In [1]:
```
import pandas as pd

retail_sales_df=pd.read_csv('us_retail_sales.csv')
retail_sales_df.head()
```

Out[1]:

	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	
0	1992	146925	147223	146805	148032	149010	149800	150761.0	151067.0	152588.0	153521.0	153
1	1993	157555	156266	154752	158979	160605	160127	162816.0	162506.0	163258.0	164685.0	166
2	1994	167518	169649	172766	173106	172329	174241	174781.0	177295.0	178787.0	180561.0	180
3	1995	182413	179488	181013	181686	183536	186081	185431.0	186806.0	187366.0	186565.0	189
4	1996	189135	192266	194029	194744	196205	196136	196187.0	196218.0	198859.0	200509.0	200

In [2]:
```
retail_sales_df.shape
```

Out[2]:
```
(30, 13)
```

In [3]:
```
# Transpose Data
Transpose_retail_sales_df=pd.melt(retail_sales_df, id_vars =['YEAR'])
Transpose_retail_sales_df.head()
```

Out[3]:

	YEAR	variable	value
0	1992	JAN	146925.0
1	1993	JAN	157555.0
2	1994	JAN	167518.0
3	1995	JAN	182413.0
4	1996	JAN	189135.0

In [4]:
```
# Check Nulls
Transpose_retail_sales_df.isnull().sum()
```

Out[4]:
```
YEAR        0
variable    0
value       6
dtype: int64
```

In [5]:
```
# Drop Nulls
Transpose_retail_sales_df.dropna(inplace=True)
Transpose_retail_sales_df.isnull().sum()
Transpose_retail_sales_df.head()
```

Out[5]:

	YEAR	variable	value

	YEAR	variable	value
0	1992	JAN	146925.0
1	1993	JAN	157555.0
2	1994	JAN	167518.0
3	1995	JAN	182413.0
4	1996	JAN	189135.0

In [6]:
```
import datetime as dt

#convert date and hour to str, concatenate them and then convert them to datetime forma
Transpose_retail_sales_df['new_date'] = Transpose_retail_sales_df[['YEAR','variable']].
```

In [7]:
```
# Order the values and set the new date field as the index

final_retail_sales_df=Transpose_retail_sales_df[['new_date','value']]
final_retail_sales_df.sort_values(by=['new_date'], inplace=True)
final_retail_sales_df.reset_index(drop=True, inplace=True)
final_retail_sales_df.set_index('new_date',inplace=True)
final_retail_sales_df.head(100)
```

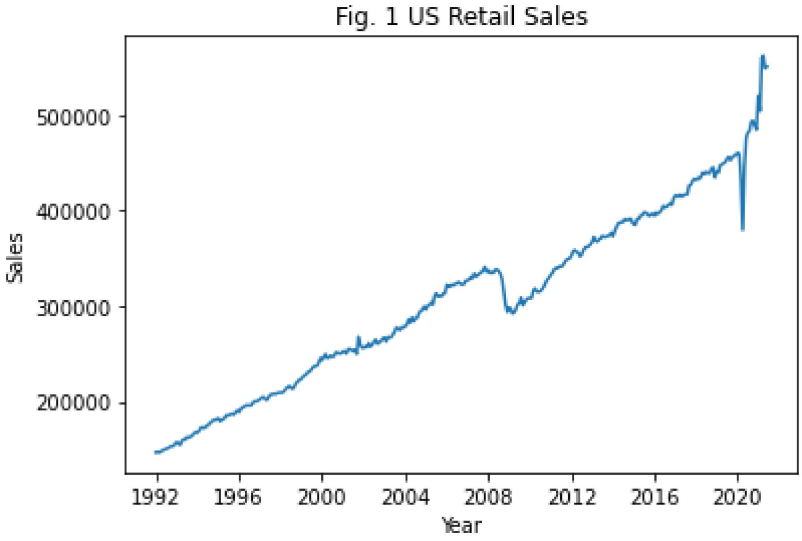
```
<ipython-input-7-e08b33fa83ee>:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  final_retail_sales_df.sort_values(by=['new_date'], inplace=True)
```

Out[7]:

	value
new_date	
1992-01-01	146925.0
1992-02-01	147223.0
1992-03-01	146805.0
1992-04-01	148032.0
1992-05-01	149010.0
...	...
1999-12-01	245485.0
2000-01-01	243436.0
2000-02-01	247133.0
2000-03-01	249825.0
2000-04-01	245831.0

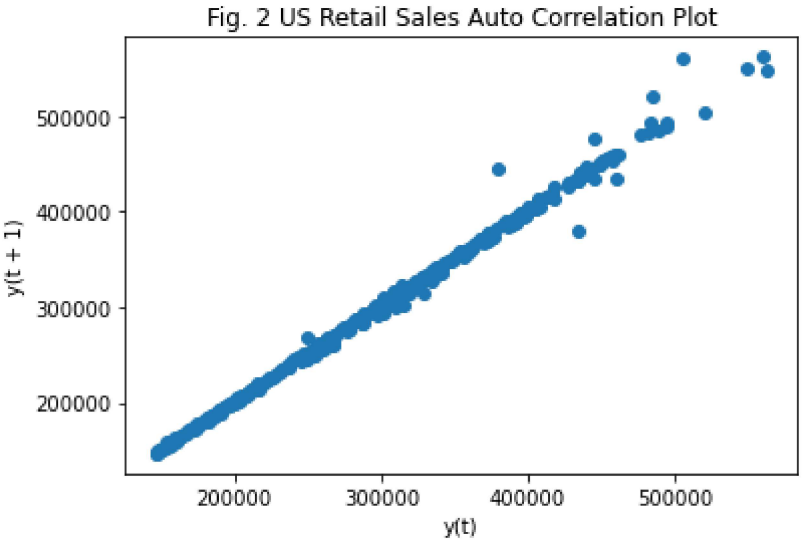
100 rows × 1 columns

In [8]:
```
# Line plot

import matplotlib.pyplot as plt

plt.plot(final_retail_sales_df)
plt.xlabel("Year")
plt.ylabel("Sales")
plt.title("Fig. 1 US Retail Sales")
plt.show()
```



From the line plot we can infer that sales grew strongly over time although there were noticeable dips during 2008 and 2020 when there was an economic slowdown

In [9]:
```
#Check Auto Correlation
pd.plotting.lag_plot(final_retail_sales_df,lag=1)
plt.title("Fig. 2 US Retail Sales Auto Correlation Plot")
plt.show()
```



We can see a large ball of observations along a diagonal line of the plot. It clearly shows strong correlation.

In [10]:
```

```

```
from pandas import read_csv
from pandas import DataFrame
from pandas import concat

values = DataFrame(final_retail_sales_df)
dataframe = concat([values.shift(1), values], axis=1)
dataframe.columns = ['t-1', 't+1']
result = dataframe.corr()
print(result)
```

```
          t-1       t+1
t-1  1.000000  0.997354
t+1  0.997354  1.000000
```

In [11]:

```
# create and evaluate a static autoregressive model

from statsmodels.tsa.ar_model import AutoReg
from sklearn.metrics import mean_squared_error
from math import sqrt

# split dataset
X = final_retail_sales_df.values
train, test = X[1:len(X)-12], X[len(X)-12:]
```

In [13]:

```
# train autoregression
model = AutoReg(train, lags=29)
model_fit = model.fit()
print('Coefficients: %s' % model_fit.params)
# make predictions
predictions = model_fit.predict(start=len(train), end=len(train)+len(test)-1, dynamic=F
for i in range(len(predictions)):
        print('predicted=%f, expected=%f' % (predictions[i], test[i]))
rmse = sqrt(mean_squared_error(test, predictions))
print('Test RMSE: %.3f' % rmse)
# plot results
plt.plot(test)
plt.plot(predictions, color='red')
plt.title("Fig. 3 Original Vs Predicted Value")
plt.xlabel("Iteration")
plt.ylabel("Value")
plt.show()
```

```
C:\Users\kiran\anaconda3\lib\site-packages\statsmodels\tsa\ar_model.py:248: FutureWarnin
g: The parameter names will change after 0.12 is released. Set old_names to False to use
the new names now. Set old_names to True to use the old names.
  warnings.warn(
Coefficients: [ 2.20424835e+03  8.78872100e-01 -3.60867752e-01  3.44408784e-01
  2.72624784e-01 -2.21552823e-01  1.65049627e-01  8.35543692e-03
 -1.94172346e-01  1.68899969e-01 -1.38659003e-02  3.17476649e-02
 -2.05193864e-01  3.51037306e-02  1.91318789e-01 -6.44582931e-02
  2.64535613e-01 -5.15897445e-01  3.40840732e-02  3.19259770e-01
 -1.57077398e-01  4.76717928e-03  1.51880104e-01 -2.81862225e-01
 -1.11082273e-02  1.60691634e-01 -1.70967353e-01  2.23886941e-01
 -1.37176649e-01  7.66363949e-02]
predicted=445515.494493, expected=481627.000000
predicted=422256.678222, expected=483716.000000
predicted=446066.473177, expected=493327.000000
predicted=451949.982676, expected=493991.000000
predicted=442227.695371, expected=488652.000000
```

```
predicted=450286.767245, expected=484782.000000
predicted=446613.649392, expected=520162.000000
predicted=438267.782201, expected=504458.000000
predicted=444921.157325, expected=559871.000000
predicted=470506.850108, expected=562269.000000
predicted=455556.374313, expected=548987.000000
predicted=424719.228433, expected=550782.000000
Test RMSE: 75538.510
```

Fig. 3 Original Vs Predicted Value