In [5]:
```
import pandas as pd
import numpy as np

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

In [6]:
```
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 [7]:
```
from statsmodels.stats.diagnostic import acorr_ljungbox
from statsmodels.tsa.stattools import adfuller, kpss,grangercausalitytests
```

In [8]:
```
from sklearn.metrics import mean_absolute_percentage_error
```

In [10]:
```
dfSamples=pd.read_csv('samples.csv',index_col=0,parse_dates=True)
dfSamples.index.freq='MS'
dfSamples
```

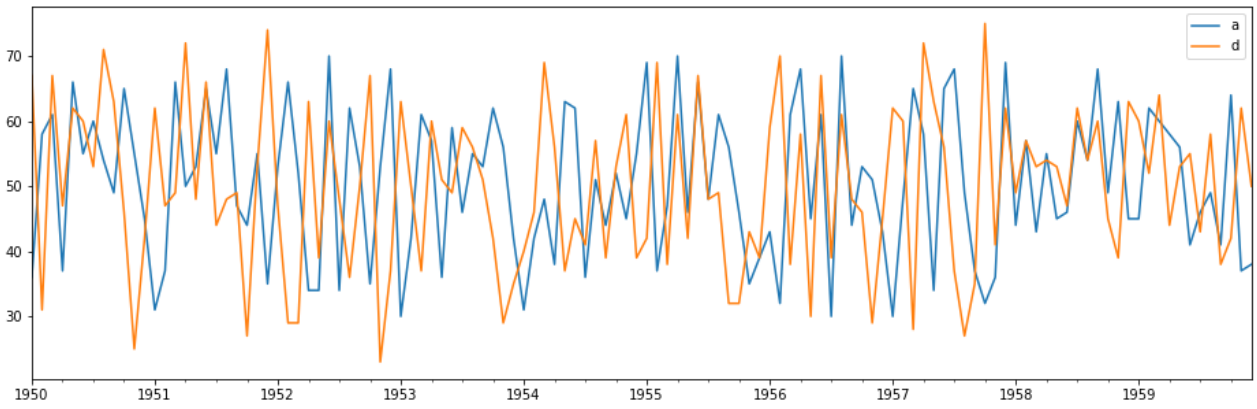
Out[10]:

	a	b	c	d
1950-01-01	36	27	0	67
1950-02-01	58	22	3	31
1950-03-01	61	17	5	67
1950-04-01	37	15	8	47
1950-05-01	66	13	8	62
...	...	...	...	...
1959-08-01	49	73	9338	58
1959-09-01	41	77	9502	38
1959-10-01	64	70	9667	42
1959-11-01	37	87	9833	62
1959-12-01	38	73	10000	50

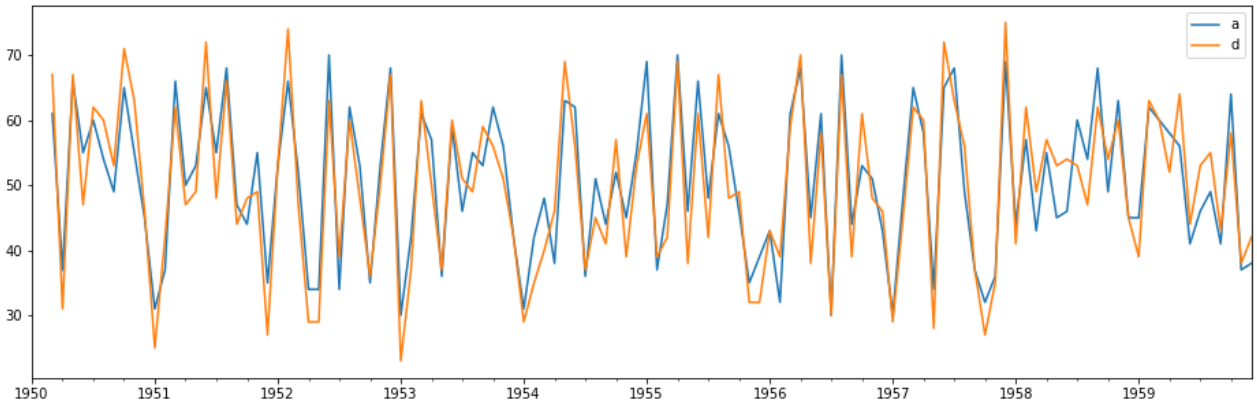
120 rows × 4 columns

In [11]:
```
dfSamples[['a','d']].plot(figsize=(16,5))
```

Out[11]: <AxesSubplot:>



In [13]:
```
dfSamples['a'].iloc[2:].plot(figsize=(16,5),legend=True);
dfSamples['d'].shift(2).plot(figsize=(16,5),legend=True);
```



In [15]:
```
grangercausalitytests(dfSamples[['d','a']],maxlag=4)
```

```
Granger Causality
number of lags (no zero) 1
ssr based F test:         F=0.0092  , p=0.9239  , df_denom=116, df_num=1
ssr based chi2 test:   chi2=0.0094  , p=0.9228  , df=1
likelihood ratio test: chi2=0.0094  , p=0.9228  , df=1
parameter F test:         F=0.0092  , p=0.9239  , df_denom=116, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:         F=0.5442  , p=0.5818  , df_denom=113, df_num=2
ssr based chi2 test:   chi2=1.1366  , p=0.5665  , df=2
likelihood ratio test: chi2=1.1311  , p=0.5680  , df=2
parameter F test:         F=0.5442  , p=0.5818  , df_denom=113, df_num=2

Granger Causality
number of lags (no zero) 3
ssr based F test:         F=1.6950  , p=0.1723  , df_denom=110, df_num=3
ssr based chi2 test:   chi2=5.4085  , p=0.1442  , df=3
likelihood ratio test: chi2=5.2873  , p=0.1519  , df=3
parameter F test:         F=1.6950  , p=0.1723  , df_denom=110, df_num=3

Granger Causality
```

```
number of lags (no zero) 4
ssr based F test:         F=1.3850  , p=0.2440  , df_denom=107, df_num=4
ssr based chi2 test:   chi2=6.0059  , p=0.1987  , df=4
likelihood ratio test: chi2=5.8556  , p=0.2102  , df=4
parameter F test:         F=1.3850  , p=0.2440  , df_denom=107, df_num=4
```

Out[15]:

```
{1: ({'ssr_ftest': (0.00915407063793226, 0.9239422726021401, 116.0, 1),
   'ssr_chi2test': (0.00939081384408568, 0.922800875894224, 1),
   'lrtest': (0.009390443328243236, 0.922802394099048, 1),
   'params_ftest': (0.009154070637939259, 0.9239422726021401, 116.0, 1.0)},
  [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
6db3220>,
   <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
640fa30>,
   array([[0., 1., 0.]])]),
 2: ({'ssr_ftest': (0.5441965653931243, 0.5818209772404546, 113.0, 2),
   'ssr_chi2test': (1.1365521188741359, 0.5665012117884213, 2),
   'lrtest': (1.1311134934840084, 0.5680438021676295, 2),
   'params_ftest': (0.544196565393138, 0.5818209772404471, 113.0, 2.0)},
  [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682b310>,
   <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682b3d0>,
   array([[0., 0., 1., 0., 0.],
          [0., 0., 0., 1., 0.]])]),
 3: ({'ssr_ftest': (1.694986067080327, 0.1722845111183823, 110.0, 3),
   'ssr_chi2test': (5.408546450410861, 0.14421203241858088, 3),
   'lrtest': (5.287260043746414, 0.15193120699400733, 3),
   'params_ftest': (1.6949860670802845, 0.17228451111839088, 110.0, 3.0)},
  [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682bd60>,
   <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682be20>,
   array([[0., 0., 0., 1., 0., 0., 0.],
          [0., 0., 0., 0., 1., 0., 0.],
          [0., 0., 0., 0., 0., 1., 0.]])]),
 4: ({'ssr_ftest': (1.3849832650886376, 0.24404203798834062, 107.0, 4),
   'ssr_chi2test': (6.005908738328298, 0.1987074396751317, 4),
   'lrtest': (5.85559702931414, 0.21019503942673007, 4),
   'params_ftest': (1.3849832650886118, 0.24404203798834984, 107.0, 4.0)},
  [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682bc70>,
   <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fe52
682b1f0>,
   array([[0., 0., 0., 0., 1., 0., 0., 0., 0.],
          [0., 0., 0., 0., 0., 1., 0., 0., 0.],
          [0., 0., 0., 0., 0., 0., 1., 0., 0.],
          [0., 0., 0., 0., 0., 0., 0., 1., 0.]])])}
```

In [ ]: