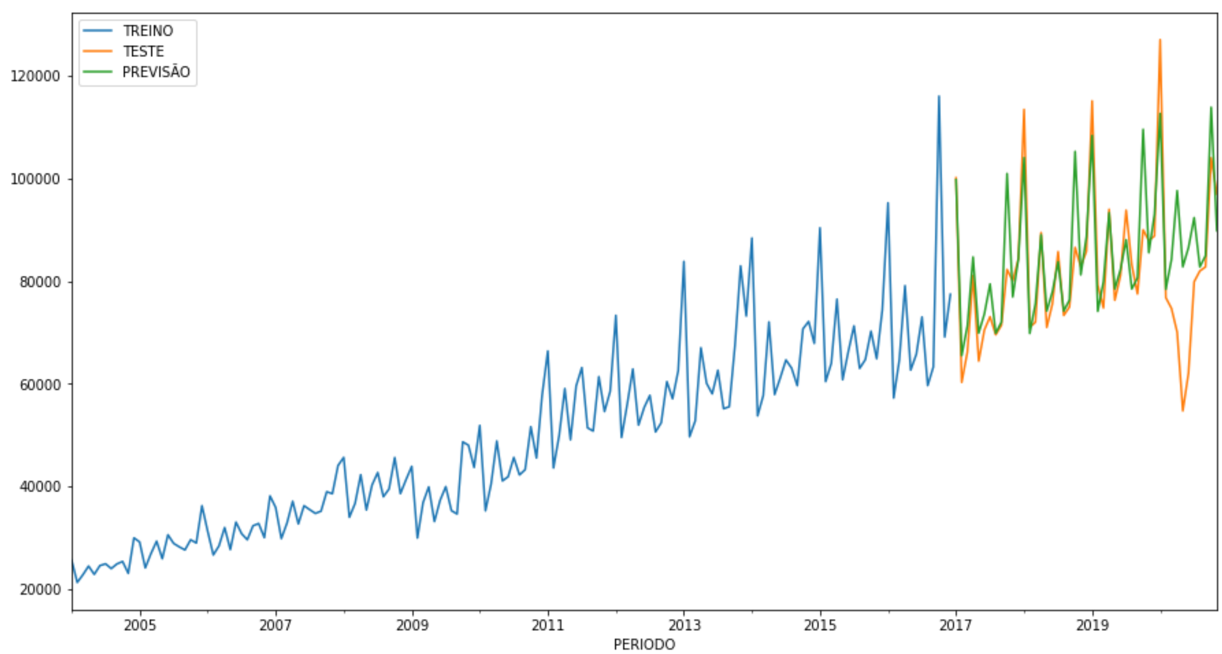
In [37]:
```python
test_predictions
```

Out[37]:
```
2017-01-01     99766.540530
2017-02-01     65490.184742
2017-03-01     71294.847855
2017-04-01     84712.339580
2017-05-01     69873.433739
2017-06-01     73623.741157
2017-07-01     79454.973457
2017-08-01     69862.045782
2017-09-01     72015.517091
2017-10-01    100983.455183
2017-11-01     76932.560039
2017-12-01     84384.348746
2018-01-01    104076.494057
2018-02-01     69800.138269
2018-03-01     75604.801381
2018-04-01     89022.293107
2018-05-01     74183.387266
2018-06-01     77933.694684
2018-07-01     83764.926984
2018-08-01     74171.999309
2018-09-01     76325.470618
2018-10-01    105293.408710
2018-11-01     81242.513566
2018-12-01     88694.302272
2019-01-01    108386.447584
2019-02-01     74110.091796
2019-03-01     79914.754908
2019-04-01     93332.246634
2019-05-01     78493.340793
2019-06-01     82243.648210
2019-07-01     88074.880511
2019-08-01     78481.952836
2019-09-01     80635.424145
2019-10-01    109603.362237
2019-11-01     85552.467093
2019-12-01     93004.255799
2020-01-01    112696.401111
2020-02-01     78420.045322
2020-03-01     84224.708435
2020-04-01     97642.200160
2020-05-01     82803.294320
2020-06-01     86553.601737
2020-07-01     92384.834038
2020-08-01     82791.906363
2020-09-01     84945.377671
2020-10-01    113913.315764
2020-11-01     89862.420619
Freq: MS, Name: Previsão - Holt-Winters, dtype: float64
```

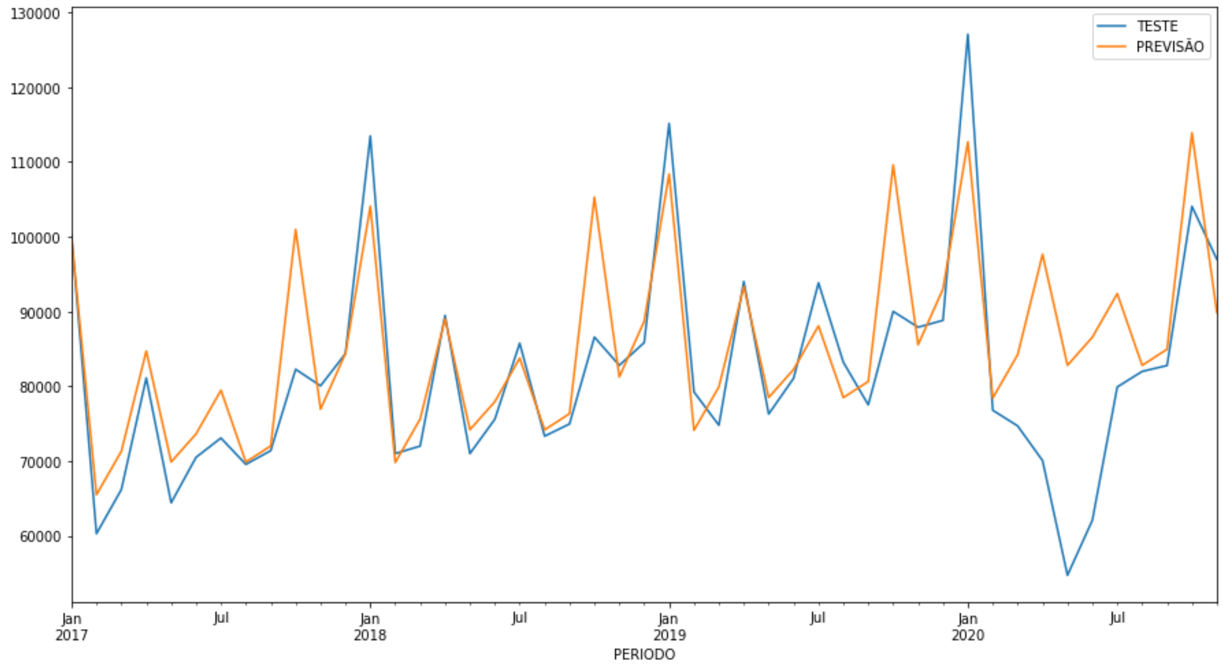
In [38]:
```
train['total'].plot(legend=True,label='TREINO')
test['total'].plot(legend=True,label='TESTE',figsize=(15,8));
```



In [39]:
```
train['total'].plot(legend=True,label='TREINO')
test['total'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions.plot(legend=True,label='PREVISÃO');
```



In [40]:
```
test['total'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions.plot(legend=True,label='PREVISÃO',xlim=['2017-01-01','2020-11-01
```



In [41]:
```
from sklearn.metrics import mean_squared_error,mean_absolute_error
```

In [42]:
```
mean_absolute_error(test['total'],test_predictions)
```

Out[42]: 6354.68830118632

In [43]:
```
mean_squared_error(test['total'],test_predictions)
```

Out[43]: 92167824.49046035

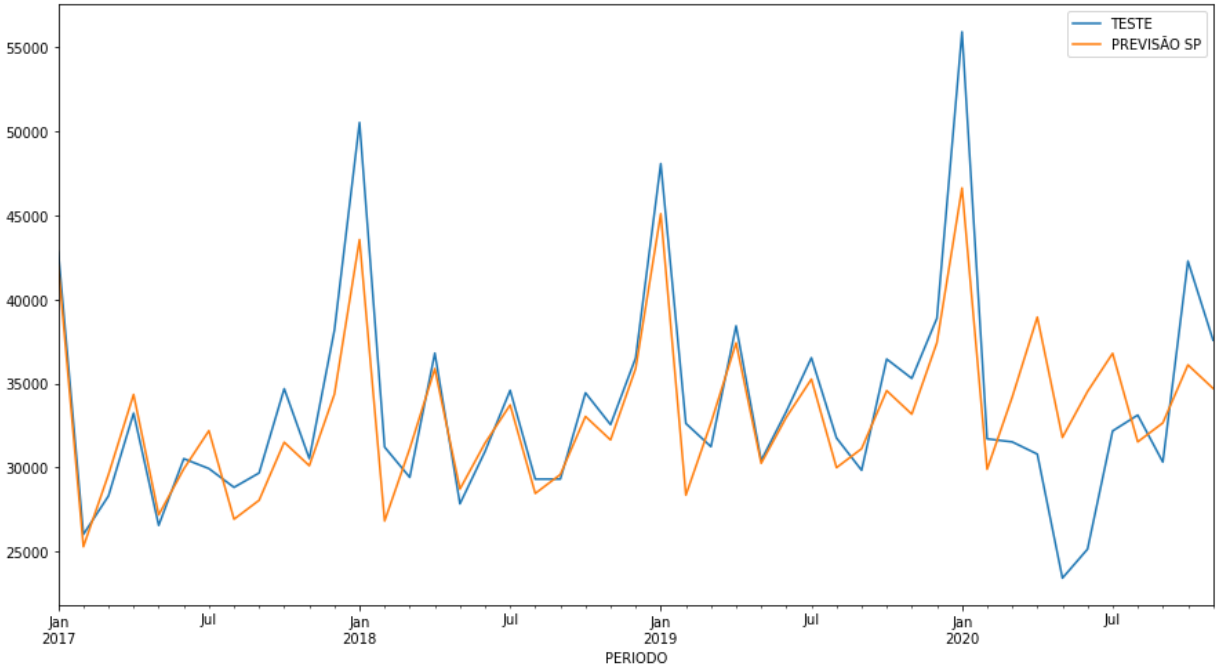
In [44]:
```
np.sqrt(mean_squared_error(test['total'],test_predictions))
```

Out[44]: 9600.40751689533

In [45]:
```
import warnings
warnings.filterwarnings("ignore")
```

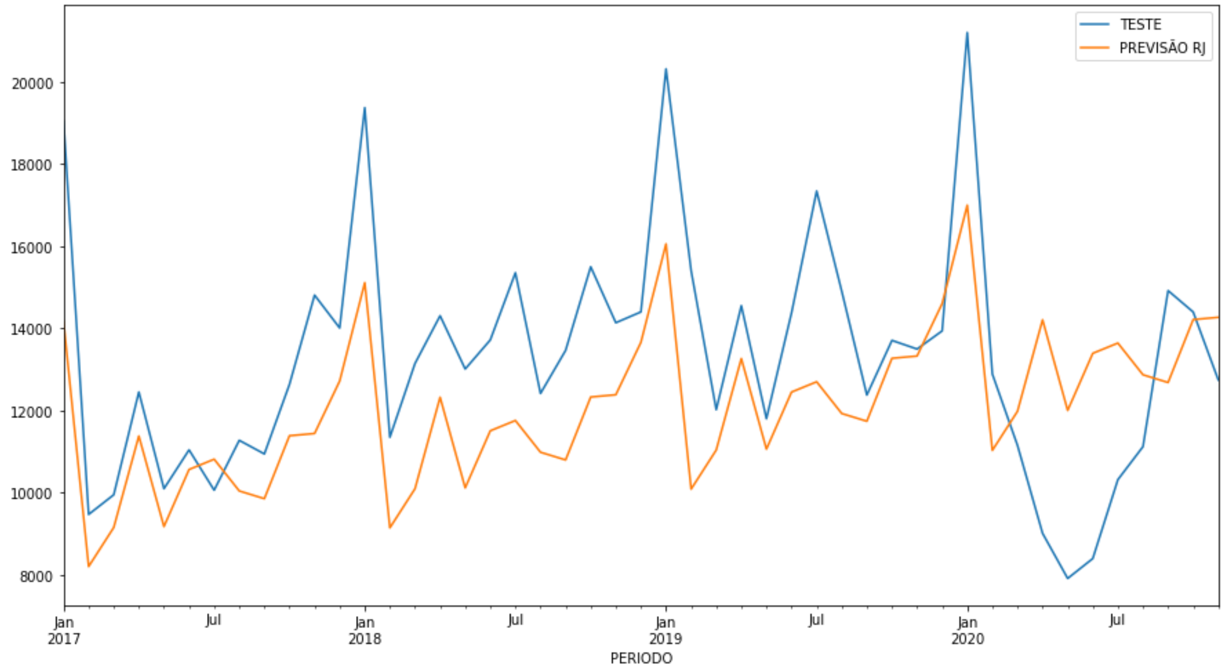
Comparando Dados: SÃO PAULO

In [46]:
```
fitted_model_SP = ExponentialSmoothing(train['SP'],trend='add',seasonal='add',sea
test_predictions_SP = fitted_model_SP.forecast(47).rename('Previsão - Holt-Winter
test['SP'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions_SP.plot(legend=True,label='PREVISÃO SP',xlim=['2017-01-01','202(
```



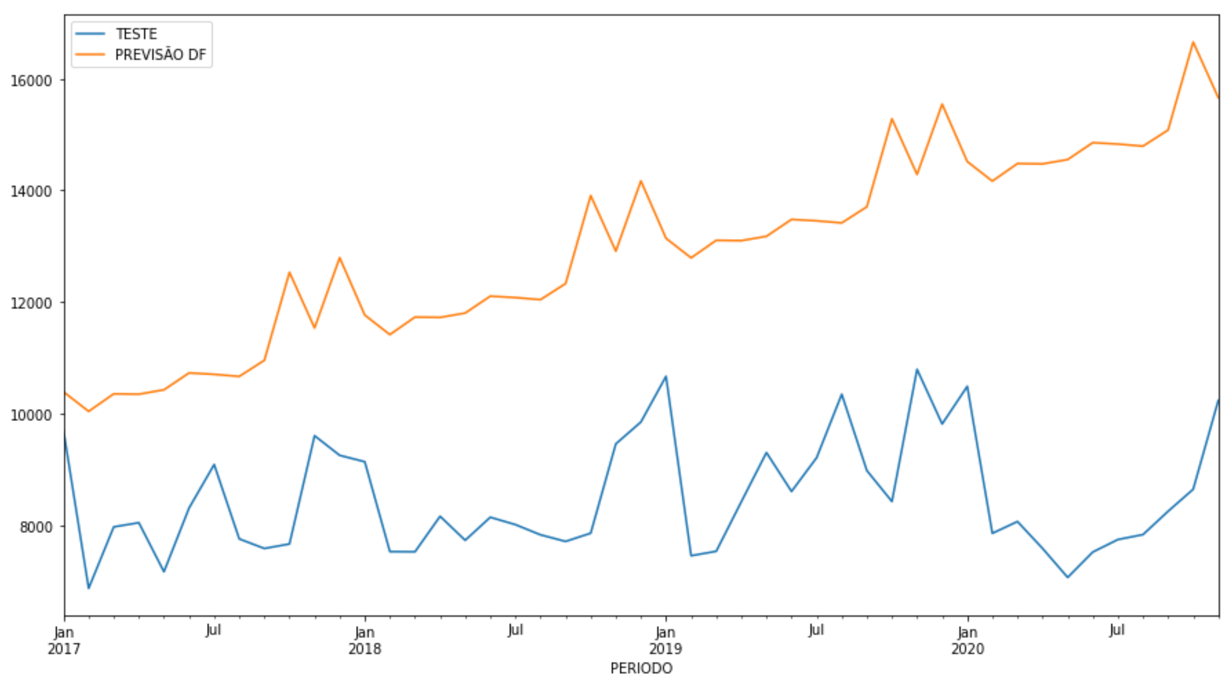
Comparando Dados: RIO DE JANEIRO

In [47]:
```
fitted_model_RJ = ExponentialSmoothing(train['RJ'],trend='add',seasonal='add',sea
test_predictions_RJ = fitted_model_RJ.forecast(47).rename('Previsão - Holt-Winter
test['RJ'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions_RJ.plot(legend=True,label='PREVISÃO RJ',xlim=['2017-01-01','2020
```



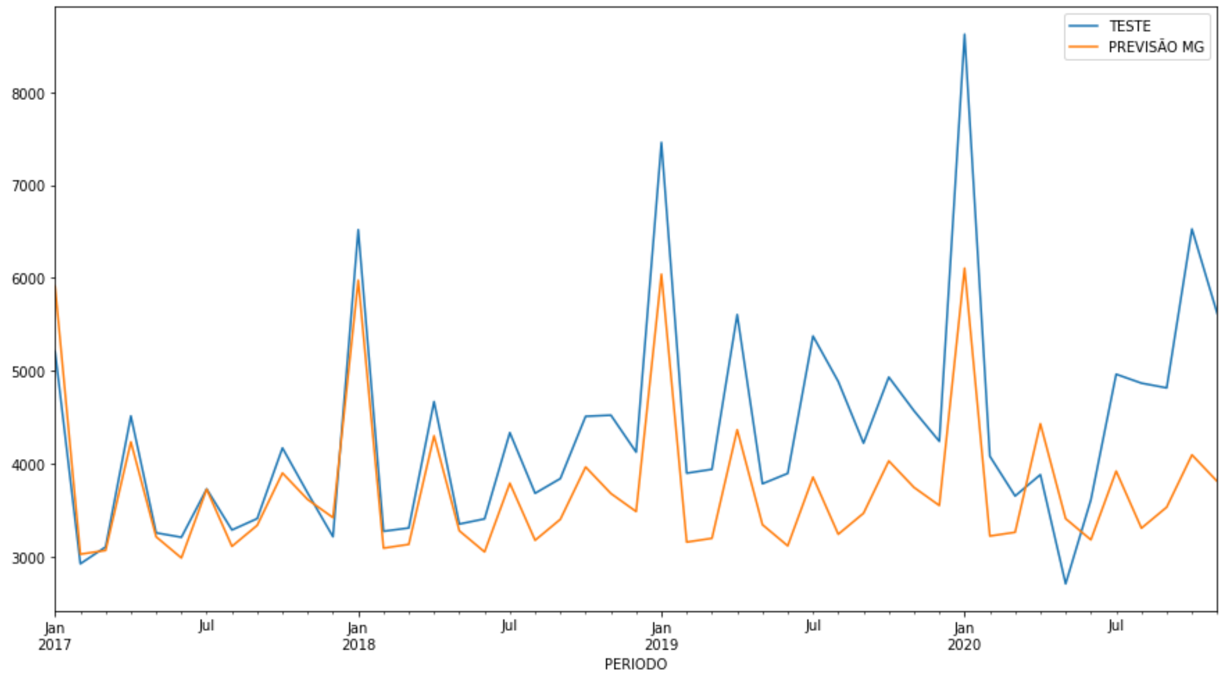
Comparando Dados: DISTRITO FEDERAL

In [48]:
```
fitted_model_DF = ExponentialSmoothing(train['DF'],trend='add',seasonal='add',sea
test_predictions_DF = fitted_model_DF.forecast(47).rename('Previsão - Holt-Winter
test['DF'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions_DF.plot(legend=True,label='PREVISÃO DF',xlim=['2017-01-01','2020
```



Comparando Dados: MINAS GERAIS

In [49]:
```
fitted_model_MG = ExponentialSmoothing(train['MG'],trend='add',seasonal='add',sea
test_predictions_MG = fitted_model_MG.forecast(47).rename('Previsão - Holt-Winter
test['MG'].plot(legend=True,label='TESTE',figsize=(15,8))
test_predictions_MG.plot(legend=True,label='PREVISÃO MG',xlim=['2017-01-01','2020
```

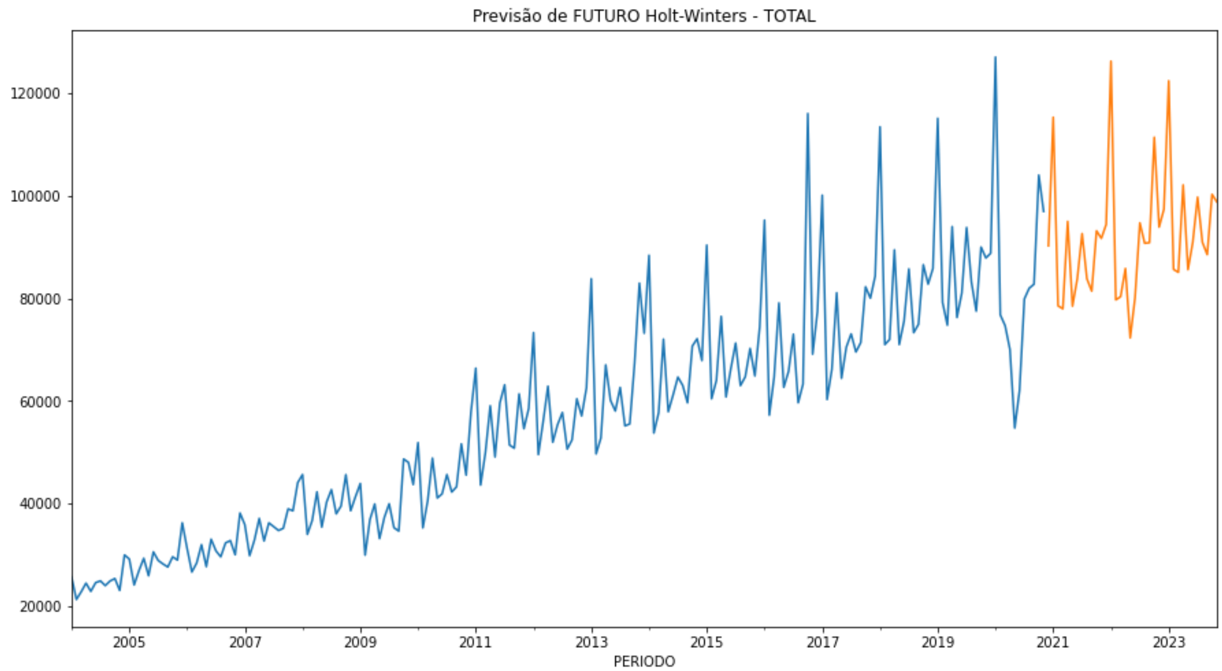


Prevendo Futuro - "Holt-Winters"

In [50]:
```
modelo_HW_final = ExponentialSmoothing(df['total'],trend='add',seasonal='add',sea
```

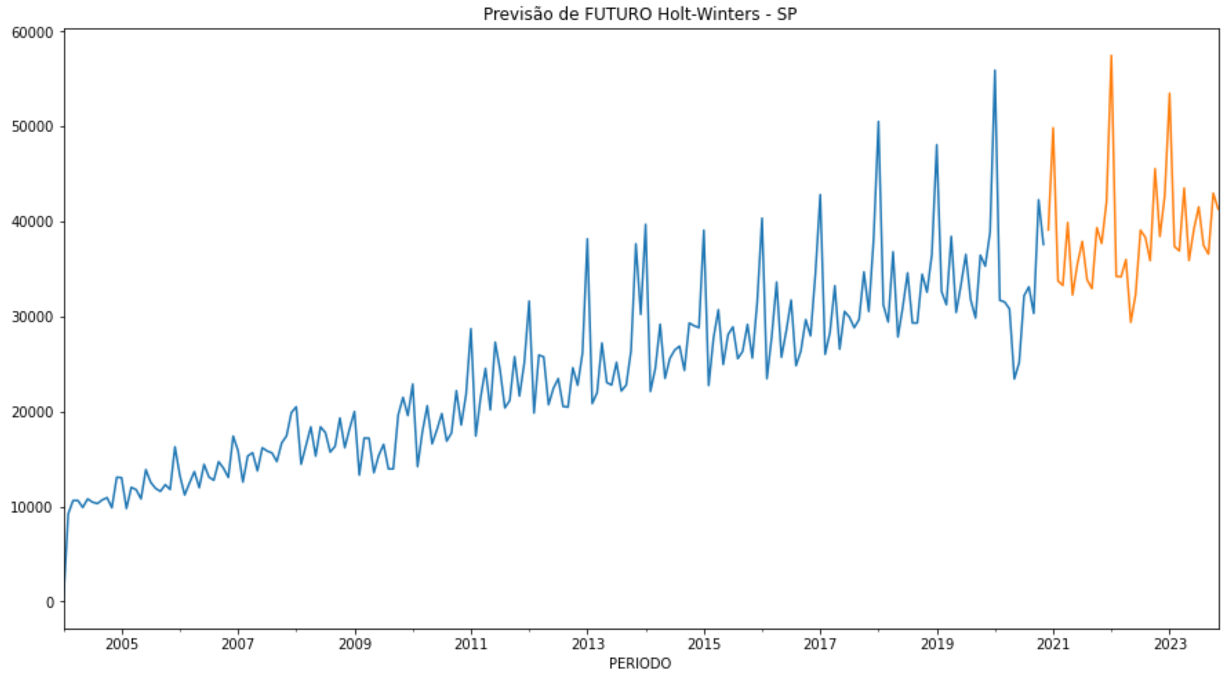
In [51]:
```
predição_HW = modelo_HW_final.forecast(36)
```

```
In [52]: df['total'].plot(figsize=(15,8), title = 'Previsão de FUTURO Holt-Winters - TOTAL
         predição_HW.plot();
```



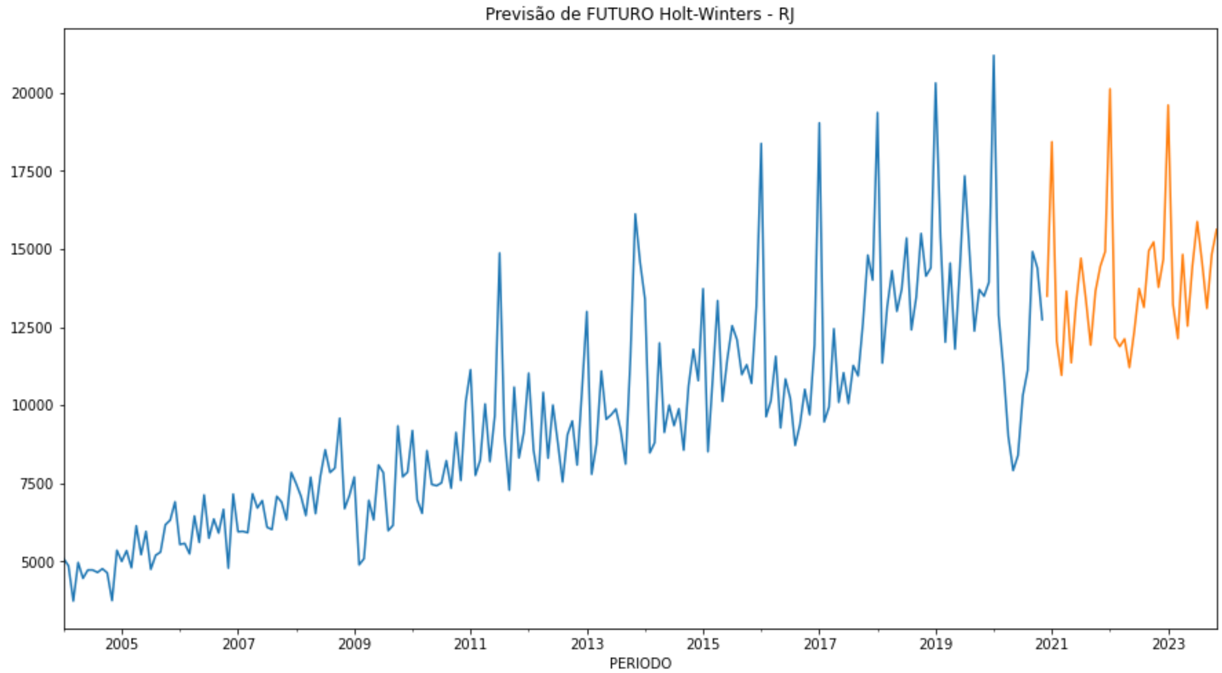
Previsão HOLT-WINTERS: SÃO PAULO

```
In [53]: modelo_HW_final_SP = ExponentialSmoothing(df['SP'],trend='add',seasonal='add',sea
predição_HW_SP = modelo_HW_final_SP.forecast(36)
df['SP'].plot(figsize=(15,8), title = 'Previsão de FUTURO Holt-Winters - SP')
predição_HW_SP.plot();
```



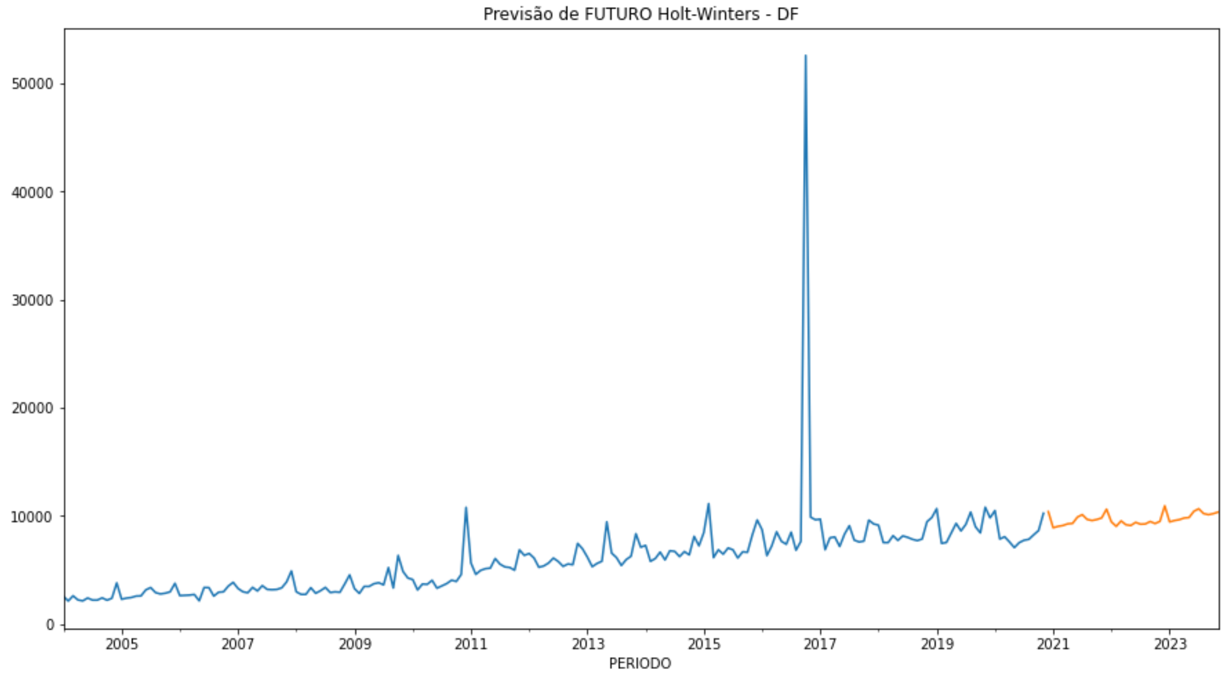
Previsão HOLT-WINTERS: RIO DE JANEIRO

In [54]:
```
modelo_HW_final_RJ = ExponentialSmoothing(df['RJ'],trend='add',seasonal='add',sea
predição_HW_RJ = modelo_HW_final_RJ.forecast(36)
df['RJ'].plot(figsize=(15,8), title = 'Previsão de FUTURO Holt-Winters - RJ')
predição_HW_RJ.plot();
```



Previsão HOLT-WINTERS: DISTRITO FEDERAL

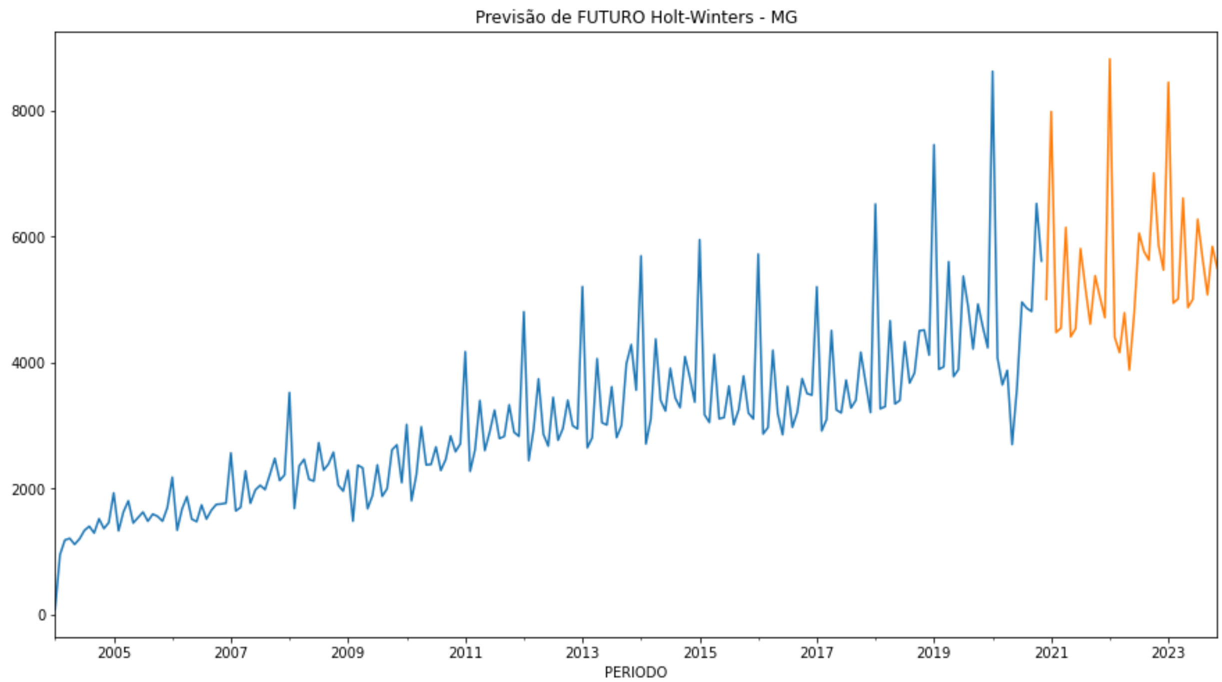
In [55]:
```
modelo_HW_final_DF = ExponentialSmoothing(df['DF'],trend='add',seasonal='add',sea
predição_HW_DF = modelo_HW_final_DF.forecast(36)
df['DF'].plot(figsize=(15,8), title = 'Previsão de FUTURO Holt-Winters - DF')
predição_HW_DF.plot();
```



- É possível observar um Outlier no DF, mas, não influenciou na previsão;
- Como objetivo do trabalho é prever da melhor maneira as datas futuras próximas, optou-se por manter os dados intactos, sem exclusão de outliers

Previsão HOLT-WINTERS: MINAS GERAIS

In [56]:
```
modelo_HW_final_MG = ExponentialSmoothing(df['MG'],trend='add',seasonal='add',sea
predição_HW_MG = modelo_HW_final_MG.forecast(36)
df['MG'].plot(figsize=(15,8), title = 'Previsão de FUTURO Holt-Winters - MG')
predição_HW_MG.plot();
```



SARIMA

Automatizar o teste de Dickey-Fuller Test Aumentado

- Código extraído do curso "Python for Time Series Data Analysis" - Jose Portilla

In [57]:

```
from statsmodels.tsa.stattools import adfuller

def adf_test(series,title=''):
    """
    Passar uma série temporal e um titulo opcional, retorna um relatório ADF
    """
    print(f'Teste de Dickey-Fuller Aumentado: {title}')
    result = adfuller(series.dropna(),autolag='AIC') # .dropna() para lidar com d

    labels = ['ADF teste estatístico','p-value','# lags used','# observações']
    out = pd.Series(result[0:4],index=labels)

    for key,val in result[4].items():
        out[f'valor crítico ({key})']=val

    print(out.to_string())          # .to_string() removes the line "dtype: float

    if result[1] <= 0.05:
        print("Fortes evidências contra a hipótese nula")
        print("Rejeita a hipótese nula")
        print("É estacionário")
    else:
        print("Fracas evidências contra a hipótese nula")
        print("Falha ao rejeitar a hipótese nula")
        print("É não-estacionária")
```

In [58]:

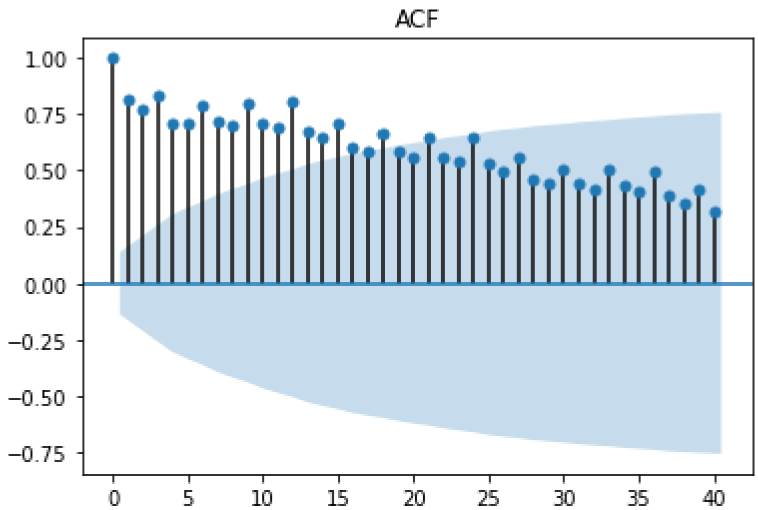
```
adf_test(df['total'])
```

```
Teste de Dickey-Fuller Aumentado:
ADF teste estatístico     -0.928537
p-value                    0.778429
# lags used               12.000000
# observações            190.000000
valor crítico (1%)        -3.465244
valor crítico (5%)        -2.876875
valor crítico (10%)       -2.574945
Fracas evidências contra a hipótese nula
Falha ao rejeitar a hipótese nula
É não-estacionária
```

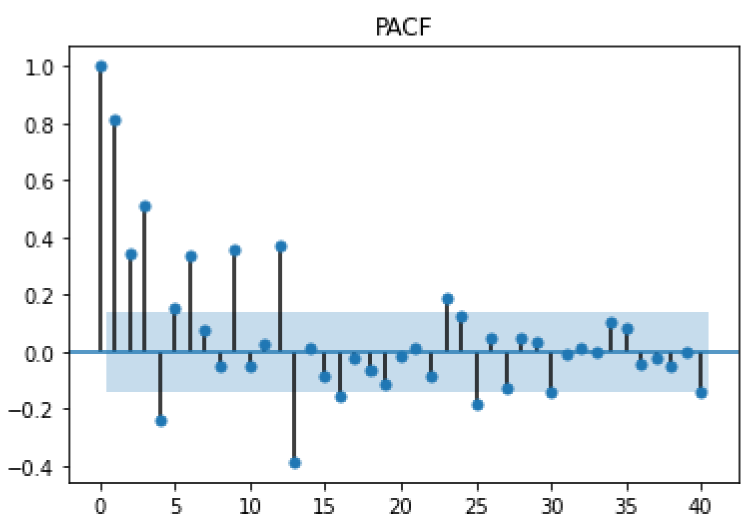
In [59]:

```
from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
```

In [60]:
```
plot_acf(df['total'],title='ACF',lags=40);
```



In [61]:
```
plot_pacf(df['total'],title='PACF',lags=40);
```



- Neste projeto vamos optar por utilizar o Auto-Arima para partir de um modelo e melhorar se houver necessidade a partir do sugerido automaticamente.

AUTO-ARIMA

Rodar `pmdarima.auto_arima` para obter as ordens recomendadas

In [62]:
```
!pip install pmdarima
```

```
Requirement already satisfied: pmdarima in /usr/local/lib/python3.6/dist-packag
es (1.8.0)
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.6/d
ist-packages (from pmdarima) (0.22.2.post1)
Requirement already satisfied: statsmodels!=0.12.0,>=0.11 in /usr/local/lib/pyt
hon3.6/dist-packages (from pmdarima) (0.12.1)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.0.0)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.6/dist-package
s (from pmdarima) (1.24.3)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/py
thon3.6/dist-packages (from pmdarima) (51.3.3)
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.1.5)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.6/dist-pa
ckages (from pmdarima) (1.4.1)
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.6/dist-p
ackages (from pmdarima) (1.19.5)
Requirement already satisfied: Cython<0.29.18,>=0.29 in /usr/local/lib/python3.
6/dist-packages (from pmdarima) (0.29.17)
Requirement already satisfied: patsy>=0.5 in /usr/local/lib/python3.6/dist-pack
ages (from statsmodels!=0.12.0,>=0.11->pmdarima) (0.5.1)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python
3.6/dist-packages (from pandas>=0.19->pmdarima) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.6/dist-pa
ckages (from pandas>=0.19->pmdarima) (2018.9)
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (f
rom patsy>=0.5->statsmodels!=0.12.0,>=0.11->pmdarima) (1.15.0)
```

In [63]:
```
# Load specific forecasting tools
from statsmodels.tsa.statespace.sarimax import SARIMAX

from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
from statsmodels.tsa.seasonal import seasonal_decompose
from pmdarima import auto_arima
```

In [64]:
```
auto_arima(df['total'],seasonal=True,m=12).summary()
```

Out[64]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	203
Model:	SARIMAX(1, 1, 1)x(1, 0, 1, 12)	**Log Likelihood**	-2056.439
Date:	Wed, 27 Jan 2021	**AIC**	4122.878
Time:	00:47:41	**BIC**	4139.419
Sample:	0	**HQIC**	4129.570
	- 203		
Covariance Type:	opg		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
ar.L1	0.3053	0.045	6.856	0.000	0.218	0.393
ma.L1	-0.9388	0.025	-37.376	0.000	-0.988	-0.890
ar.S.L12	0.9599	0.021	45.797	0.000	0.919	1.001
ma.S.L12	-0.5574	0.065	-8.641	0.000	-0.684	-0.431
sigma2	3.754e+07	1.48e-09	2.54e+16	0.000	3.75e+07	3.75e+07

Ljung-Box (L1) (Q):	0.28	**Jarque-Bera (JB):**	1475.99
Prob(Q):	0.59	**Prob(JB):**	0.00
Heteroskedasticity (H):	5.18	**Skew:**	1.48
Prob(H) (two-sided):	0.00	**Kurtosis:**	15.91

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number 1.63e+31. Standard errors may be unstable.

Ajustar modelo SARIMA(1,1,1)(1,0,1,12)

In [65]:
```
model_sarima = SARIMAX(train['total'],order=(1,1,1),seasonal_order=(1,0,1,12))
results_sarima = model_sarima.fit()
results_sarima.summary()
```

Out[65]:

SARIMAX Results

Dep. Variable:	total	**No. Observations:**	156
Model:	SARIMAX(1, 1, 1)x(1, 0, 1, 12)	**Log Likelihood**	-1567.706
Date:	Wed, 27 Jan 2021	**AIC**	3145.412
Time:	00:47:42	**BIC**	3160.629
Sample:	01-01-2004	**HQIC**	3151.593
	- 12-01-2016		
Covariance Type:	opg		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
ar.L1	0.0344	0.084	0.409	0.682	-0.130	0.199
ma.L1	-0.8434	0.043	-19.607	0.000	-0.928	-0.759
ar.S.L12	0.9161	0.044	20.799	0.000	0.830	1.002
ma.S.L12	-0.4487	0.110	-4.094	0.000	-0.663	-0.234
sigma2	3.299e+07	8.91e-09	3.7e+15	0.000	3.3e+07	3.3e+07

Ljung-Box (L1) (Q):	0.04	**Jarque-Bera (JB):**	3440.35
Prob(Q):	0.85	**Prob(JB):**	0.00
Heteroskedasticity (H):	4.81	**Skew:**	3.46
Prob(H) (two-sided):	0.00	**Kurtosis:**	25.02

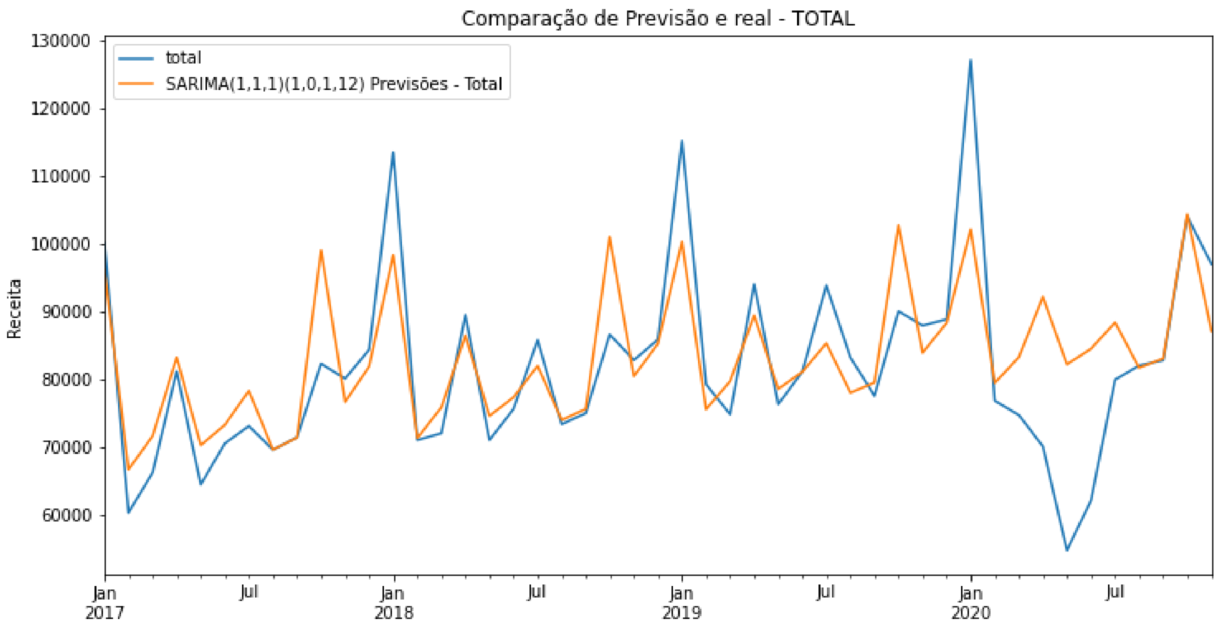
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number 2.61e+30. Standard errors may be unstable.

In [66]:
```
# Obtendo a previsão
inicio = len(train)
fim = len(train)+len(test)-1
predictions_sarima = results_sarima.predict(start=inicio, end=fim, dynamic=False,
```

In [67]:
```python
# Comparando a previsão com os valores esperados
for i in range(len(predictions_sarima)):
    print(f"predicted={predictions_sarima[i]:<11.10}, expected={test['total'][i]}
```

```
predicted=96132.29197, expected=100148.014887
predicted=66647.0279 , expected=60271.210211
predicted=71591.87634, expected=66180.971782
predicted=83183.67703, expected=81104.88495
predicted=70226.73635, expected=64408.962779
predicted=73224.8447 , expected=70492.986619
predicted=78279.46844, expected=73068.612012
predicted=69558.88379, expected=69546.521454
predicted=71349.71285, expected=71386.20537
predicted=99041.13095, expected=82264.797024
predicted=76605.22694, expected=80051.392213
predicted=81859.1369 , expected=84362.419145
predicted=98317.56027, expected=113487.900056
predicted=71282.30501, expected=70991.134079
predicted=75811.61562, expected=71996.079915
predicted=86431.13813, expected=89475.144442
predicted=74560.94712, expected=70993.247359
predicted=77307.59206, expected=75584.604725
predicted=81938.26422, expected=85761.283777
predicted=73949.11   , expected=73320.790611
predicted=75589.73505, expected=74954.670554
predicted=100958.5628, expected=86573.445882
predicted=80404.44807, expected=82794.053635
predicted=85217.69152, expected=85836.545963
predicted=100295.6809, expected=115156.05987
predicted=75527.98097, expected=79227.857591
predicted=79677.40012, expected=74780.339767
predicted=89406.22066, expected=94012.352179
predicted=78531.6302 , expected=76280.085212
predicted=81047.90301, expected=81062.515638
predicted=85290.18211, expected=93835.852349
predicted=77971.11032, expected=83194.34128
predicted=79474.12956, expected=77513.170611
predicted=102715.1719, expected=90010.849224
predicted=83885.01328, expected=87895.453667
predicted=88294.55068, expected=88814.829095
predicted=102107.8885, expected=127098.927142
predicted=79417.55505, expected=76788.052027
predicted=83218.94576, expected=74687.579872
predicted=92131.77107, expected=70049.45318
predicted=82169.27617, expected=54707.408815
predicted=84474.49907, expected=62066.20432225001
predicted=88360.9612 , expected=79896.14779777
predicted=81655.76933, expected=81982.6376846
predicted=83032.72432, expected=82771.66024725001
predicted=104324.4471, expected=104062.37133639999
predicted=87073.64952, expected=96987.19743353999
```

In [68]:
```python
# Plotar previsões em relação aos valores conhecidos
title = 'Comparação de Previsão e real - TOTAL'
ylabel='Receita'
xlabel=''

ax = test['total'].plot(legend=True,figsize=(12,6),title=title)
predictions_sarima.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Comparando Dados: SÃO PAULO

In [69]:
```
auto_arima(df['SP'],seasonal=True,m=12).summary()
```

Out[69]:

SARIMAX Results

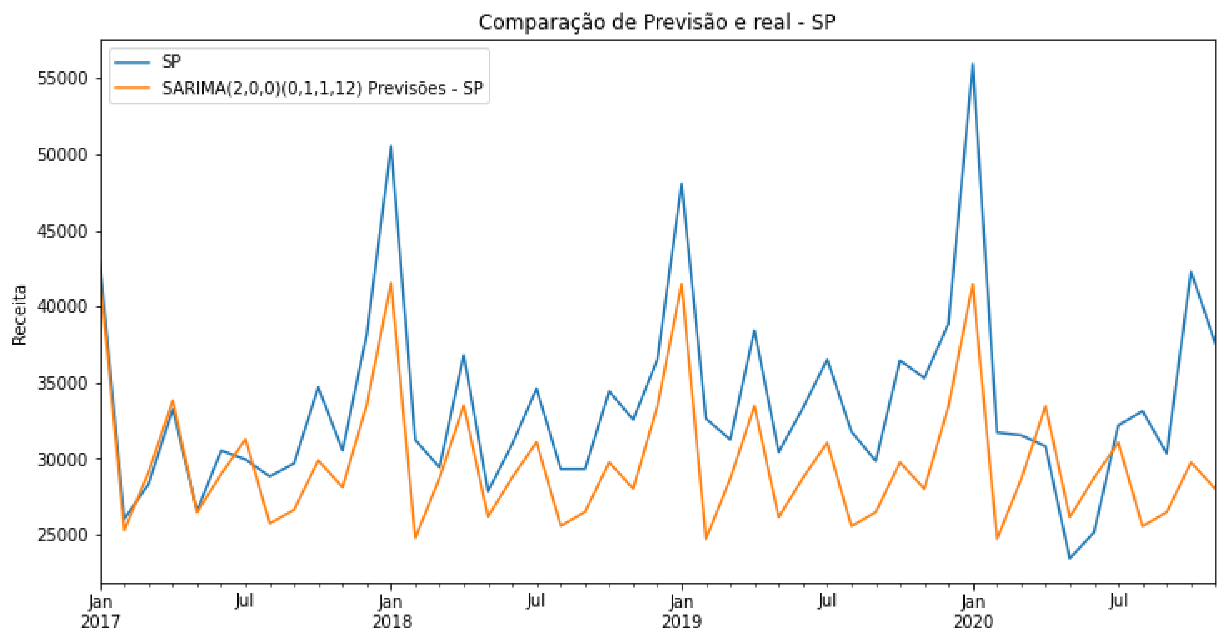
Dep. Variable:	y	**No. Observations:**	203
Model:	SARIMAX(2, 0, 0)x(0, 1, [1], 12)	**Log Likelihood**	-1753.527
Date:	Wed, 27 Jan 2021	**AIC**	3517.054
Time:	00:48:17	**BIC**	3533.316
Sample:	0	**HQIC**	3523.641
	- 203		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	790.5877	151.586	5.215	0.000	493.484	1087.691
ar.L1	0.3770	0.071	5.292	0.000	0.237	0.517
ar.L2	0.1650	0.077	2.137	0.033	0.014	0.316
ma.S.L12	-0.3937	0.066	-5.933	0.000	-0.524	-0.264
sigma2	5.877e+06	3.56e+05	16.519	0.000	5.18e+06	6.57e+06

Ljung-Box (L1) (Q):	0.31	**Jarque-Bera (JB):**	275.38
Prob(Q):	0.58	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.95	**Skew:**	0.75
Prob(H) (two-sided):	0.01	**Kurtosis:**	8.69

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [70]:
```
# Plotar previsões em relação aos valores conhecidos
title = 'Comparação de Previsão e real - SP'
ylabel='Receita'
xlabel=''

model_sarima_SP = SARIMAX(train['SP'],order=(2,0,0),seasonal_order=(0,1,1,12))
results_sarima_SP = model_sarima_SP.fit()

# Obtendo a previsão
inicio = len(train)
fim = len(train)+len(test)-1
predictions_sarima_SP = results_sarima_SP.predict(start=inicio, end=fim, dynamic=

ax = test['SP'].plot(legend=True,figsize=(12,6),title=title)
predictions_sarima_SP.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Comparando Dados: RIO DE JANEIRO

In [71]:
```
auto_arima(df['RJ'],seasonal=True,m=12).summary()
```

Out[71]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	203
Model:	SARIMAX(5, 1, 0)x(1, 0, [1], 12)	**Log Likelihood**	-1760.599
Date:	Wed, 27 Jan 2021	**AIC**	3537.198
Time:	00:50:18	**BIC**	3563.664
Sample:	0	**HQIC**	3547.906
	- 203		
Covariance Type:	opg		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
ar.L1	-0.4060	0.064	-6.302	0.000	-0.532	-0.280
ar.L2	-0.4395	0.073	-6.028	0.000	-0.582	-0.297
ar.L3	-0.2792	0.077	-3.603	0.000	-0.431	-0.127
ar.L4	-0.2147	0.079	-2.724	0.006	-0.369	-0.060
ar.L5	-0.2138	0.069	-3.121	0.002	-0.348	-0.080
ar.S.L12	0.9199	0.050	18.246	0.000	0.821	1.019
ma.S.L12	-0.5469	0.100	-5.483	0.000	-0.742	-0.351
sigma2	2.053e+06	1.47e+05	13.936	0.000	1.76e+06	2.34e+06

Ljung-Box (L1) (Q):	0.14	**Jarque-Bera (JB):**	88.52
Prob(Q):	0.70	**Prob(JB):**	0.00
Heteroskedasticity (H):	4.80	**Skew:**	0.65
Prob(H) (two-sided):	0.00	**Kurtosis:**	5.97

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

```
In [72]: auto_arima(df['RJ'], start_p=1, start_q=1,
                                max_p=4, max_q=4, m=12,
                                seasonal=True,
                                d=1,D=1, trace=True,
                                error_action='ignore',
                                suppress_warnings=True,
                                stepwise=False)
```

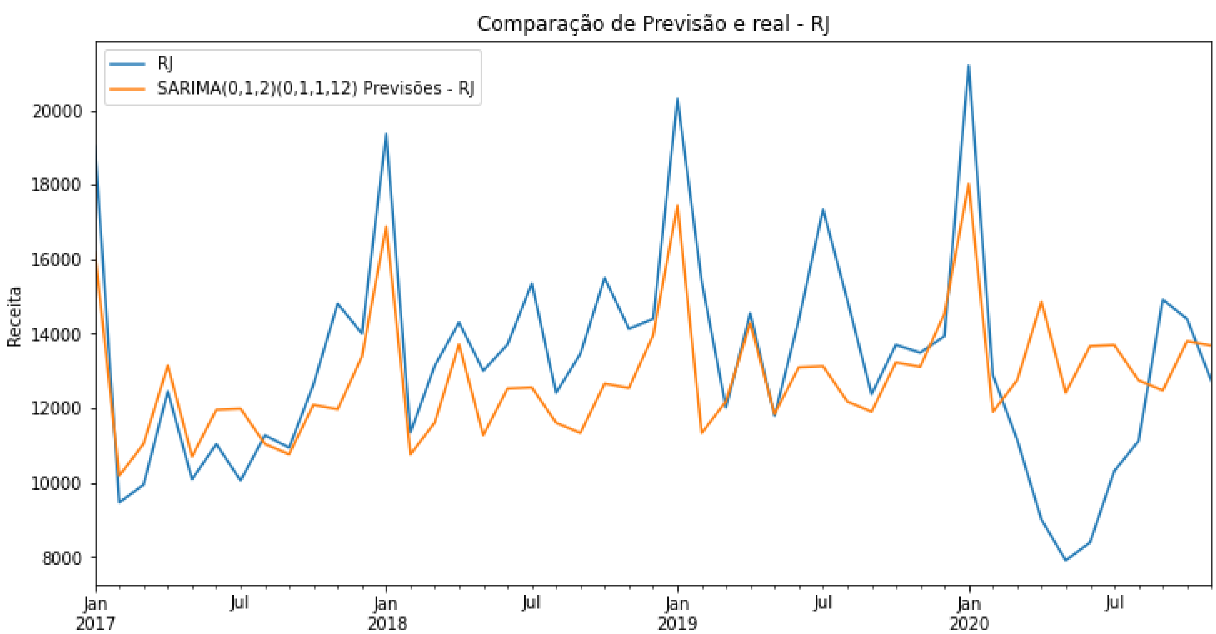
```
ARIMA(0,1,0)(0,1,0)[12]             : AIC=3409.351, Time=0.04 sec
ARIMA(0,1,0)(0,1,1)[12]             : AIC=3355.348, Time=0.41 sec
ARIMA(0,1,0)(0,1,2)[12]             : AIC=3356.373, Time=1.28 sec
ARIMA(0,1,0)(1,1,0)[12]             : AIC=3369.118, Time=0.14 sec
ARIMA(0,1,0)(1,1,1)[12]             : AIC=3356.575, Time=0.67 sec
ARIMA(0,1,0)(1,1,2)[12]             : AIC=inf, Time=2.12 sec
ARIMA(0,1,0)(2,1,0)[12]             : AIC=3361.071, Time=0.39 sec
ARIMA(0,1,0)(2,1,1)[12]             : AIC=3358.029, Time=1.89 sec
ARIMA(0,1,0)(2,1,2)[12]             : AIC=3359.099, Time=3.58 sec
ARIMA(0,1,1)(0,1,0)[12]             : AIC=3383.440, Time=0.09 sec
ARIMA(0,1,1)(0,1,1)[12]             : AIC=3330.660, Time=0.72 sec
ARIMA(0,1,1)(0,1,2)[12]             : AIC=3331.958, Time=1.85 sec
ARIMA(0,1,1)(1,1,0)[12]             : AIC=3349.638, Time=0.59 sec
ARIMA(0,1,1)(1,1,1)[12]             : AIC=3332.251, Time=0.95 sec
ARIMA(0,1,1)(1,1,2)[12]             : AIC=3332.507, Time=5.33 sec
ARIMA(0,1,1)(2,1,0)[12]             : AIC=3334.370, Time=1.66 sec
ARIMA(0,1,1)(2,1,1)[12]             : AIC=3331.056, Time=2.30 sec
ARIMA(0,1,1)(2,1,2)[12]             : AIC=3330.186, Time=4.26 sec
ARIMA(0,1,2)(0,1,0)[12]             : AIC=3368.793, Time=0.11 sec
ARIMA(0,1,2)(0,1,1)[12]             : AIC=3314.719, Time=1.24 sec
ARIMA(0,1,2)(0,1,2)[12]             : AIC=3315.425, Time=2.03 sec
ARIMA(0,1,2)(1,1,0)[12]             : AIC=3329.891, Time=0.79 sec
ARIMA(0,1,2)(1,1,1)[12]             : AIC=3315.840, Time=1.38 sec
ARIMA(0,1,2)(1,1,2)[12]             : AIC=3318.263, Time=4.90 sec
ARIMA(0,1,2)(2,1,0)[12]             : AIC=3318.830, Time=2.13 sec
ARIMA(0,1,2)(2,1,1)[12]             : AIC=3316.260, Time=3.07 sec
ARIMA(0,1,3)(0,1,0)[12]             : AIC=3370.470, Time=0.20 sec
ARIMA(0,1,3)(0,1,1)[12]             : AIC=inf, Time=1.96 sec
ARIMA(0,1,3)(0,1,2)[12]             : AIC=3317.130, Time=3.05 sec
ARIMA(0,1,3)(1,1,0)[12]             : AIC=3331.702, Time=1.17 sec
ARIMA(0,1,3)(1,1,1)[12]             : AIC=3317.480, Time=1.90 sec
ARIMA(0,1,3)(2,1,0)[12]             : AIC=3320.635, Time=2.62 sec
ARIMA(0,1,4)(0,1,0)[12]             : AIC=3372.375, Time=0.24 sec
ARIMA(0,1,4)(0,1,1)[12]             : AIC=inf, Time=1.59 sec
ARIMA(0,1,4)(1,1,0)[12]             : AIC=3333.702, Time=1.25 sec
ARIMA(1,1,0)(0,1,0)[12]             : AIC=3401.399, Time=0.05 sec
ARIMA(1,1,0)(0,1,1)[12]             : AIC=3347.430, Time=0.64 sec
ARIMA(1,1,0)(0,1,2)[12]             : AIC=3348.794, Time=1.62 sec
ARIMA(1,1,0)(1,1,0)[12]             : AIC=3363.735, Time=0.66 sec
ARIMA(1,1,0)(1,1,1)[12]             : AIC=3348.972, Time=0.83 sec
ARIMA(1,1,0)(1,1,2)[12]             : AIC=inf, Time=2.93 sec
ARIMA(1,1,0)(2,1,0)[12]             : AIC=3352.751, Time=1.59 sec
ARIMA(1,1,0)(2,1,1)[12]             : AIC=3349.736, Time=2.33 sec
ARIMA(1,1,0)(2,1,2)[12]             : AIC=3350.270, Time=4.20 sec
ARIMA(1,1,1)(0,1,0)[12]             : AIC=inf, Time=0.27 sec
ARIMA(1,1,1)(0,1,1)[12]             : AIC=inf, Time=1.32 sec
ARIMA(1,1,1)(0,1,2)[12]             : AIC=inf, Time=3.54 sec
ARIMA(1,1,1)(1,1,0)[12]             : AIC=inf, Time=1.15 sec
ARIMA(1,1,1)(1,1,1)[12]             : AIC=inf, Time=1.90 sec
```

```
 ARIMA(1,1,1)(1,1,2)[12]             : AIC=inf, Time=6.12 sec
 ARIMA(1,1,1)(2,1,0)[12]             : AIC=inf, Time=2.53 sec
 ARIMA(1,1,1)(2,1,1)[12]             : AIC=inf, Time=4.07 sec
 ARIMA(1,1,2)(0,1,0)[12]             : AIC=inf, Time=0.58 sec
 ARIMA(1,1,2)(0,1,1)[12]             : AIC=inf, Time=2.24 sec
 ARIMA(1,1,2)(0,1,2)[12]             : AIC=inf, Time=4.56 sec
 ARIMA(1,1,2)(1,1,0)[12]             : AIC=3331.700, Time=1.27 sec
 ARIMA(1,1,2)(1,1,1)[12]             : AIC=3317.476, Time=1.84 sec
 ARIMA(1,1,2)(2,1,0)[12]             : AIC=inf, Time=4.73 sec
 ARIMA(1,1,3)(0,1,0)[12]             : AIC=3370.225, Time=0.32 sec
 ARIMA(1,1,3)(0,1,1)[12]             : AIC=inf, Time=2.76 sec
 ARIMA(1,1,3)(1,1,0)[12]             : AIC=3333.651, Time=2.01 sec
 ARIMA(1,1,4)(0,1,0)[12]             : AIC=3371.718, Time=0.43 sec
 ARIMA(2,1,0)(0,1,0)[12]             : AIC=3381.130, Time=0.09 sec
 ARIMA(2,1,0)(0,1,1)[12]             : AIC=3331.068, Time=0.83 sec
 ARIMA(2,1,0)(0,1,2)[12]             : AIC=3332.088, Time=1.96 sec
 ARIMA(2,1,0)(1,1,0)[12]             : AIC=3345.134, Time=1.03 sec
 ARIMA(2,1,0)(1,1,1)[12]             : AIC=3332.419, Time=1.18 sec
 ARIMA(2,1,0)(1,1,2)[12]             : AIC=3333.935, Time=5.34 sec
 ARIMA(2,1,0)(2,1,0)[12]             : AIC=3341.887, Time=0.76 sec
 ARIMA(2,1,0)(2,1,1)[12]             : AIC=3332.776, Time=2.87 sec
 ARIMA(2,1,1)(0,1,0)[12]             : AIC=inf, Time=0.61 sec
 ARIMA(2,1,1)(0,1,1)[12]             : AIC=inf, Time=1.27 sec
 ARIMA(2,1,1)(0,1,2)[12]             : AIC=inf, Time=4.86 sec
 ARIMA(2,1,1)(1,1,0)[12]             : AIC=inf, Time=2.08 sec
 ARIMA(2,1,1)(1,1,1)[12]             : AIC=inf, Time=2.56 sec
 ARIMA(2,1,1)(2,1,0)[12]             : AIC=inf, Time=5.26 sec
 ARIMA(2,1,2)(0,1,0)[12]             : AIC=inf, Time=1.08 sec
 ARIMA(2,1,2)(0,1,1)[12]             : AIC=inf, Time=2.46 sec
 ARIMA(2,1,2)(1,1,0)[12]             : AIC=3333.696, Time=2.47 sec
 ARIMA(2,1,3)(0,1,0)[12]             : AIC=3368.181, Time=0.66 sec
 ARIMA(3,1,0)(0,1,0)[12]             : AIC=3375.600, Time=0.12 sec
 ARIMA(3,1,0)(0,1,1)[12]             : AIC=3327.077, Time=0.98 sec
 ARIMA(3,1,0)(0,1,2)[12]             : AIC=3328.426, Time=2.33 sec
 ARIMA(3,1,0)(1,1,0)[12]             : AIC=3342.652, Time=1.11 sec
 ARIMA(3,1,0)(1,1,1)[12]             : AIC=3328.675, Time=1.65 sec
 ARIMA(3,1,0)(2,1,0)[12]             : AIC=3330.098, Time=2.37 sec
 ARIMA(3,1,1)(0,1,0)[12]             : AIC=inf, Time=0.77 sec
 ARIMA(3,1,1)(0,1,1)[12]             : AIC=inf, Time=2.01 sec
 ARIMA(3,1,1)(1,1,0)[12]             : AIC=inf, Time=2.19 sec
 ARIMA(3,1,2)(0,1,0)[12]             : AIC=inf, Time=0.84 sec
 ARIMA(4,1,0)(0,1,0)[12]             : AIC=3377.600, Time=0.16 sec
 ARIMA(4,1,0)(0,1,1)[12]             : AIC=3327.343, Time=1.28 sec
 ARIMA(4,1,0)(1,1,0)[12]             : AIC=3341.717, Time=1.48 sec
 ARIMA(4,1,1)(0,1,0)[12]             : AIC=inf, Time=1.11 sec

Best model:  ARIMA(0,1,2)(0,1,1)[12]
Total fit time: 170.354 seconds
```

Out[72]:
```
ARIMA(maxiter=50, method='lbfgs', order=(0, 1, 2), out_of_sample_size=0,
      scoring='mse', scoring_args={}, seasonal_order=(0, 1, 1, 12),
      start_params=None, suppress_warnings=True, trend=None,
      with_intercept=False)
```

In [73]:

```
# Plotar previsões em relação aos valores conhecidos
title = 'Comparação de Previsão e real - RJ'
ylabel='Receita'
xlabel=''

model_sarima_RJ = SARIMAX(train['RJ'],order=(0,1,2),seasonal_order=(0,1,1,12))
results_sarima_RJ = model_sarima_RJ.fit()

# Obtendo a previsão
inicio = len(train)
fim = len(train)+len(test)-1
predictions_sarima_RJ = results_sarima_RJ.predict(start=inicio, end=fim, dynamic=

ax = test['RJ'].plot(legend=True,figsize=(12,6),title=title)
predictions_sarima_RJ.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Comparando Dados: DISTRITO FEDERAL

In [74]:
```python
auto_arima(df['DF'], start_p=1, start_q=1,
                          max_p=4, max_q=4, m=12,
                          seasonal=True,
                          d=1,D=1, trace=True,
                          error_action='ignore',
                          suppress_warnings=True,
                          stepwise=False)
```

```
 ARIMA(0,1,0)(0,1,0)[12]             : AIC=3886.998, Time=0.03 sec
 ARIMA(0,1,0)(0,1,1)[12]             : AIC=inf, Time=0.39 sec
 ARIMA(0,1,0)(0,1,2)[12]             : AIC=inf, Time=1.39 sec
 ARIMA(0,1,0)(1,1,0)[12]             : AIC=3834.123, Time=0.12 sec
 ARIMA(0,1,0)(1,1,1)[12]             : AIC=inf, Time=0.86 sec
 ARIMA(0,1,0)(1,1,2)[12]             : AIC=inf, Time=4.17 sec
 ARIMA(0,1,0)(2,1,0)[12]             : AIC=3816.879, Time=0.40 sec
 ARIMA(0,1,0)(2,1,1)[12]             : AIC=inf, Time=2.03 sec
 ARIMA(0,1,0)(2,1,2)[12]             : AIC=3806.781, Time=0.84 sec
 ARIMA(0,1,1)(0,1,0)[12]             : AIC=inf, Time=0.17 sec
 ARIMA(0,1,1)(0,1,1)[12]             : AIC=inf, Time=0.90 sec
 ARIMA(0,1,1)(0,1,2)[12]             : AIC=inf, Time=3.18 sec
 ARIMA(0,1,1)(1,1,0)[12]             : AIC=inf, Time=0.67 sec
 ARIMA(0,1,1)(1,1,1)[12]             : AIC=inf, Time=1.67 sec
 ARIMA(0,1,1)(1,1,2)[12]             : AIC=inf, Time=6.51 sec
 ARIMA(0,1,1)(2,1,0)[12]             : AIC=inf, Time=1.92 sec
 ARIMA(0,1,1)(2,1,1)[12]             : AIC=inf, Time=4.35 sec
 ARIMA(0,1,1)(2,1,2)[12]             : AIC=inf, Time=6.88 sec
 ARIMA(0,1,2)(0,1,0)[12]             : AIC=inf, Time=0.32 sec
 ARIMA(0,1,2)(0,1,1)[12]             : AIC=inf, Time=1.41 sec
 ARIMA(0,1,2)(0,1,2)[12]             : AIC=inf, Time=4.05 sec
 ARIMA(0,1,2)(1,1,0)[12]             : AIC=inf, Time=1.08 sec
 ARIMA(0,1,2)(1,1,1)[12]             : AIC=inf, Time=1.39 sec
 ARIMA(0,1,2)(1,1,2)[12]             : AIC=inf, Time=4.96 sec
 ARIMA(0,1,2)(2,1,0)[12]             : AIC=inf, Time=2.46 sec
 ARIMA(0,1,2)(2,1,1)[12]             : AIC=inf, Time=3.42 sec
 ARIMA(0,1,3)(0,1,0)[12]             : AIC=inf, Time=0.66 sec
 ARIMA(0,1,3)(0,1,1)[12]             : AIC=inf, Time=1.49 sec
 ARIMA(0,1,3)(0,1,2)[12]             : AIC=inf, Time=3.75 sec
 ARIMA(0,1,3)(1,1,0)[12]             : AIC=inf, Time=1.28 sec
 ARIMA(0,1,3)(1,1,1)[12]             : AIC=inf, Time=2.85 sec
 ARIMA(0,1,3)(2,1,0)[12]             : AIC=inf, Time=3.41 sec
 ARIMA(0,1,4)(0,1,0)[12]             : AIC=inf, Time=0.57 sec
 ARIMA(0,1,4)(0,1,1)[12]             : AIC=inf, Time=2.40 sec
 ARIMA(0,1,4)(1,1,0)[12]             : AIC=inf, Time=1.57 sec
 ARIMA(1,1,0)(0,1,0)[12]             : AIC=3838.533, Time=0.06 sec
 ARIMA(1,1,0)(0,1,1)[12]             : AIC=inf, Time=0.97 sec
 ARIMA(1,1,0)(0,1,2)[12]             : AIC=inf, Time=1.98 sec
 ARIMA(1,1,0)(1,1,0)[12]             : AIC=3791.984, Time=0.20 sec
 ARIMA(1,1,0)(1,1,1)[12]             : AIC=inf, Time=1.18 sec
 ARIMA(1,1,0)(1,1,2)[12]             : AIC=inf, Time=4.60 sec
 ARIMA(1,1,0)(2,1,0)[12]             : AIC=3764.913, Time=1.84 sec
 ARIMA(1,1,0)(2,1,1)[12]             : AIC=inf, Time=2.43 sec
 ARIMA(1,1,0)(2,1,2)[12]             : AIC=inf, Time=3.00 sec
 ARIMA(1,1,1)(0,1,0)[12]             : AIC=inf, Time=0.34 sec
 ARIMA(1,1,1)(0,1,1)[12]             : AIC=inf, Time=1.55 sec
 ARIMA(1,1,1)(0,1,2)[12]             : AIC=inf, Time=4.66 sec
 ARIMA(1,1,1)(1,1,0)[12]             : AIC=inf, Time=1.04 sec
 ARIMA(1,1,1)(1,1,1)[12]             : AIC=inf, Time=2.62 sec
```

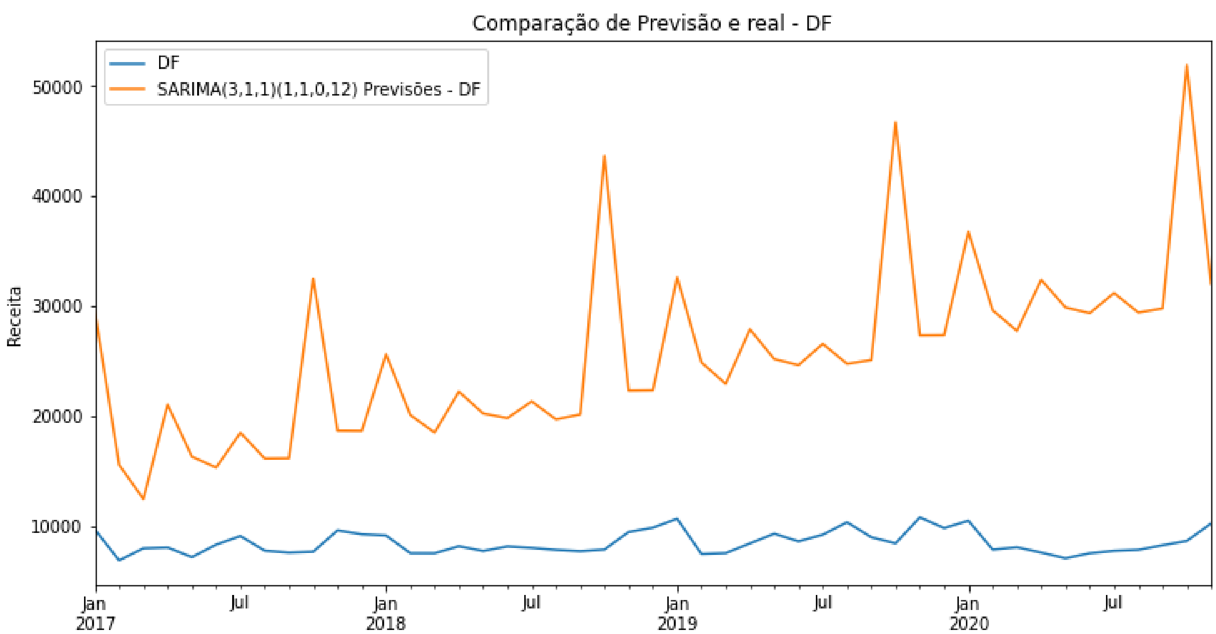
```
 ARIMA(1,1,1)(1,1,2)[12]             : AIC=inf, Time=5.38 sec
 ARIMA(1,1,1)(2,1,0)[12]             : AIC=inf, Time=2.74 sec
 ARIMA(1,1,1)(2,1,1)[12]             : AIC=inf, Time=4.48 sec
 ARIMA(1,1,2)(0,1,0)[12]             : AIC=inf, Time=0.40 sec
 ARIMA(1,1,2)(0,1,1)[12]             : AIC=inf, Time=2.05 sec
 ARIMA(1,1,2)(0,1,2)[12]             : AIC=inf, Time=4.17 sec
 ARIMA(1,1,2)(1,1,0)[12]             : AIC=inf, Time=1.47 sec
 ARIMA(1,1,2)(1,1,1)[12]             : AIC=inf, Time=5.18 sec
 ARIMA(1,1,2)(2,1,0)[12]             : AIC=inf, Time=4.77 sec
 ARIMA(1,1,3)(0,1,0)[12]             : AIC=inf, Time=0.78 sec
 ARIMA(1,1,3)(0,1,1)[12]             : AIC=inf, Time=3.02 sec
 ARIMA(1,1,3)(1,1,0)[12]             : AIC=inf, Time=2.06 sec
 ARIMA(1,1,4)(0,1,0)[12]             : AIC=inf, Time=1.11 sec
 ARIMA(2,1,0)(0,1,0)[12]             : AIC=3816.348, Time=0.08 sec
 ARIMA(2,1,0)(0,1,1)[12]             : AIC=inf, Time=1.62 sec
 ARIMA(2,1,0)(0,1,2)[12]             : AIC=inf, Time=2.29 sec
 ARIMA(2,1,0)(1,1,0)[12]             : AIC=3771.049, Time=0.29 sec
 ARIMA(2,1,0)(1,1,1)[12]             : AIC=inf, Time=2.32 sec
 ARIMA(2,1,0)(1,1,2)[12]             : AIC=inf, Time=4.85 sec
 ARIMA(2,1,0)(2,1,0)[12]             : AIC=3757.876, Time=0.65 sec
 ARIMA(2,1,0)(2,1,1)[12]             : AIC=inf, Time=4.25 sec
 ARIMA(2,1,1)(0,1,0)[12]             : AIC=inf, Time=0.38 sec
 ARIMA(2,1,1)(0,1,1)[12]             : AIC=inf, Time=2.02 sec
 ARIMA(2,1,1)(0,1,2)[12]             : AIC=inf, Time=4.99 sec
 ARIMA(2,1,1)(1,1,0)[12]             : AIC=inf, Time=1.63 sec
 ARIMA(2,1,1)(1,1,1)[12]             : AIC=inf, Time=2.95 sec
 ARIMA(2,1,1)(2,1,0)[12]             : AIC=inf, Time=3.56 sec
 ARIMA(2,1,2)(0,1,0)[12]             : AIC=inf, Time=0.66 sec
 ARIMA(2,1,2)(0,1,1)[12]             : AIC=inf, Time=2.75 sec
 ARIMA(2,1,2)(1,1,0)[12]             : AIC=inf, Time=3.10 sec
 ARIMA(2,1,3)(0,1,0)[12]             : AIC=inf, Time=1.44 sec
 ARIMA(3,1,0)(0,1,0)[12]             : AIC=3808.279, Time=0.10 sec
 ARIMA(3,1,0)(0,1,1)[12]             : AIC=inf, Time=1.98 sec
 ARIMA(3,1,0)(0,1,2)[12]             : AIC=inf, Time=4.06 sec
 ARIMA(3,1,0)(1,1,0)[12]             : AIC=3764.819, Time=0.37 sec
 ARIMA(3,1,0)(1,1,1)[12]             : AIC=inf, Time=1.66 sec
 ARIMA(3,1,0)(2,1,0)[12]             : AIC=3750.906, Time=0.80 sec
 ARIMA(3,1,1)(0,1,0)[12]             : AIC=inf, Time=0.40 sec
 ARIMA(3,1,1)(0,1,1)[12]             : AIC=inf, Time=2.56 sec
 ARIMA(3,1,1)(1,1,0)[12]             : AIC=3743.501, Time=1.02 sec
 ARIMA(3,1,2)(0,1,0)[12]             : AIC=inf, Time=0.54 sec
 ARIMA(4,1,0)(0,1,0)[12]             : AIC=3801.215, Time=0.13 sec
 ARIMA(4,1,0)(0,1,1)[12]             : AIC=inf, Time=1.66 sec
 ARIMA(4,1,0)(1,1,0)[12]             : AIC=3757.206, Time=0.50 sec
 ARIMA(4,1,1)(0,1,0)[12]             : AIC=inf, Time=0.65 sec

Best model:  ARIMA(3,1,1)(1,1,0)[12]
Total fit time: 194.210 seconds
```

Out[74]:

```
ARIMA(maxiter=50, method='lbfgs', order=(3, 1, 1), out_of_sample_size=0,
      scoring='mse', scoring_args={}, seasonal_order=(1, 1, 0, 12),
      start_params=None, suppress_warnings=True, trend=None,
      with_intercept=False)
```

In [75]:

```
# Plotar previsões em relação aos valores conhecidos
title = 'Comparação de Previsão e real - DF'
ylabel='Receita'
xlabel=''

model_sarima_DF = SARIMAX(train['DF'],order=(3,1,1),seasonal_order=(1,1,1,12))
results_sarima_DF = model_sarima_DF.fit()

# Obtendo a previsão
inicio = len(train)
fim = len(train)+len(test)-1
predictions_sarima_DF = results_sarima_DF.predict(start=inicio, end=fim, dynamic=

ax = test['DF'].plot(legend=True,figsize=(12,6),title=title)
predictions_sarima_DF.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Comparando Dados: MINAS GERAIS

In [76]:
```
auto_arima(df['MG'], start_p=1, start_q=1,
                          max_p=4, max_q=4, m=12,
                          seasonal=True,
                          d=1,D=1, trace=True,
                          error_action='ignore',
                          suppress_warnings=True,
                          stepwise=False)
```

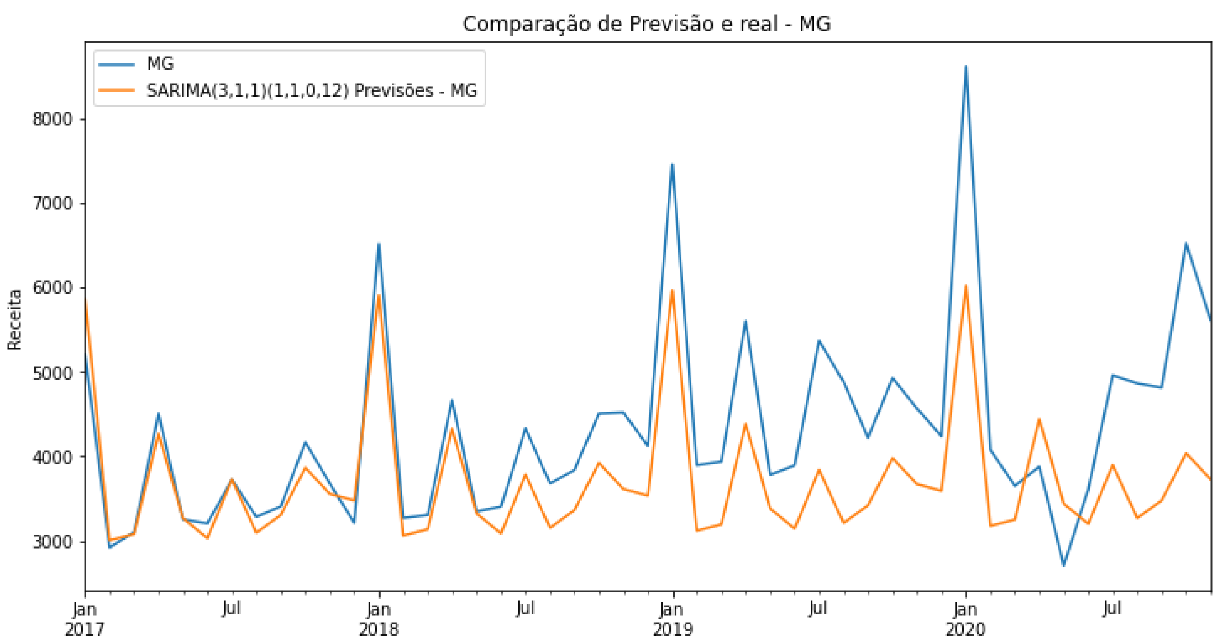
```
 ARIMA(0,1,0)(0,1,0)[12]             : AIC=2825.226, Time=0.03 sec
 ARIMA(0,1,0)(0,1,1)[12]             : AIC=2815.724, Time=0.35 sec
 ARIMA(0,1,0)(0,1,2)[12]             : AIC=2816.528, Time=0.92 sec
 ARIMA(0,1,0)(1,1,0)[12]             : AIC=2814.817, Time=0.10 sec
 ARIMA(0,1,0)(1,1,1)[12]             : AIC=2816.773, Time=0.45 sec
 ARIMA(0,1,0)(1,1,2)[12]             : AIC=inf, Time=1.98 sec
 ARIMA(0,1,0)(2,1,0)[12]             : AIC=2816.854, Time=0.20 sec
 ARIMA(0,1,0)(2,1,1)[12]             : AIC=2818.654, Time=2.34 sec
 ARIMA(0,1,0)(2,1,2)[12]             : AIC=2820.500, Time=2.94 sec
 ARIMA(0,1,1)(0,1,0)[12]             : AIC=2801.798, Time=0.10 sec
 ARIMA(0,1,1)(0,1,1)[12]             : AIC=2792.612, Time=0.24 sec
 ARIMA(0,1,1)(0,1,2)[12]             : AIC=2793.989, Time=0.60 sec
 ARIMA(0,1,1)(1,1,0)[12]             : AIC=2792.315, Time=0.29 sec
 ARIMA(0,1,1)(1,1,1)[12]             : AIC=2794.121, Time=0.32 sec
 ARIMA(0,1,1)(1,1,2)[12]             : AIC=inf, Time=3.22 sec
 ARIMA(0,1,1)(2,1,0)[12]             : AIC=2794.060, Time=0.34 sec
 ARIMA(0,1,1)(2,1,1)[12]             : AIC=inf, Time=2.86 sec
 ARIMA(0,1,1)(2,1,2)[12]             : AIC=inf, Time=4.79 sec
 ARIMA(0,1,2)(0,1,0)[12]             : AIC=2797.472, Time=0.17 sec
 ARIMA(0,1,2)(0,1,1)[12]             : AIC=2787.302, Time=0.69 sec
 ARIMA(0,1,2)(0,1,2)[12]             : AIC=2788.438, Time=1.61 sec
 ARIMA(0,1,2)(1,1,0)[12]             : AIC=2786.859, Time=0.47 sec
 ARIMA(0,1,2)(1,1,1)[12]             : AIC=2788.638, Time=0.76 sec
 ARIMA(0,1,2)(1,1,2)[12]             : AIC=inf, Time=3.54 sec
 ARIMA(0,1,2)(2,1,0)[12]             : AIC=2788.565, Time=1.24 sec
 ARIMA(0,1,2)(2,1,1)[12]             : AIC=2790.333, Time=2.99 sec
 ARIMA(0,1,3)(0,1,0)[12]             : AIC=2798.236, Time=0.12 sec
 ARIMA(0,1,3)(0,1,1)[12]             : AIC=2788.172, Time=1.03 sec
 ARIMA(0,1,3)(0,1,2)[12]             : AIC=2789.321, Time=2.08 sec
 ARIMA(0,1,3)(1,1,0)[12]             : AIC=2787.820, Time=0.70 sec
 ARIMA(0,1,3)(1,1,1)[12]             : AIC=2789.562, Time=1.21 sec
 ARIMA(0,1,3)(2,1,0)[12]             : AIC=2789.448, Time=1.55 sec
 ARIMA(0,1,4)(0,1,0)[12]             : AIC=2800.200, Time=0.17 sec
 ARIMA(0,1,4)(0,1,1)[12]             : AIC=2789.342, Time=1.44 sec
 ARIMA(0,1,4)(1,1,0)[12]             : AIC=2789.136, Time=0.92 sec
 ARIMA(1,1,0)(0,1,0)[12]             : AIC=2812.364, Time=0.11 sec
 ARIMA(1,1,0)(0,1,1)[12]             : AIC=2802.901, Time=0.18 sec
 ARIMA(1,1,0)(0,1,2)[12]             : AIC=2804.101, Time=0.55 sec
 ARIMA(1,1,0)(1,1,0)[12]             : AIC=2802.413, Time=0.10 sec
 ARIMA(1,1,0)(1,1,1)[12]             : AIC=2804.275, Time=0.30 sec
 ARIMA(1,1,0)(1,1,2)[12]             : AIC=inf, Time=2.74 sec
 ARIMA(1,1,0)(2,1,0)[12]             : AIC=2804.229, Time=0.25 sec
 ARIMA(1,1,0)(2,1,1)[12]             : AIC=inf, Time=2.10 sec
 ARIMA(1,1,0)(2,1,2)[12]             : AIC=2806.699, Time=3.30 sec
 ARIMA(1,1,1)(0,1,0)[12]             : AIC=inf, Time=0.28 sec
 ARIMA(1,1,1)(0,1,1)[12]             : AIC=inf, Time=1.89 sec
 ARIMA(1,1,1)(0,1,2)[12]             : AIC=2786.278, Time=2.66 sec
 ARIMA(1,1,1)(1,1,0)[12]             : AIC=inf, Time=1.63 sec
 ARIMA(1,1,1)(1,1,1)[12]             : AIC=2786.435, Time=1.37 sec
```

```
 ARIMA(1,1,1)(1,1,2)[12]             : AIC=inf, Time=6.54 sec
 ARIMA(1,1,1)(2,1,0)[12]             : AIC=2786.335, Time=2.19 sec
 ARIMA(1,1,1)(2,1,1)[12]             : AIC=2787.836, Time=4.70 sec
 ARIMA(1,1,2)(0,1,0)[12]             : AIC=inf, Time=0.58 sec
 ARIMA(1,1,2)(0,1,1)[12]             : AIC=inf, Time=1.18 sec
 ARIMA(1,1,2)(0,1,2)[12]             : AIC=inf, Time=2.98 sec
 ARIMA(1,1,2)(1,1,0)[12]             : AIC=inf, Time=1.09 sec
 ARIMA(1,1,2)(1,1,1)[12]             : AIC=inf, Time=1.59 sec
 ARIMA(1,1,2)(2,1,0)[12]             : AIC=inf, Time=2.88 sec
 ARIMA(1,1,3)(0,1,0)[12]             : AIC=2799.415, Time=0.52 sec
 ARIMA(1,1,3)(0,1,1)[12]             : AIC=2790.544, Time=1.73 sec
 ARIMA(1,1,3)(1,1,0)[12]             : AIC=2790.059, Time=1.42 sec
 ARIMA(1,1,4)(0,1,0)[12]             : AIC=2802.277, Time=0.20 sec
 ARIMA(2,1,0)(0,1,0)[12]             : AIC=2806.094, Time=0.15 sec
 ARIMA(2,1,0)(0,1,1)[12]             : AIC=2796.694, Time=0.24 sec
 ARIMA(2,1,0)(0,1,2)[12]             : AIC=2798.013, Time=0.61 sec
 ARIMA(2,1,0)(1,1,0)[12]             : AIC=2796.240, Time=0.14 sec
 ARIMA(2,1,0)(1,1,1)[12]             : AIC=2798.114, Time=0.46 sec
 ARIMA(2,1,0)(1,1,2)[12]             : AIC=inf, Time=4.67 sec
 ARIMA(2,1,0)(2,1,0)[12]             : AIC=2798.093, Time=0.39 sec
 ARIMA(2,1,0)(2,1,1)[12]             : AIC=2799.960, Time=1.90 sec
 ARIMA(2,1,1)(0,1,0)[12]             : AIC=inf, Time=0.59 sec
 ARIMA(2,1,1)(0,1,1)[12]             : AIC=inf, Time=1.22 sec
 ARIMA(2,1,1)(0,1,2)[12]             : AIC=inf, Time=2.88 sec
 ARIMA(2,1,1)(1,1,0)[12]             : AIC=inf, Time=1.12 sec
 ARIMA(2,1,1)(1,1,1)[12]             : AIC=inf, Time=1.86 sec
 ARIMA(2,1,1)(2,1,0)[12]             : AIC=inf, Time=3.03 sec
 ARIMA(2,1,2)(0,1,0)[12]             : AIC=inf, Time=0.48 sec
 ARIMA(2,1,2)(0,1,1)[12]             : AIC=inf, Time=2.18 sec
 ARIMA(2,1,2)(1,1,0)[12]             : AIC=inf, Time=1.83 sec
 ARIMA(2,1,3)(0,1,0)[12]             : AIC=inf, Time=1.28 sec
 ARIMA(3,1,0)(0,1,0)[12]             : AIC=2801.718, Time=0.19 sec
 ARIMA(3,1,0)(0,1,1)[12]             : AIC=2794.801, Time=0.30 sec
 ARIMA(3,1,0)(0,1,2)[12]             : AIC=2796.067, Time=0.79 sec
 ARIMA(3,1,0)(1,1,0)[12]             : AIC=2794.339, Time=0.16 sec
 ARIMA(3,1,0)(1,1,1)[12]             : AIC=2796.272, Time=0.44 sec
 ARIMA(3,1,0)(2,1,0)[12]             : AIC=2796.244, Time=0.41 sec
 ARIMA(3,1,1)(0,1,0)[12]             : AIC=inf, Time=0.52 sec
 ARIMA(3,1,1)(0,1,1)[12]             : AIC=inf, Time=1.92 sec
 ARIMA(3,1,1)(1,1,0)[12]             : AIC=inf, Time=1.70 sec
 ARIMA(3,1,2)(0,1,0)[12]             : AIC=inf, Time=0.90 sec
 ARIMA(4,1,0)(0,1,0)[12]             : AIC=2802.564, Time=0.28 sec
 ARIMA(4,1,0)(0,1,1)[12]             : AIC=2794.157, Time=0.46 sec
 ARIMA(4,1,0)(1,1,0)[12]             : AIC=2793.547, Time=0.30 sec
 ARIMA(4,1,1)(0,1,0)[12]             : AIC=inf, Time=0.77 sec

Best model:  ARIMA(1,1,1)(0,1,2)[12]
Total fit time: 122.197 seconds
```

Out[76]:

```
ARIMA(maxiter=50, method='lbfgs', order=(1, 1, 1), out_of_sample_size=0,
      scoring='mse', scoring_args={}, seasonal_order=(0, 1, 2, 12),
      start_params=None, suppress_warnings=True, trend=None,
      with_intercept=False)
```

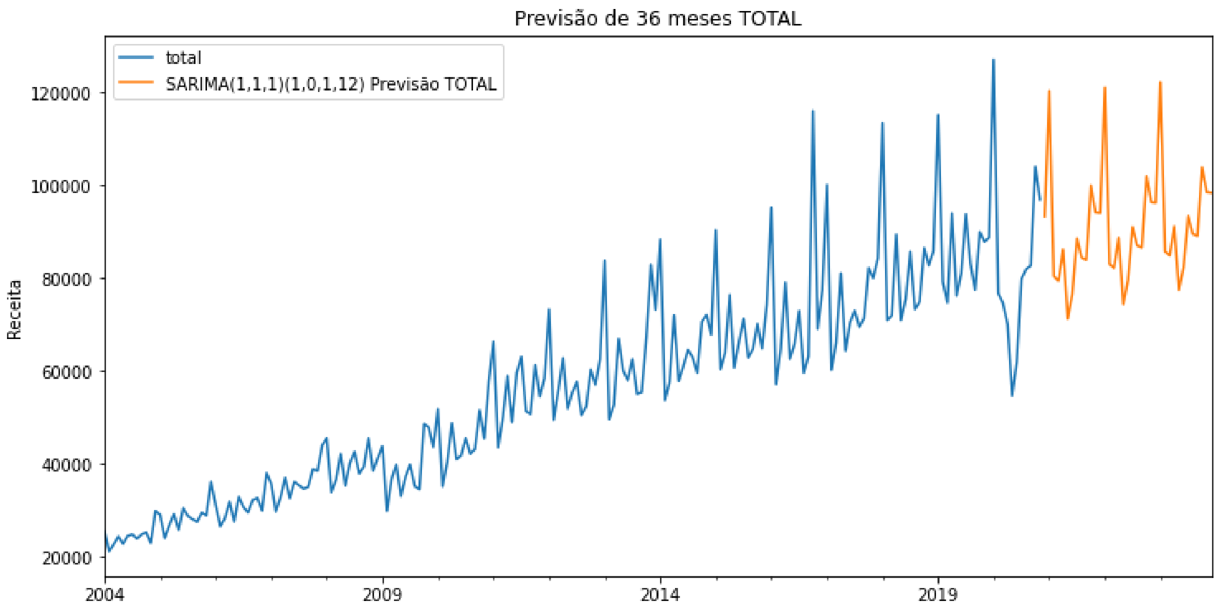
In [77]:
```
# Plotar previsões em relação aos valores conhecidos
title = 'Comparação de Previsão e real - MG'
ylabel='Receita'
xlabel=''

model_sarima_MG = SARIMAX(train['MG'],order=(1,1,1),seasonal_order=(0,1,2,12))
results_sarima_MG = model_sarima_MG.fit()

# Obtendo a previsão
inicio = len(train)
fim = len(train)+len(test)-1
predictions_sarima_MG = results_sarima_MG.predict(start=inicio, end=fim, dynamic=

ax = test['MG'].plot(legend=True,figsize=(12,6),title=title)
predictions_sarima_MG.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Prevendo o futuro com SARIMA

In [78]:
```
modelo_final_sarima = SARIMAX(df['total'],order=(1,1,1),seasonal_order=(1,0,1,12)
resultado_final_sarima = modelo_final_sarima.fit()
previsao_final_sarima = resultado_final_sarima.predict(len(df),len(df)+36,typ='le
```

In [79]:
```
# Plotar previsões de 36 meses para frente
title = 'Previsão de 36 meses TOTAL'
ylabel='Receita'
xlabel=''

ax = df['total'].plot(legend=True,figsize=(12,6),title=title)
previsao_final_sarima.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Prevendo futuro com SARIMA: SÃO PAULO

In [80]:
```
auto_arima(df['SP'],seasonal=True,m=12).summary()
```

Out[80]:

SARIMAX Results

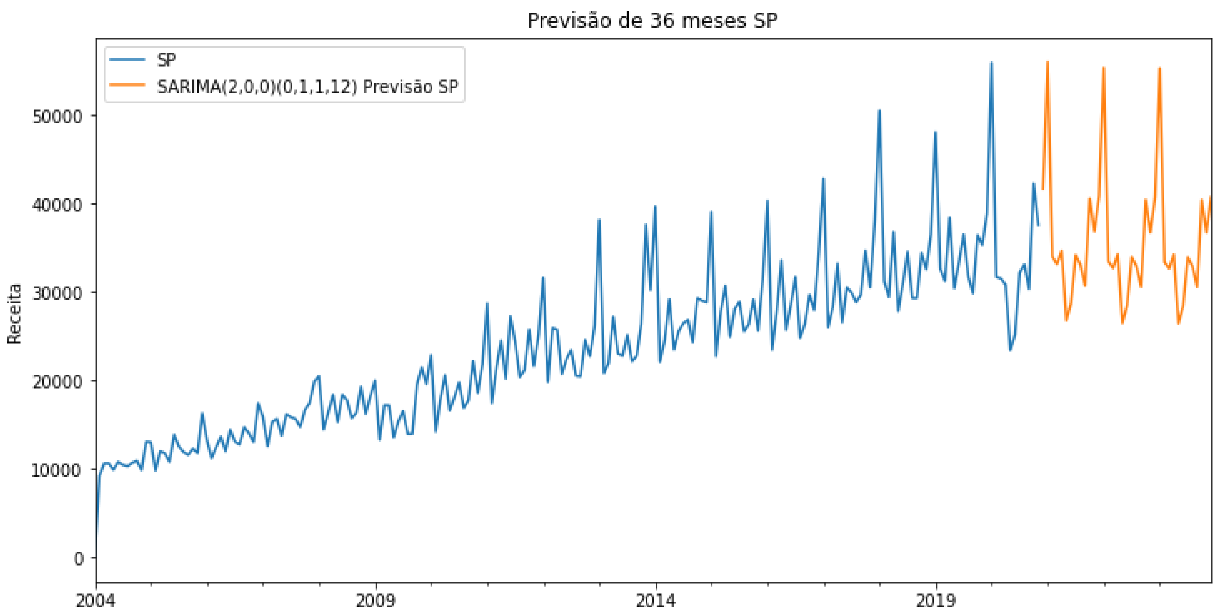
Dep. Variable:	y	**No. Observations:**	203
Model:	SARIMAX(2, 0, 0)x(0, 1, [1], 12)	**Log Likelihood**	-1753.527
Date:	Wed, 27 Jan 2021	**AIC**	3517.054
Time:	00:59:05	**BIC**	3533.316
Sample:	0	**HQIC**	3523.641
	- 203		
Covariance Type:	opg		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
intercept	790.5877	151.586	5.215	0.000	493.484	1087.691
ar.L1	0.3770	0.071	5.292	0.000	0.237	0.517
ar.L2	0.1650	0.077	2.137	0.033	0.014	0.316
ma.S.L12	-0.3937	0.066	-5.933	0.000	-0.524	-0.264
sigma2	5.877e+06	3.56e+05	16.519	0.000	5.18e+06	6.57e+06

Ljung-Box (L1) (Q):	0.31	**Jarque-Bera (JB):**	275.38
Prob(Q):	0.58	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.95	**Skew:**	0.75
Prob(H) (two-sided):	0.01	**Kurtosis:**	8.69

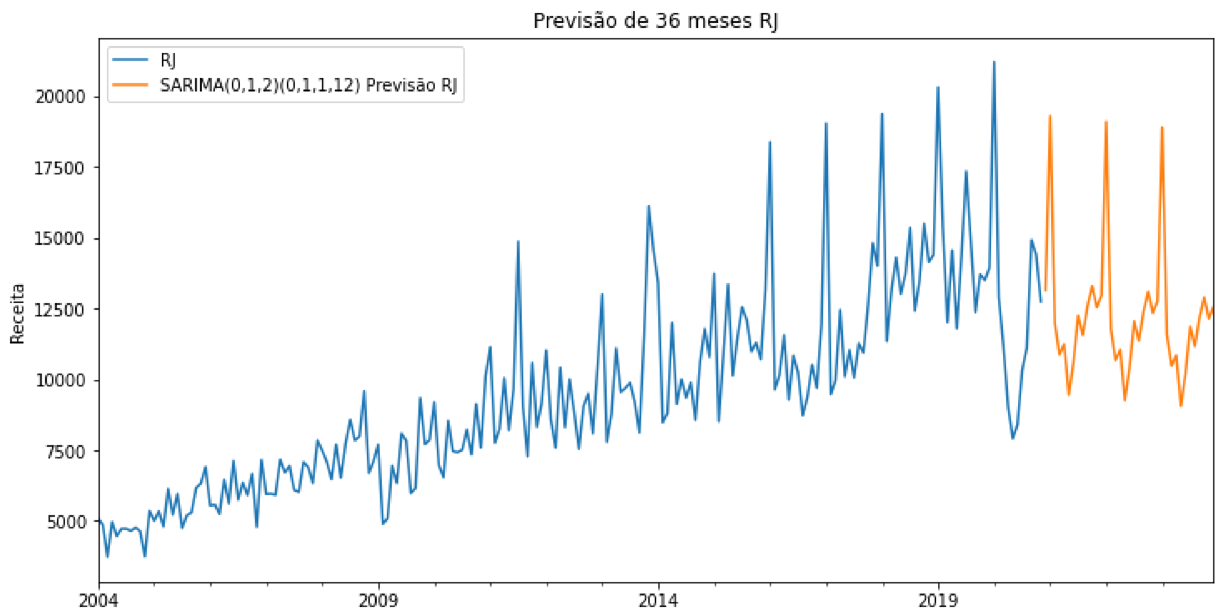
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [81]:
```
modelo_final_sarima_SP = SARIMAX(df['SP'],order=(2,0,0),seasonal_order=(0,1,1,12)
resultado_final_sarima_SP = modelo_final_sarima_SP.fit()
previsao_final_sarima_SP = resultado_final_sarima_SP.predict(len(df),len(df)+36,t

# Plotar previsões de 36 meses para frente
title = 'Previsão de 36 meses SP'
ylabel='Receita'
xlabel=''

ax = df['SP'].plot(legend=True,figsize=(12,6),title=title)
previsao_final_sarima_SP.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



Prevendo futuro com SARIMA: RIO DE JANEIRO

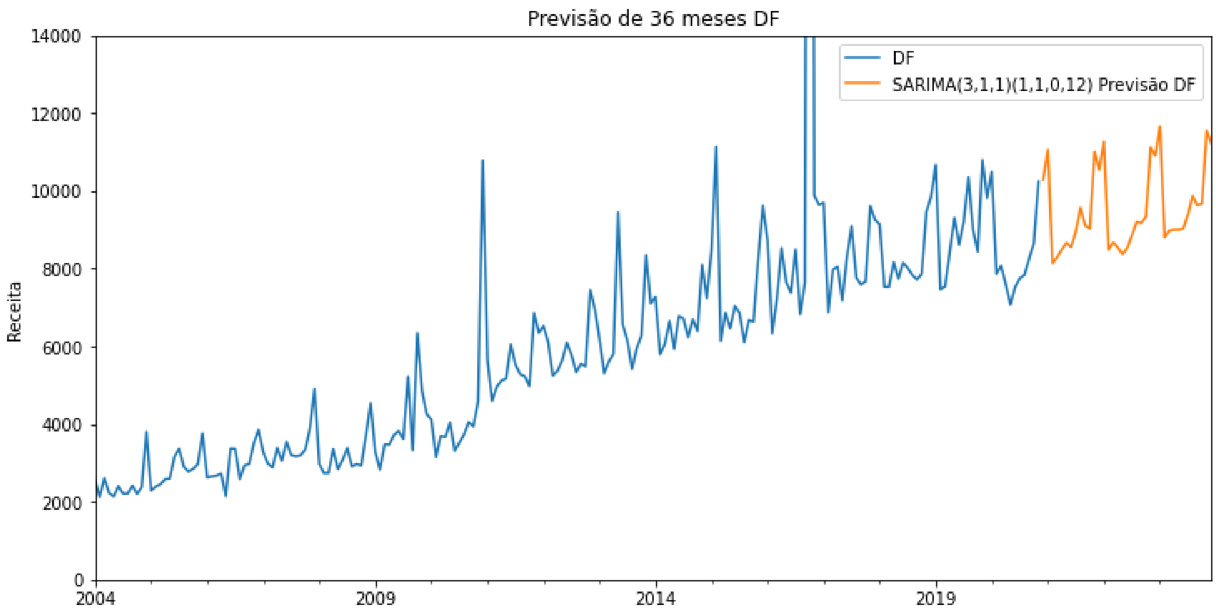
In [82]:
```
modelo_final_sarima_RJ = SARIMAX(df['RJ'],order=(0,1,2),seasonal_order=(0,1,1,12)
resultado_final_sarima_RJ = modelo_final_sarima_RJ.fit()
previsao_final_sarima_RJ = resultado_final_sarima_RJ.predict(len(df),len(df)+36,t

# Plotar previsões de 36 meses para frente
title = 'Previsão de 36 meses RJ'
ylabel='Receita'
xlabel=''

ax = df['RJ'].plot(legend=True,figsize=(12,6),title=title)
previsao_final_sarima_RJ.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



In [82]:

Prevendo futuro com SARIMA: DISTRITO FEDERAL

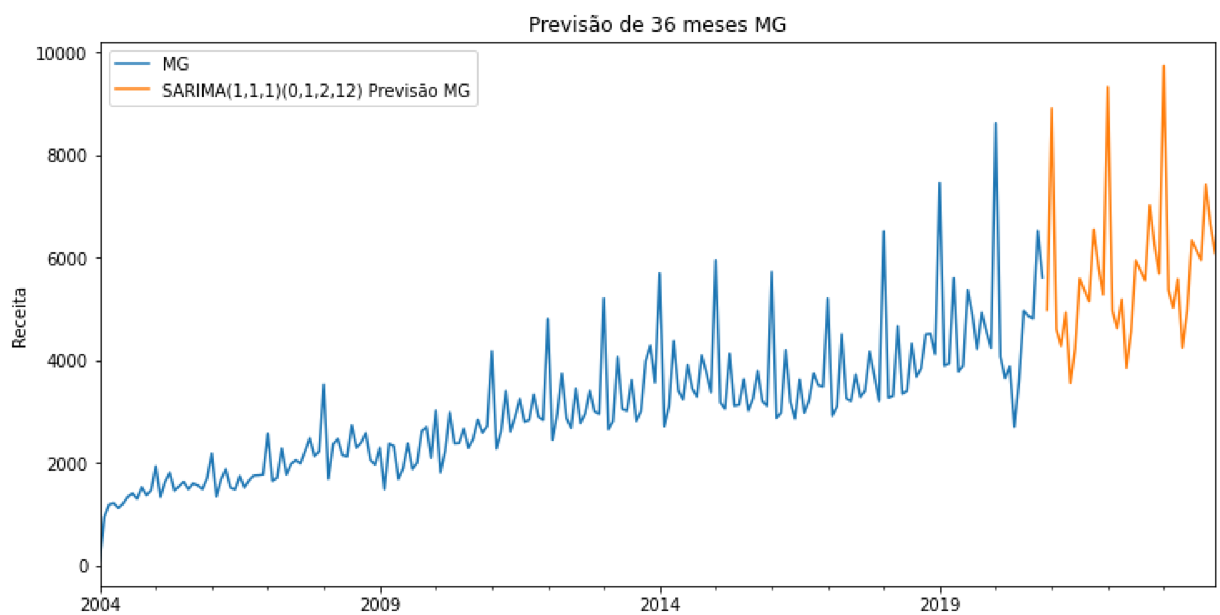
```
In [83]: modelo_final_sarima_DF = SARIMAX(df['DF'],order=(3,1,1),seasonal_order=(1,1,0,12)
         resultado_final_sarima_DF = modelo_final_sarima_DF.fit()
         previsao_final_sarima_DF = resultado_final_sarima_DF.predict(len(df),len(df)+36,t

         # Plotar previsões de 36 meses para frente
         title = 'Previsão de 36 meses DF'
         ylabel='Receita'
         xlabel=''

         ax = df['DF'].plot(legend=True,figsize=(12,6),title=title, ylim=(0,14000))
         previsao_final_sarima_DF.plot(legend=True)
         ax.autoscale(axis='x',tight=True)
         ax.set(xlabel=xlabel, ylabel=ylabel);
```



Prevendo futuro com SARIMA: MINAS GERAIS

In [84]:

```
modelo_final_sarima_MG = SARIMAX(df['MG'],order=(1,1,1),seasonal_order=(0,1,2,12)
resultado_final_sarima_MG = modelo_final_sarima_MG.fit()
previsao_final_sarima_MG = resultado_final_sarima_MG.predict(len(df),len(df)+36,t

# Plotar previsões de 36 meses para frente
title = 'Previsão de 36 meses MG'
ylabel='Receita'
xlabel=''

ax = df['MG'].plot(legend=True,figsize=(12,6),title=title)
previsao_final_sarima_MG.plot(legend=True)
ax.autoscale(axis='x',tight=True)
ax.set(xlabel=xlabel, ylabel=ylabel);
```



In [84]: