econ_Offline_Regession_RLS_new

August 15, 2019

```
In [2]:  # core array and table libraries
         import numpy as np
         import pandas as pd


         # signal processing, optimization, and linear algebra libraries
         from scipy import signal
         from scipy import optimize
         from scipy.spatial import distance
         import scipy, scipy.stats
         from scipy import interpolate

         from numpy import linalg as la

         # machine learning libraries
         from sklearn import linear_model
         from sklearn import preprocessing
         from sklearn.ensemble import RandomForestRegressor
         from sklearn.model_selection import train_test_split, cross_val_score
         from scipy.optimize import curve_fit
         from scipy.ndimage.interpolation import shift

         #from pyearth import Earth

         # Kalman filter libraries
         from scipy.linalg import block_diag
         from filterpy.kalman import KalmanFilter as KF_fp, FixedLagSmoother as KS_fp # https:/
         from filterpy.kalman import predict, update, batch_filter
         from pykalman import KalmanFilter as KF_pk # https://pykalman.github.io

         # statistics libraries
         import statsmodels.api as sm

         # date and time libraries
         import time as tm
         import datetime as dt
```

```python
# plotting libraries
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
import seaborn as sns; sns.set()
%matplotlib inline

# system and OS libraries
import os.path

# MISCl
import copy
from collections import Counter
from sklearn import decomposition
from numpy.random import RandomState
import itertools
import pickle
import pprint
from contextlib import contextmanager
import gc; gc.collect()

pp = pprint.PrettyPrinter(indent = 2)
plt.rcParams.update({
    'axes.titlesize':'16',
    'xtick.labelsize':'14',
    'ytick.labelsize':'14',
    'legend.fontsize': '16'
})
```

In [3]:
```python
from IPython.core.display import display, HTML
display(HTML("<style>.container { width:90% !important; }</style>"))

sns.set_context('talk') # notebook, paper, poster, talk

USE_DARK_THEME = False

dct_colors = {
    'dark blue': '#08519c',
    'dark red': '#b30000',
    'dark green': '#276419',
    'dark orange': '#b35806',
    'dark purple': '#40004b',
    'dark turquoise': '#01665e',

    'blue': '#4292c6',
    'red': '#d7301f',
    'green': '#33a02c',
    'orange': '#ff7f00',
    'purple': '#762a83',
```

```python
            'turquoise': '#35978f',

            'light blue': '#9ecae1',
            'light red': '#fb6a4a',
            'light green': '#7fbc41',
            'light orange': '#fdb863',
            'light purple': '#9970ab',
            'light turquoise': '#80cdc1',
        }

    if USE_DARK_THEME:
        color_pallette = [
            '#08519c', # dark blue
            '#b30000', # dark burned red
            '#276419', # dark green
            '#b35806', # dark orange
            '#40004b', # dark purple
            '#01665e', # dark turquoise

            '#4292c6', # blue
            '#d7301f', # red
            '#33a02c', # green
            '#ff7f00', # orange
            '#762a83', # purple
            '#35978f', # turquoise

            '#9ecae1', # light blue
            '#fb6a4a', # light red
            '#7fbc41', # light green
            '#fdb863', # light orange
            '#9970ab', # light purple
            '#80cdc1', # light turquoise
        ]

        #color_pallette = sns.choose_colorbrewer_palette('q', as_cmap=False)

    else:
        sns.set_style("whitegrid")
        color_pallette = sns.choose_colorbrewer_palette('q', as_cmap=False)

    #color_pallette = sns.color_palette('Paired')

<IPython.core.display.HTML object>


interactive(children=(Dropdown(description='name', options=('Set1', 'Set2', 'Set3', 'Paired',

In [4]: if USE_DARK_THEME:
```

3

```python
sns.set_style(
    "darkgrid",
    {
        'figure.facecolor': '#2E2E2E',
        'grid.color': '#424242',
        'grid.linestyle': u'--',
        'xtick.color': '.55',
        'ytick.color': '.55',
        'text.color': '.85',
        "axes.facecolor": "#2E2E2E",
        'axes.labelcolor': '.85',

        'axes.axisbelow': True,
        'axes.linewidth': 0,
        'image.cmap': 'pink',
        'legend.frameon': False,
        'legend.numpoints': 1,
        'legend.scatterpoints': 1,
        'lines.solid_capstyle': 'round',
        'patch.edgecolor': '#424242',
        'patch.force_edgecolor': True,

        'font.family': ['sans-serif'],
        'font.sans-serif': [
            'Arial',
            'DejaVu Sans',
            'Liberation Sans',
            'Bitstream Vera Sans',
            'sans-serif'],

    })
#sns.set_palette(color_pallette)

plt.close('all')
plt.plot(np.random.random(200), label = 'Label 1')
plt.plot(0.6 * np.random.random(200), label = 'Label 2')
plt.plot(0.3 * np.random.random(200), label = 'Label 3')
plt.axvline(
    100,
    0,
    1,
    color = '#762a83',
    linestyle = 'dashed',
    linewidth = 2,
    label = 'Full VHS')
plt.legend()
plt.xlabel('x_label')
plt.ylabel('y_label')
```

```
plt.title('Title')
plt.show()

#plt.close('all')
#sns.palplot(color_pallette)
#plt.show()

plt.rc("axes.spines", left=False, bottom=False, right=False, top=False)
```
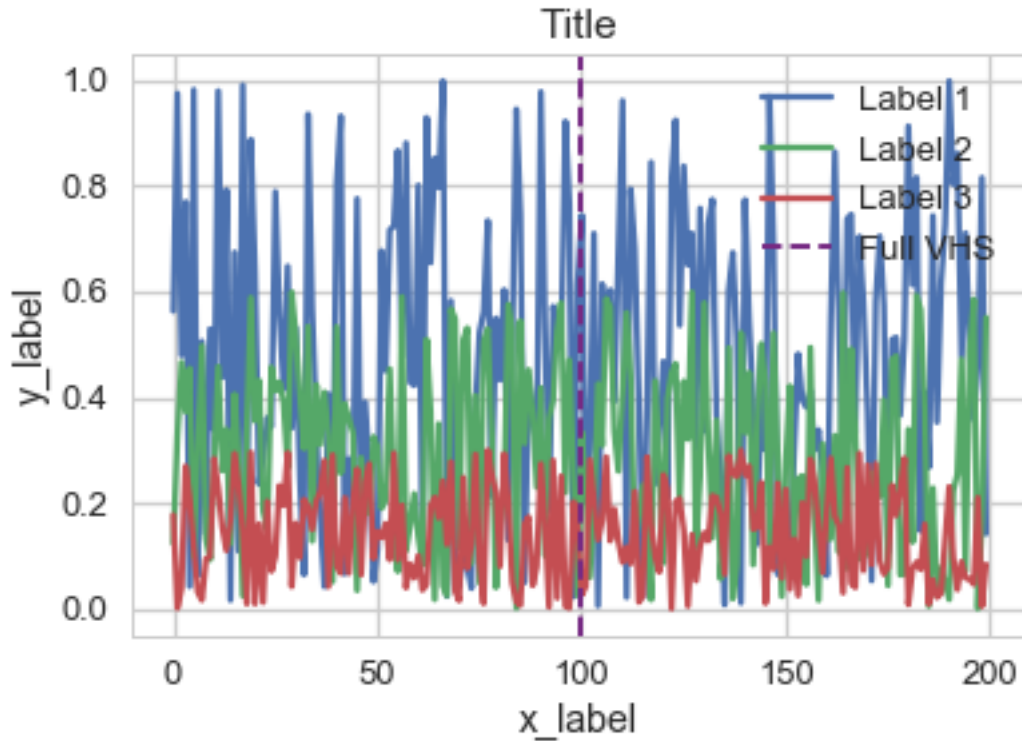

1 FUNCTIONS

```
In [5]: @contextmanager
        def timer(title, n_blanks = 1):
            print(n_blanks * ' ' + 'STARTING: {}'.format(title))
            t0 = tm.time()
            yield
            print(n_blanks * ' ' + "FINISHED in {:.2f}m \n".format((tm.time() - t0)/60))

In [6]: def rts_smoother(Xs, Ps, F, Q, enforceNonNegative = False):
            n, dim_x = Xs.shape

            # smoother gain
```

```python
        K = np.zeros((n,dim_x, dim_x))
        x, P = Xs.copy(), Ps.copy()

        for k in range(n-2,-1,-1):
            P_pred = np.dot(F, P[k]).dot(F.T) + Q

            K[k]  = np.dot(P[k], F.T).dot(la.inv(P_pred))
            x[k] += np.dot(K[k], x[k+1] - np.dot(F, x[k]))
            if enforceNonNegative:
                x[k] = np.clip(x[k], a_min=0, a_max=np.Inf)
            P[k] += np.dot(K[k], P[k+1] - P_pred).dot(K[k].T)
        return (x, P, K)


def fit_kalman(dct_io, dct_mask, x_inl = None, p = 1.0, q = 0.01, r = 0.5,
               prmNoiseScale = 0.01, nReps = 200,
               enforceNonNegative = False,
               plotCoefs = False, verbose = False):

    idxMask = copy.deepcopy(dct_mask)
    y = copy.deepcopy(dct_io['output']['values']).flatten()
    y = y[idxMask]
    u = copy.deepcopy(dct_io['inputs']['values'])
    nInp = u.shape[1] #- 1
    u = u[:, 0:nInp]

    if verbose:
        print(u[idxMask,:].shape)

    nSmpls = len(y)
    meanY = np.mean(y)
    y -= meanY
    scaleY =np.max(y) - np.min(y)
    y /= scaleY

    dimInputs = u.shape[1]
    dimHidden = 0
    dimCycles = 0

    # Observation matrix
    C = np.concatenate(
        [
            np.ones((nSmpls, dimHidden)) + 1e-12*np.random.randn(nSmpls, dimHidden),
            u[idxMask,:]
        ], axis=1)
    dim = C.shape[1]

    # State (parameter) vector
```

```python
x = np.zeros((nSmpls,dim))
if x_inl is not None:
    x[0,:] = x_inl
else:
    x[0,:] = 1.0 * (np.random.rand(dim) - 0.0)
if verbose:
    print('x_0 = ', x[0,:])

# State Transition matrix
A = np.eye(dim)

# State (parameter) covariance matrix
P = np.diag(np.concatenate([p * np.ones(dimInputs), 10.0*np.ones(dimCycles)]))
#np.diag(np.concatenate([np.array([0.01]),
#                        1.1*np.ones(dimInputs),
#                        1.1*np.ones(dimCycles)]))


# Process noise matrix (random walk step size)
Q = np.diag(np.concatenate([q * np.ones(dimInputs),
                            .01*np.ones(dimCycles)]))
#Q = np.diag(np.concatenate([np.array([.000001]),
#                            0.1*np.ones(dimInputs),
#                            .01*np.ones(dimCycles)]))


#Measurement noise matrix
R = np.linspace(1.1,1,nSmpls) * r
#R[0] = 1000

I = np.eye(dim)

if verbose:
    print()
    print (' STARTING KALMAN RLS  ')
    print ('----------------------')
    print('dim inputs = ', dimInputs)
    print('dim hidden = ', dimHidden)
    print('dim seasonal = ', dimCycles)
    print('Shape x = ', x.shape)
    print('Shape P = ', P.shape)
    print('Shape A = ', A.shape)
    print('Shape Q = ', Q.shape)
    print('Shape y = ', y.shape)
    print('Shape R = ', R.shape)

# Start the Kalman filter
kf = KF_fp(dim_x=dim, dim_z=1)
```

```python
kf.F = A
kf.Q = Q
kf.x = x[0,:]
kf.P = P
kf.H = np.zeros((1, dim))
z = np.zeros((1,))


x_p, x_u, P_p, P_u, ps, likelihoods = [], [], [], [], [], []
for j in range(nSmpls):
    kf.H =  C[j,:].reshape((1,dim))
    kf.R = R[j]
    z = y[j]

    if dimHidden > 0:
        dTr = np.mean(np.abs(
                y[j]
                - np.dot(kf.H[:, dimHidden: dimHidden + dimInputs],
                        kf.x[dimHidden: dimHidden + dimInputs])
            ))

        kf.Q[0,0] = dTr

    # KALMAN prediction stage
    kf.predict()
    if enforceNonNegative:
        kf.x[dimHidden: dimHidden + dimInputs] = np.clip(kf.x[dimHidden: dimHidden
                                                        a_min = 0,
                                                        a_max=np.Inf)
    x_p.append(kf.x)
    P_p.append(kf.P)

    # KALMAN update stage
    kf.update(z)
    if enforceNonNegative:
        kf.x[dimHidden: dimHidden + dimInputs] = np.clip(kf.x[dimHidden: dimHidden
                                                        a_min = 0,
                                                        a_max=np.Inf)

    x_u.append(kf.x)
    P_u.append(kf.P)

    ps.append(kf.P.diagonal()) # just save variances
    likelihoods.append(kf.likelihood)

x_p = np.array(x_p)
x_u = np.array(x_u)
P_p = np.array(P_p)
P_u = np.array(P_u)
```

```python
# Smooth the estimates
x_RTS, P_RTS, K_RTS = rts_smoother(x_u, P_u, A, 2*Q)

# prepare indices and data to interpolate/extrapolate x and P to masked time steps
temp = np.empty_like(dct_io['output']['values']) *  np.nan
#temp[idxMask] = idxMask.flatten()
nan_indexes = np.isnan(temp)
if verbose:
    print('Number masked indices = ', len(nan_indexes) - len(idxMask))

del temp

# get only the diagonal elements of the covariance matrix and standardise them (st
#PP = np.empty((nSmpls, dim))
#for j, p in enumerate(P_u):
#    PP[j,:] = np.sqrt(np.diag(p))
#PP_RTS = np.empty((nSmpls, dim))
#for j, p in enumerate(P_RTS):
#    PP_RTS[j,:] = np.sqrt(np.diag(p))

# interpolate/extrapolate x and P to masked time steps for the filtered estimates
nSmpls = len(dct_io['output']['values'])
x_Full = np.empty((nSmpls, dim))
for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
    x_Full[:,j]  = np.interp(
        nan_indexes.nonzero()[0],
        idxMask,
        x_u[:,j]
    ).flatten()

P_Full = np.empty((nSmpls, dim, dim))
for j1 in range(dim):
    for j2 in range(dim):
        P_Full[:,j1, j2]  = np.interp(
            nan_indexes.nonzero()[0],
            idxMask,
            P_u[:,j1,j2]
        ).flatten()


# interpolate/extrapolate x and P to masked time steps for the smoothed estimates
x_RTS_Full = np.empty((nSmpls, dim))
for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
    x_RTS_Full[:,j]  = np.interp(
        nan_indexes.nonzero()[0],
        idxMask,
        x_RTS[:,j]
```

```python
    ).flatten()


P_RTS_Full = np.empty((nSmpls, dim, dim))
for j1 in range(dim):
    for j2 in range(dim):
        P_RTS_Full[:,j1, j2]  = np.interp(
            nan_indexes.nonzero()[0],
            idxMask,
            P_RTS[:,j1,j2]
        ).flatten()


# get estimates with various combinations of the smoothed x values, to get error m
# First, get full lenght inputs and outputs
y = copy.deepcopy(dct_io['output']['values'])
C = np.concatenate(
    [np.ones((nSmpls, dimHidden)) + 1e-12*np.random.randn(nSmpls, dimHidden),
     u
    ], axis=1)


x = np.zeros(((nSmpls, dim)))
cnt = 0
scaleP = 1.0e-2
yyEst = np.zeros((nSmpls, nReps))
x = np.zeros(((nSmpls, dim)))
P_mean = np.diag(np.sqrt(np.diag(np.mean(P_RTS_Full, axis=0))))
for cnt in range(nReps):
    x *= 0
    temp = np.random.multivariate_normal(np.zeros((dim,)), prmNoiseScale * P_mean)
    #print('temp', temp)
    for dim_ in range(dim):
        x[:,dim_] = x_RTS_Full[:,dim_] + temp[dim_]
        yyEst[:,cnt] += x[:,dim_] * C[:,dim_]

    yyEst[:,cnt] *= scaleY
    yyEst[:,cnt] += meanY

yEst = np.zeros_like(y).flatten()
for j in range(dim):
    yEst += x_RTS_Full[:,j] * C[:,j]
yEst *= scaleY
yEst += meanY

if plotCoefs:
    arr_mask =np.zeros(nSmpls)
    arr_mask[idxMask] = 0.5
```

```python
idxLabel = dct_io['indexes']
prd = int(12 / 1 / 2)
zz = np.arange(prd-1,nSmpls, prd)



g = plt.figure(figsize=(32, 30))
inputs_to_plot = [
    'Keyword Position',
    'CPC per Keyword Position',
    'Keyword Position per CPC',
    'Inverse Flight Margin',
    'Inverse Hotel Margin',
    'Employment',
    'CCI',
    'Competitor Advantage',
    'GbpEur',
    #'Offline Spent Competitors'
]
cnt = 0
for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
    splited_input = input_.split('_')
    if splited_input[0] in inputs_to_plot and splited_input[-1] == '0':
        cnt += 1
        plt.subplot(6,3,cnt)
        plt.plot(y, linewidth = 5, c='#08519c', alpha=0.6, label='output')
        plt.plot(u[:,j], linewidth = 3, c = '#b30000', alpha = 0.8, label='inpu
        plt.legend()
        plt.title(splited_input[0])



#plt.plot(arr_mask*.5, '--', c='gray')
#u_Average = np.mean(np.abs(u), axis=1)
#plt.plot(u_Average, '--', linewidth = 8, c=[0.4, 0.4, 0.4], alpha=0.8, label=
#plt.plot(y, linewidth = 8, c='#83f442', alpha=0.6, label='output')
#plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
#sns.plt.legend(loc='upper left',bbox_to_anchor=(1.05, 1.0), borderaxespad=0.)
#plt.title('Inputs')

dct_x = {
    'x_Full':{},
    'x_RTS_Full':{}
}
input_labels = []
for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
    splited_input = input_.split('_')
    if splited_input[-1] == '0':
        input_labels.append(splited_input[0])
```

```python
            dct_x['x_Full'][splited_input[0]] = {'values':copy.deepcopy(np.abs(x_Fu
            dct_x['x_RTS_Full'][splited_input[0]] = {'values':copy.deepcopy(np.abs
        else:
            dct_x['x_Full'][splited_input[0]]['values'] += np.abs(x_Full[:,j])
            dct_x['x_Full'][splited_input[0]]['counts'] += 1
            dct_x['x_RTS_Full'][splited_input[0]]['values'] += np.abs(x_RTS_Full[:
            dct_x['x_RTS_Full'][splited_input[0]]['counts'] += 1


plt.subplot(6,1,4)
#for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
#    splited_input = input_.split('_')
#    if splited_input[-1] == '0':
#        plt.plot(x_Full[:,j], linewidth = 3, label=input_)

x_Full_Total = np.zeros_like(x_Full[:,0])
x_RTS_Full_Total = np.zeros_like(x_Full[:,0])
for j, input_ in enumerate(input_labels):
    temp = dct_x['x_Full'][input_]['values'] / dct_x['x_Full'][input_]['counts
    plt.plot(temp, linewidth = 3, label=input_)
    x_Full_Total += temp
    x_RTS_Full_Total = dct_x['x_RTS_Full'][input_]['values'] / dct_x['x_RTS_Ful
x_Full_Average = x_Full_Total / (j+1)
x_RTS_Full_Average = x_RTS_Full_Total / (j+1)

plt.plot(arr_mask*.5, '--', c='gray')
plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
#plt.legend()
plt.legend(loc='upper left',bbox_to_anchor=(1.05, 1.0), borderaxespad=0.)
#plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.title('Coefs, updated')

plt.subplot(6,1,5)
#x_RTS_Full_Average = np.mean(np.abs(x_RTS_Full), axis=1)
plt.plot(x_RTS_Full_Average, '--', linewidth = 8, c=[0.4, 0.4, 0.4], alpha=0.7

#for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
#    splited_input = input_.split('_')
#    if splited_input[-1] == '0':
#        plt.plot(x_RTS_Full[:,j], linewidth = 5, label=input_)
#    if verbose:
#        print(input_)
for j, input_ in enumerate(input_labels):
    plt.plot(dct_x['x_RTS_Full'][input_]['values'] / dct_x['x_RTS_Full'][input_
    if verbose:
        print(input_)
plt.plot(arr_mask*.5, '--', c='gray')
plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
```

```python
        plt.legend(loc='upper left',bbox_to_anchor=(1.05, 1.0), borderaxespad=0.)
        plt.title('Coefs, RTS smoothed')

        plt.subplot(6,1,6)
        #x_RTS_Full_Total = np.sum(np.abs(x_RTS_Full), axis=1)
        #for j, input_ in enumerate(dct_io['inputs']['newInputLabels'][0:nInp]):
        #    splited_input = input_.split('_')
        #    if splited_input[-1] == '0':
        #        plt.plot(x_RTS_Full[:,j] / x_RTS_Full_Total, linewidth = 5, label=inp
        #    if verbose:
        #        print(input_)
        for j, input_ in enumerate(input_labels):
            #plt.plot(dct_x['x_Full'][input_]['values'] / dct_x['x_Full'][input_]['cou
            plt.plot(dct_x['x_RTS_Full'][input_]['values'] / dct_x['x_RTS_Full'][input_
            if verbose:
                print(input_)

        plt.plot(arr_mask*.5, '--', c='gray')
        plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
        plt.legend(loc='upper left',bbox_to_anchor=(1.05, 1.0), borderaxespad=0.)
        plt.title('Relative RTS smoothed Coefs')

        plt.tight_layout()

        for j, ax in enumerate(g.axes):
            if j > 4:
                box = ax.get_position()
                ax.set_position([box.x0,box.y0,box.width*0.80,box.height])


output = {
    'coefs':{
        'filtered': x_Full,
        'smoothed': x_RTS_Full
    },
    'errorSTDs': {
        'filtered': x,
        'smoothed': P_RTS_Full
    },
    'simulations': {
        'extremes': yyEst,
        'mean': yEst,
    },
    'logLikelyhoods': np.log(likelihoods),
    'inputLabelsAndIndices': {val:j for j, val in enumerate(dct_io['inputs']['newIn
    'outputCenteringParams': {
        'mean': meanY,
        'scale': scaleY
```

```python
        }
    }

    return output


def adjust_to_trend(arr_actual, arr_estimated, loc_adjust, arr_trend = None):
    def initiate_tracking_kalman(actual_, trend_ = 0):
        var_act_trend = np.var(actual_ - trend_) / np.mean(actual_)
        var_act_trend_inl = np.var((actual_ - trend_)[:6])  / np.mean(actual_[:6])
        return KF_pk(
            n_dim_state = 2,
            n_dim_obs = 1,
            observation_covariance = 1e4*var_act_trend,
            initial_state_mean = [np.mean(actual_[:6]),0],
            initial_state_covariance = 1e4*var_act_trend_inl * np.array([[1, 1 / 2], [
            transition_matrices = [[1,1], [0,1]],
            observation_matrices = [1,0]
        )
    arr_actual = copy.deepcopy(arr_actual)
    arr_estimated = copy.deepcopy(arr_estimated)

    # get means and STDs of actual and estimated signals
    mean_act = np.mean(arr_actual)
    std_act = np.std(arr_actual)
    min_act = np.min(arr_actual)


    mean_est = np.mean(arr_estimated)
    std_est = np.std(arr_estimated)
    min_est = np.min(arr_estimated)

    min_both = np.min([min_act, min_est])
    arr_actual -= min_both
    arr_estimated -= min_both

    #print('min_act, min_est, min_both', min_act, min_est, min_both)

    # rescale the trend signal to the levele of the actual signal or build a new one
    if arr_trend is None:
        #print('arr_trend is None')
        kf = initiate_tracking_kalman(arr_actual)
        arr_trend = kf.smooth(arr_actual)[0][:,0]
    else:
        arr_trend = arr_trend * std_act + mean_act

    # use Kalman smoother to smooth the actual signal and use this as its trend
    kf = initiate_tracking_kalman(arr_actual, arr_trend)
```

```
        actual_smth = kf.smooth(arr_actual)[0][:,0]

        # use Kalman smoother to smooth the estimated signal and use this as its trend
        kf = initiate_tracking_kalman(arr_estimated, arr_trend)
        estimated_smth = kf.smooth(arr_estimated)[0][:,0]

        # adjust the estimated signal to follow the trend for the positiuons defined by
        arr_estimated_adj = copy.deepcopy(arr_estimated)
        arr_estimated_adj[loc_adjust] = arr_estimated_adj[loc_adjust] - estimated_smth[loc_

        arr_estimated_adj += min_both
        estimated_smth += min_both
        actual_smth += min_both
        arr_trend += min_both


        return arr_estimated_adj, estimated_smth, actual_smth, arr_trend

In [7]: def get_values_by_year_and_month(df_results, df_scales, year, last_month, result_type,
        return (
            df_results.loc[:,(visitor_type, channel, region ,result_type)].sum(axis=1).grou
        ).loc[(year,1):(year, last_month)]

    def get_values_by_year_and_month_rescaled(df_results, df_scales, year, last_month, resu
        return (
            df_results.loc[:,(visitor_type, channel, region ,result_type)].sum(axis=1).grou
            /
            df_scales[visitor_type]
        ).loc[(year,1):(year, last_month)]
```

2 WORKSPACE

2.1 Initiate some parameters and load THE master table

```
In [8]: includeOffline = True

        device = 'laptop'

        ROOT_PATH = {
            'server':  os.path.join('G:', os.sep, 'bilgin_sherifov',),
            'laptop': os.path.join(
                'C:', os.sep, 'Users', 'bilgin.sherifov', 'Documents',
                'PYTHON', 'Jupyter Notebooks','Econometrics', 'Active', '2019', '2018 Style'),
            'home': os.path.join(
                'E:', os.sep, 'JupyterNB', 'OTB', 'Econometrics', 'Active', '2019', '2018 Style
        }

        RESULTS_PATH = os.path.join(ROOT_PATH[device], 'Results')
```

```python
    WORKSPACE_COMMON_PATH = os.path.join(ROOT_PATH[device], 'WORKSPACE_Common')
    if includeOffline:
        WORKSPACE_PATH = os.path.join(ROOT_PATH[device], 'WORKSPACE_w_Offline')
    else:
        WORKSPACE_PATH = os.path.join(ROOT_PATH[device], 'WORKSPACE_wo_Offline')
    DATA_PATH = os.path.join(ROOT_PATH[device], 'Data')


    with open(os.path.join(WORKSPACE_COMMON_PATH, 'CONFIG.pkl'), 'rb') as handle:
        CONFIG = pickle.load(handle)

    with open(os.path.join(WORKSPACE_PATH, 'PARAMS.pkl'), 'rb') as handle:
        PARAMS = pickle.load(handle)

    with open(os.path.join(WORKSPACE_PATH, 'GA_COMBINATIONS.pkl'), 'rb') as handle:
        GA_COMBINATIONS = pickle.load(handle)


    DATE_START = CONFIG['dates']['series range']['start']
    DATE_END = CONFIG['dates']['series range']['end']

    BASE_START = CONFIG['dates']['base range']['start']
    BASE_END   = CONFIG['dates']['base range']['end']

    ADD_YEARLY_AVERAGES = False

    CONFIG
```

Out[8]: {'dates': {'base range': {'end': datetime.date(2016, 12, 31),
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         'start': datetime.date(2010, 1, 1)}},
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       'MAD': 'Morocco',
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In [9]: pp.pprint(PARAMS)

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                               'Non Brand'],
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```
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```

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```

```
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  'lags': [[0, 4]],
  'names': ['Offline Spent OTB'],
```

```
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                'Month',
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             'HTV Wales',
             'HTV West',
             'London',
             'Meridian (exc. Channel Islands)',
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             'North Scotland',
             'North West',
             'South West',
             'Ulster',
             'Yorkshire'],
'subLevelOut': [ 'Brand PPC',
                 'Brand Direct',
                 'Brand Organic',
                 'Non Brand PPC']}
```

3   ESTIMATE

3.1   RLS with Kalman filter

3.1.1   Rauch–Tung–Striebel Smoother

Predict Step

$$\mathbf{P} = \mathbf{F}\mathbf{P}_k\mathbf{F}^\mathsf{T} + \mathbf{Q}$$

Update Step

$$\mathbf{K}_k = \mathbf{P}_k\mathbf{F}\ \mathbf{P}^{-1}$$
$$\mathbf{x}_k = \mathbf{x}_k + \mathbf{K}_k(\mathbf{x}_{x+1} - \mathbf{F}\mathbf{X}_k)$$
$$\mathbf{P}_k = \mathbf{P}_k + \mathbf{K}_k(\mathbf{P}_{K+1} - \mathbf{P})\mathbf{K}_k^\mathsf{T}$$

3.2 EM estimation of Kalman filter parameters

This class implements the Kalman Filter, Kalman Smoother, and EM Algorithm for a Linear Gaussian model specified by,

$$x_{t+1} = A_t x_t + b_t + \mathrm{Normal}(0, Q_t)$$
$$z_t = C_t x_t + d_t + \mathrm{Normal}(0, R_t)$$

```
The Kalman Filter is an algorithm designed to estimate
:math:`P(x_t | z_{0:t})`.  As all state transitions and observations are
linear with Gaussian distributed noise, these distributions can be
represented exactly as Gaussian distributions with mean
`filtered_state_means[t]` and covariances `filtered_state_covariances[t]`.


Similarly, the Kalman Smoother is an algorithm designed to estimate
:math:`P(x_t | z_{0:T-1})`.


The EM algorithm aims to find for
:math:`\\theta = (A, b, C, d, Q, R, \\mu_0, \\Sigma_0)`


$$


    \\max_{\\theta} P(z_{0:T-1}; \\theta)
$$


If we define :math:`L(x_{0:T-1},\\theta) = \\log P(z_{0:T-1}, x_{0:T-1};
\\theta)`, then the EM algorithm works by iteratively finding,


.. math::


    P(x_{0:T-1} | z_{0:T-1}, \\theta_i)


then by maximizing,


.. math::


    \\theta_{i+1} = \\arg\\max_{\\theta}
        \\mathbb{E}_{x_{0:T-1}} [
            L(x_{0:T-1}, \\theta)| z_{0:T-1}, \\theta_i
        ]
```

```python
In [10]: idxInl = 0
         [str(j+idxInl) +': ' + '\\'.join(run['folders'])+': '+run['output'] for j,run in enume
```

```
Out[10]: ['0: Transactions\\New Visitors\\Brand\\Organic: Central Scotland',
          '1: Transactions\\New Visitors\\Brand\\Organic: East Of England',
          '2: Transactions\\New Visitors\\Brand\\Organic: HTV Wales',
          '3: Transactions\\New Visitors\\Brand\\Organic: HTV West',
          '4: Transactions\\New Visitors\\Brand\\Organic: London',
          '5: Transactions\\New Visitors\\Brand\\Organic: Meridian (exc. Channel Islands)',
          '6: Transactions\\New Visitors\\Brand\\Organic: Midlands',
          '7: Transactions\\New Visitors\\Brand\\Organic: North East',
          '8: Transactions\\New Visitors\\Brand\\Organic: North Scotland',
          '9: Transactions\\New Visitors\\Brand\\Organic: North West',
          '10: Transactions\\New Visitors\\Brand\\Organic: South West',
          '11: Transactions\\New Visitors\\Brand\\Organic: Ulster',
          '12: Transactions\\New Visitors\\Brand\\Organic: Yorkshire',
          '13: Transactions\\New Visitors\\Brand\\PPC: Central Scotland',
          '14: Transactions\\New Visitors\\Brand\\PPC: East Of England',
          '15: Transactions\\New Visitors\\Brand\\PPC: HTV Wales',
          '16: Transactions\\New Visitors\\Brand\\PPC: HTV West',
          '17: Transactions\\New Visitors\\Brand\\PPC: London',
          '18: Transactions\\New Visitors\\Brand\\PPC: Meridian (exc. Channel Islands)',
          '19: Transactions\\New Visitors\\Brand\\PPC: Midlands',
          '20: Transactions\\New Visitors\\Brand\\PPC: North East',
          '21: Transactions\\New Visitors\\Brand\\PPC: North Scotland',
          '22: Transactions\\New Visitors\\Brand\\PPC: North West',
          '23: Transactions\\New Visitors\\Brand\\PPC: South West',
          '24: Transactions\\New Visitors\\Brand\\PPC: Ulster',
          '25: Transactions\\New Visitors\\Brand\\PPC: Yorkshire',
          '26: Transactions\\New Visitors\\Brand\\Direct: Central Scotland',
          '27: Transactions\\New Visitors\\Brand\\Direct: East Of England',
          '28: Transactions\\New Visitors\\Brand\\Direct: HTV Wales',
          '29: Transactions\\New Visitors\\Brand\\Direct: HTV West',
          '30: Transactions\\New Visitors\\Brand\\Direct: London',
          '31: Transactions\\New Visitors\\Brand\\Direct: Meridian (exc. Channel Islands)',
          '32: Transactions\\New Visitors\\Brand\\Direct: Midlands',
          '33: Transactions\\New Visitors\\Brand\\Direct: North East',
          '34: Transactions\\New Visitors\\Brand\\Direct: North Scotland',
          '35: Transactions\\New Visitors\\Brand\\Direct: North West',
          '36: Transactions\\New Visitors\\Brand\\Direct: South West',
          '37: Transactions\\New Visitors\\Brand\\Direct: Ulster',
          '38: Transactions\\New Visitors\\Brand\\Direct: Yorkshire']
```

```python
In [11]: print('DATA_PATH', DATA_PATH)
```

```
DATA_PATH C:\Users\bilgin.sherifov\Documents\PYTHON\Jupyter Notebooks\Econometrics\Active\2019\
```

```python
In [ ]: mstrTbl = pd.read_pickle(os.path.join(DATA_PATH, 'Data_Master_Table.pkl'))
        mstrTbl.iloc[[0,1,2,3,-4,-3,-2,-1]]
```

```
In [13]: regions = [
             'Central Scotland',
             'East Of England',
             'HTV Wales',
             'HTV West',
             'London',
             'Meridian (exc. Channel Islands)',
             'Midlands',
             'North East',
             'North Scotland',
             'North West',
             'South West',
             'Ulster',
             'Yorkshire'
         ]

In [ ]: # Returning Visitors
        tblTemp_RV = (
            mstrTbl[['Year', 'Month','Transactions: Returning Visitor']]
            .groupby(['Year','Month'])
            .sum()
        )

        tblTemp_RV_sub = tblTemp_RV.iloc[:, tblTemp_RV.columns.get_level_values(1).isin(['Bran
        tblTemp_RV_sub = tblTemp_RV_sub.iloc[:, tblTemp_RV_sub.columns.get_level_values(2).isi

        # New Visitors
        tblTemp_NV = (
            mstrTbl[['Year', 'Month','Transactions: New Visitor']]
            .groupby(['Year','Month'])
            .sum()
        )
        tblTemp_NV_sub = tblTemp_NV.iloc[:, tblTemp_NV.columns.get_level_values(1).isin(['Bran
        tblTemp_NV_sub = tblTemp_NV_sub.iloc[:, tblTemp_NV_sub.columns.get_level_values(2).isi


        tblRescaleFactors = pd.DataFrame(
            {
                'Returning Visitors':tblTemp_RV_sub.sum(axis=1) / tblTemp_RV.sum(axis=1),
                'New Visitors':tblTemp_NV_sub.sum(axis=1) / tblTemp_NV.sum(axis=1)
            }
        )

        tblTotalTransactions = pd.DataFrame(
            {
                'Returning Visitors':tblTemp_RV.sum(axis=1),
                'New Visitors':tblTemp_NV.sum(axis=1)
            }
```

```
        )

        pd.concat([tblRescaleFactors.tail(6), tblTotalTransactions.tail(6)], axis= 1)

In [14]: tblTemp_NV.columns.get_level_values(1).unique()

Out[14]: Index(['Brand Direct', 'Brand Email', 'Brand Organic', 'Brand PPC',
               'Brand Social', 'Non Brand Other', 'Non Brand PPC', 'Non-Brand Other'],
              dtype='object')

In [16]: pd.DataFrame({
             'Brand Direct': tblTemp_NV['Transactions: New Visitor']['Brand Direct'].sum(axis=
             'Brand PPC': tblTemp_NV['Transactions: New Visitor']['Brand PPC'].sum(axis=1),
             'Brand Organic': tblTemp_NV['Transactions: New Visitor']['Brand Organic'].sum(axi
             'Brand Social': tblTemp_NV['Transactions: New Visitor']['Brand Social'].sum(axis=
             'Brand Email': tblTemp_NV['Transactions: New Visitor']['Brand Email'].sum(axis=1)
             'Non Brand PPC': tblTemp_NV['Transactions: New Visitor']['Non Brand PPC'].sum(axis
             'Non-Brand Other': tblTemp_NV['Transactions: New Visitor']['Non-Brand Other'].sum
         }).to_csv(os.path.join(RESULTS_PATH,'transactions by month - new visitors.csv'))

         pd.DataFrame({
             'Brand Direct': tblTemp_RV['Transactions: Returning Visitor']['Brand Direct'].sum
             'Brand PPC': tblTemp_RV['Transactions: Returning Visitor']['Brand PPC'].sum(axis=
             'Brand Organic': tblTemp_RV['Transactions: Returning Visitor']['Brand Organic'].su
             'Brand Social': tblTemp_RV['Transactions: Returning Visitor']['Brand Social'].sum
             'Brand Email': tblTemp_RV['Transactions: Returning Visitor']['Brand Email'].sum(a
             'Non Brand PPC': tblTemp_RV['Transactions: Returning Visitor']['Non Brand PPC'].su
             'Non-Brand Other': tblTemp_RV['Transactions: Returning Visitor']['Non-Brand Other
         }).to_csv(os.path.join(RESULTS_PATH,'transactions by month - returning visitors.csv')

In [17]: RESULTS_PATH

Out[17]: 'C:\\Users\\bilgin.sherifov\\Documents\\PYTHON\\Jupyter Notebooks\\Econometrics\\Acti

In [18]: for j0, runParams in enumerate(PARAMS['LTI']['runs']):
             print(j0, runParams['folders'])

0 ['Transactions', 'New Visitors', 'Brand', 'Organic']
1 ['Transactions', 'New Visitors', 'Brand', 'Organic']
2 ['Transactions', 'New Visitors', 'Brand', 'Organic']
3 ['Transactions', 'New Visitors', 'Brand', 'Organic']
4 ['Transactions', 'New Visitors', 'Brand', 'Organic']
5 ['Transactions', 'New Visitors', 'Brand', 'Organic']
6 ['Transactions', 'New Visitors', 'Brand', 'Organic']
7 ['Transactions', 'New Visitors', 'Brand', 'Organic']
8 ['Transactions', 'New Visitors', 'Brand', 'Organic']
9 ['Transactions', 'New Visitors', 'Brand', 'Organic']
10 ['Transactions', 'New Visitors', 'Brand', 'Organic']
11 ['Transactions', 'New Visitors', 'Brand', 'Organic']
```

```
12 ['Transactions', 'New Visitors', 'Brand', 'Organic']
13 ['Transactions', 'New Visitors', 'Brand', 'PPC']
14 ['Transactions', 'New Visitors', 'Brand', 'PPC']
15 ['Transactions', 'New Visitors', 'Brand', 'PPC']
16 ['Transactions', 'New Visitors', 'Brand', 'PPC']
17 ['Transactions', 'New Visitors', 'Brand', 'PPC']
18 ['Transactions', 'New Visitors', 'Brand', 'PPC']
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52 ['Transactions', 'Returning Visitors', 'Brand', 'Organic']
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59 ['Transactions', 'Returning Visitors', 'Brand', 'Organic']
```

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In [19]: del tblTemp_RAW, tblTemp_SA
         gc.collect();

In [14]: DO_TREND_ADJUSTMENT = False

         with timer('RLS Estimations'):
             pathIO = os.path.join(WORKSPACE_PATH, 'S2_IO_Holder')

             # List of RGB triplets
             #rgb_values = sns.color_palette("Set2", 12)

             # Map label to RGB
             #color_map = dict(zip(color_labels, rgb_values))

             #sns.set_palette("deep", 12)

             with open(
                 os.path.join(
                     WORKSPACE_COMMON_PATH,
                     'S1_Extract_Tables', 'offline','spent_otb',
                     'scaled.pkl')
                 , 'rb') as handle:
                 tblOffline =  pickle.load(handle)
             for year in [2014,2015,2016,2017,2018, 2019]:
                 tblOffline.loc[(year,1)] += tblOffline.loc[(year-1,12)] + tblOffline.loc[(year
                 tblOffline.loc[(year-1,11)] = 0
                 tblOffline.loc[(year-1,12)] = 0

             with open(
                 os.path.join(
                     WORKSPACE_COMMON_PATH,
                     'S1_Extract_Tables',
                     'baseLevels.pkl')
                 , 'rb') as handle:
```

```python
            baseLineScale = pickle.load(handle)


    idxLabel = tblOffline.index.values
    prd = 6
    zz = np.arange(prd-1,len(tblOffline), prd)


    # 0. Create holders for seasonally-adjusted and raw results and outputs
    tblTemp_RAW = pd.DataFrame({('u','u','u','u'):np.nan}, index = tblOffline.index)
    tblTemp_SA = pd.DataFrame({('u','u','u','u'):np.nan}, index = tblOffline.index)

    # 1. Run the whole algorithm many times, for each region, channel and visitor typ
    maxEpochs = 20
    addNoiseLevel = 0.25
    for epoch in range(1,maxEpochs+1):
        with timer ('EPOCH '+ str(epoch), n_blanks=4):
            for j0, runParams in enumerate(PARAMS['LTI']['runs'][:104]):
                pathFile = os.path.join(*runParams['folders'])
                listFolder = pathFile.split('\\')

                if epoch == 1:
                    print(4*' ', j0, ': ', pathFile, runParams['output'])

                # get the seasonal components
                tblSeasonal = pd.read_pickle(
                    os.path.join(
                        WORKSPACE_COMMON_PATH,
                        'S1_Extract_Tables',
                        'internal',
                        pathFile,
                        'seasonal.pkl'))

                # run it for the whole output and for trend only and variation-around
                for filterType, seperator in PARAMS['LTI']['IO Filter Types'].items()
                    region = runParams['output']

                    #print('- Filter type: ', filterType)
                    # ignore trend only and variation-around-trend only
                    if filterType == 'None':
                        if runParams['seasonal']:
                            typeSeasonal = 'seasonally_adjusted_'
                        else:
                            typeSeasonal = 'scaled_'

                        # 2. Load data from previous stage
                        with open(os.path.join(pathIO, pathFile,
                                    'dctIO'+ seperator + typeSeasonal + region + '.pk]
```

```python
        dctIO = pickle.load(handle)



     # 3. Add some noise to the zeros of the offline spent by comp
    idx_offline_comp = [idx for idx, inp_label in enumerate(dctIO
    for j in idx_offline_comp:
        idx_zeros = np.where(dctIO['inputs']['values'][:,j] == 0)
        dctIO['inputs']['values'][idx_zeros,j] = dctIO['inputs'][

    # 4. If offline spent by OTB is used as an input, add some no
    if includeOffline:
        # get the column numbers that correspond to offline and i
        idx_offline_otb = [idx for idx, inp_label in enumerate(dct
        # correct for the increased scale in the lagged versions
        cnt = 0
        for j in idx_offline_otb:
            if cnt > 0:
                dctIO['inputs']['values'][:,j] = dctIO['inputs'][
            cnt += 1
            # shift the offline spent forward, due to delay is ka
            if False:
                dctIO['inputs']['values'][:,j] = shift(dctIO['inp

            idx_zeros = np.where(dctIO['inputs']['values'][:,j] ==
            dctIO['inputs']['values'][idx_zeros,j] = dctIO['inputs

    #  add yearly averages of output as an extra input
    if ADD_YEARLY_AVERAGES:
        # get yearly averages into a dictionary
        yearlyAverages = {
            2010: 0,
            2011: 0,
            2012: 0,
            2013: 0,
            2014: 0,
            2015: 0,
            2016: 0,
            2017: 0,
            2018: 0,
            2019: 0,
        }

        for j, val in enumerate(dctIO['indexes']):
            yearlyAverages[val[0]] += dctIO['output']['values'][j]

        # add the yearly output averages to the inputs
        dctIO['inputs']['newInputLabels'].append('Yearly Average_(
```

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```python
        dctIO['inputs']['values'] = np.concatenate([dctIO['inputs
        j2 = len(dctIO['inputs']['newInputLabels']) - 1
        for j1, val in enumerate(dctIO['indexes']):
            dctIO['inputs']['values'][j1, j2] = yearlyAverages[val

        #print("dctIO['inputs']['values'].shape", dctIO['inputs']

    # 5. Get the indexes for the masked-out outputs (those won't
    with open(os.path.join(pathIO, pathFile,
                'dctMask'+ seperator + region + '.pkl'), 'rb') as
            dctMask = pickle.load(handle)
    if epoch ==1:
        print(10*' ', typeSeasonal + seperator + region)

    # 6. Do the Kalman-Filter and Smoother based parameter estima
    #    a. Start with a random guess, move forward, then smooth t
    #    b. Do the same two more times, but use the smoothed param
    temp = copy.deepcopy(dctIO['output']['values'].flatten())
    idxToAdjust = np.arange(0, 112)
    estimatedAdj, estimatedSmth, actualSmth, trend_ = adjust_to_tr
        temp,
        temp*0,
        idxToAdjust,
        arr_trend = None)
    varOut = np.var(temp-trend_)
    if epoch ==1:
        print(11*' '+'var(out) =', varOut)
    for j in range(3):
        if j == 0:
            xInl = None
        else:
            xInl = np.mean(rsltsKalman['coefs']['smoothed'][5:17]

        if j < 2:
            nReps = 1
            plotCoefs = False
        else:
            nReps = 250
            plotCoefs = True

        if epoch == maxEpochs:
            plotKalmanCoefs = plotCoefs
        else:
            plotKalmanCoefs = False
        if includeOffline:
            dctMask['as np index'] = np.arange(len(dctIO['output']
        rsltsKalman = fit_kalman(
```

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```python
                dctIO, dctMask['as np index'],
                x_inl = xInl,
                p = 1.0, q = 0.005, r = 10*varOut,
                prmNoiseScale = 0.0001, nReps = nReps,
                enforceNonNegative = True,
                plotCoefs = plotKalmanCoefs, verbose = False)

        prmsOut = rsltsKalman['outputCenteringParams']

        # plot the coefs
        if plotCoefs and (epoch == maxEpochs):
            title_ = '_'.join(runParams['folders']) + '__' + filterTy
            plt.title(title_)
            plt.savefig(os.path.join(WORKSPACE_PATH, 'RLS', 'model_RL
            plt.close()

        # get the number by which the output was rescaled
        baseLineLevel = baseLineScale[os.path.join(WORKSPACE_COMMON_P

        # l1 = visitor type, l2 = channel, l3 = region
        l1 = listFolder[1]
        l2 = ' '.join(listFolder[2:])
        l3 = region

        # 7. get actual and estimated seasonally-adjusted outputs, by
        arrOutActual_SA = (
            dctIO['output']['values'].flatten()
            * dctIO['output']['scales'][0]
            + dctIO['output']['centers'][0]
        )
        arrOutEst_SA = (
            np.mean(rsltsKalman['simulations']['extremes'], axis=1)
            * dctIO['output']['scales'][0]
            + dctIO['output']['centers'][0]
        )

        # 8. re-adjust SA estimates for last few years
        if DO_TREND_ADJUSTMENT:
            idxData = np.arange(len(arrOutActual_SA))
            idxToAdjust = np.arange(60, 112)
            estimatedAdj, estimatedSmth, actualSmth, trend_ = adjust_
                arrOutActual_SA,
                arrOutEst_SA,
                idxToAdjust,
                arr_trend = None)
            arrOutEst_SA = copy.deepcopy(estimatedAdj)

        # 9. get actual and estimated raw outputs (add back seasonali
```

```python
    arrOutActual_RAW = np.exp(arrOutActual_SA + tblSeasonal[region
    arrOutEst_RAW = np.exp(arrOutEst_SA + tblSeasonal[region]) * 

    # 10. Calculate residuals between actual and average model ou
    dfResiduals_SA = arrOutActual_SA - arrOutEst_SA
    dfResiduals_RAW = arrOutActual_RAW - arrOutEst_RAW

    # shift backward the estimates, due to delayed response of Ka
    if includeOffline and False:
        arrOutEst_SA = shift(arrOutEst_SA, -1, cval=0)
        arrOutEst_RAW = shift(arrOutEst_RAW, -1, cval=0)

    # 11. Add to the main results holders
    if epoch == 1:
        tblTemp_SA[(l1, l2, l3, 'actual')] = copy.deepcopy(arrOutA
        tblTemp_SA[(l1, l2, l3, 'estimated')] = copy.deepcopy(arr(
        tblTemp_SA[(l1, l2, l3, 'residual')] = dfResiduals_SA
        tblTemp_RAW[(l1, l2, l3, 'actual')] = copy.deepcopy(arrOut
        tblTemp_RAW[(l1, l2, l3, 'estimated')] = copy.deepcopy(ar
        tblTemp_RAW[(l1, l2, l3, 'residual')] = dfResiduals_RAW
    else:
        tblTemp_SA[(l1, l2, l3, 'actual')] += arrOutActual_SA
        tblTemp_SA[(l1, l2, l3, 'estimated')] += arrOutEst_SA
        tblTemp_SA[(l1, l2, l3, 'residual')] += dfResiduals_SA
        tblTemp_RAW[(l1, l2, l3, 'actual')] += arrOutActual_RAW
        tblTemp_RAW[(l1, l2, l3, 'estimated')] += arrOutEst_RAW
        tblTemp_RAW[(l1, l2, l3, 'residual')] += dfResiduals_RAW

    # 12. Get spread of estimated SA and RAW outputs around the a
    residuals_SA = (
        - arrOutEst_SA[:,None]
        + (
            rsltsKalman['simulations']['extremes']
            * dctIO['output']['scales'][0]
            + dctIO['output']['centers'][0]
        )
    )
    residuals_RAW = (
        - arrOutEst_RAW[:,None]
        + (
            np.exp(
                rsltsKalman['simulations']['extremes']
                * dctIO['output']['scales'][0]
                + dctIO['output']['centers'][0]
            )
            + tblSeasonal[region].values[:,None]
        )
        * baseLineLevel
```

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```python
)
stdRes_SA = np.std(residuals_SA, axis=1)
stdRes_RAW = np.std(residuals_RAW, axis=1)

# 13. Calculate impact
if includeOffline:
    # If offline spent by OTB is one of the inputs, find what
    if includeOffline:
        # all inputs
        inpAll = copy.deepcopy(dctIO['inputs']['values'])
        # inputs w/o offline spent
        inpNoOffline = copy.deepcopy(dctIO['inputs']['values']
        inpNoOffline[:,idx_offline_otb] *= 0
        # estimate w/ ALL inputs
        estAll = (
            np.sum((rsltsKalman['coefs']['smoothed'] * inpAll)
            * rsltsKalman['outputCenteringParams']['scale']
            + rsltsKalman['outputCenteringParams']['mean'])
        estAll = estAll * dctIO['output']['scales'][0] + dctIO
        if DO_TREND_ADJUSTMENT:
            idxToAdjust = np.arange(60, 112)
            estimatedAdj, estimatedSmth, actualSmth, trend_ =
                arrOutActual_SA,
                estAll,
                idxToAdjust,
                arr_trend = None)
            diff_ = estAll - estimatedAdj
            estAll = copy.deepcopy(estimatedAdj)

        # estimate w/o OFFLINE
        estNoOffline = (
            np.sum((rsltsKalman['coefs']['smoothed'] * inpNoO:
            * rsltsKalman['outputCenteringParams']['scale']
            + rsltsKalman['outputCenteringParams']['mean'])
        estNoOffline = estNoOffline * dctIO['output']['scales
        if DO_TREND_ADJUSTMENT:
            estNoOffline = estNoOffline - diff_

        # shift everything due to delayed Kalman gain respons
        if False:
            estAll = shift(estAll, -1, cval=0)
            estNoOffline = shift(estNoOffline, -1, cval=0)

        # estimate OFFLINE Only
        estOffline = np.clip(estAll - estNoOffline, 0, np.inf]
        #estOffline -= np.mean(estOffline[:24])
```

```python
            # add offline contribution to the main results holder
            if epoch == 1:
                tblTemp_SA[(l1, l2, l3, 'impact')] = copy.deepcop
                min_est_act = np.min([np.min(arrOutEst_SA), np.mi
                tblTemp_SA[(l1, l2, l3, 'adjusted impact')] = est0
                tblTemp_RAW[(l1, l2, l3, 'impact')] = baseLineLev
                    np.exp(estAll + tblSeasonal[region])
                    - np.exp(estNoOffline + tblSeasonal[region])
                )
                tblTemp_RAW[(l1, l2, l3, 'adjusted impact')] = ba
                    np.exp(estAll + tblSeasonal[region])
                    - np.exp(estNoOffline + tblSeasonal[region])
                ) / arrOutEst_RAW * arrOutActual_RAW
            else:
                tblTemp_SA[(l1, l2, l3, 'impact')] += estOffline
                tblTemp_SA[(l1, l2, l3, 'adjusted impact')] += es
                tblTemp_RAW[(l1, l2, l3, 'impact')] += baseLineLe
                    np.exp(estAll + tblSeasonal[region])
                    - np.exp(estNoOffline + tblSeasonal[region])
                )
                tblTemp_RAW[(l1, l2, l3, 'adjusted impact')] += ba
                    np.exp(estAll + tblSeasonal[region])
                    - np.exp(estNoOffline + tblSeasonal[region])
                ) / arrOutEst_RAW * arrOutActual_RAW
    else:
        # If offline spent by OTB is NOT one of the inputs, find
        # by looking at deviations btw actual and estimated outpu
        maxImpactDuration = 4

        arrOffline = tblOffline[region].values
        arrResiduals_RAW = dfResiduals_RAW.values
        temp = np.zeros_like(arrResiduals_RAW)
        idxCounted = []
        # For each index where the offline spend was greater than
        for idxImpct in tblOffline[region][tblOffline[region] > 0]
            offlineStrtLoc = tblOffline.index.get_loc(idxImpct)
            #print('1.0 idxImpct', idxImpct, 'offlineStrtLoc', of
            # If this is the first month of the offline campaign
            if (tblOffline[region].iloc[offlineStrtLoc] > 0) & (o
                #print('considering')
                impactTotal   = 0
                impactMax = 0
                impactDuration   = 0
                actualTotal = 0
                # While the next value is greater than the baseli
                baseLine  = 1.96 * stdRes_RAW
                cntTemp = offlineStrtLoc - 1
                cntPeriod = 1
```

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```python
                        while ((arrResiduals_RAW[offlineStrtLoc] >= baseL
                            #print('TEMP:', offlineStrtLoc, cntPeriod)

                            diffBaseLine = np.max((0,arrResiduals_RAW[off
                            if np.isnan(diffBaseLine):
                                diffBaseLine = 0.0

                            if diffBaseLine > 0.0:
                                idxCounted.append(offlineStrtLoc)

                            if False:
                                print('1.1 arrResiduals_RAW[offlineStrtLo
                                    'baseLine', baseLine[offlineStrtLoc]
                                    'diffBaseLine', diffBaseLine,
                                    )
                            # Update variables
                            cntTemp += 1
                            cntPeriod +=1
                            temp[cntTemp] += diffBaseLine
                            impactTotal += diffBaseLine
                            #actualTotal += self.tblOutputs[key_][region]
                            impactDuration += 1
                            if diffBaseLine > impactMax:
                                impactMax = diffBaseLine
                            offlineStrtLoc += 1
                            # If this is the end of the array, stop
                            if offlineStrtLoc >= len(arrResiduals_RAW):
                                break

                if epoch == 1:
                    tblTemp_RAW[(l1, l2, l3, 'impact')] = copy.deepcopy(te
                else:
                    tblTemp_RAW[(l1, l2, l3, 'impact')] += copy.deepcopy(t

        #tblAll = tblAll.merge(tblTemp_RAW, left_index = True, right_
        #tblAll = pd.concat([tblAll, tblTemp_RAW], axis = 1)
        if (True) and (epoch == maxEpochs):
            plt.figure(figsize=(24,16))
            plt.subplot(2,1,1)
            (tblTemp_SA[(l1, l2, l3, 'actual')] / epoch).plot(linewidt
            (tblTemp_SA[(l1, l2, l3, 'estimated')] / epoch).plot(linew
            if includeOffline:
                plt.plot(estNoOffline, linewidth=3, label='baseline')
                (tblTemp_SA[(l1, l2, l3, 'impact')] / epoch).plot(line
                (tblTemp_SA[(l1, l2, l3, 'adjusted impact')] / epoch)
            else:
                (tblTemp_SA[(l1, l2, l3, 'residual')] / epoch - 1).plo
                #(tblTemp_SA[(l1, l2, l3, 'impact')] / epoch).plot(st
```

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```python
        plt.plot(residuals_SA - 1, c=[0.5, 0.5, 0.5], alpha =
        plt.plot(1.96*stdRes_SA - 1, '--', c=[0.3, 0.3, 0.3])
        plt.plot(-1.96*stdRes_SA - 1, '--', c=[0.3, 0.3, 0.3]

    #plt.plot(np.exp(dctIO['output']['values']), linewidth=3,
    #plt.plot(np.exp(meanEstY), c='#b30000', label='estimated
    #plt.plot(np.exp(rsltsKalman['simulations']['mean']), lin

    #plt.plot(np.exp(residuals_RAW) - 4, c=[0.5, 0.5, 0.5], a
    #plt.plot(np.exp(residual_) - 4, c = '#ff7f00')
    #plt.plot(np.exp(1.96*stdRes_RAW) - 4, '--', c=[0.3, 0.3,
    #plt.plot(np.exp(-1.96*stdRes_RAW) - 4, '--', c=[0.3, 0.3

    plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
    plt.legend(loc='upper left')

    plt.twinx()
    plt.plot(2. * tblOffline[region].values / np.max(tblOfflin

    title_ = '_'.join(runParams['folders']) + '__' + filterTyp
    plt.title('SA: ' + title_)


    plt.subplot(2,1,2)
    (tblTemp_RAW[(l1, l2, l3, 'actual')] / epoch).plot(linewic
    (tblTemp_RAW[(l1, l2, l3, 'estimated')] / epoch).plot(line
    if includeOffline:
        (tblTemp_RAW[(l1, l2, l3, 'impact')] / epoch).plot(lin
        (tblTemp_RAW[(l1, l2, l3, 'adjusted impact')] / epoch]
    else:
        (tblTemp_RAW[(l1, l2, l3, 'residual')] / epoch).plot(e
        (tblTemp_RAW[(l1, l2, l3, 'impact')] / epoch).plot(sty
        plt.plot(residuals_RAW, c=[0.5, 0.5, 0.5], alpha = 0.0
        plt.plot(1.96*stdRes_RAW, '--', c=[0.3, 0.3, 0.3])
        plt.plot(-1.96*stdRes_RAW, '--', c=[0.3, 0.3, 0.3])

    #plt.plot(np.exp(dctIO['output']['values']), linewidth=3,
    #plt.plot(np.exp(meanEstY), c='#b30000', label='estimated
    #plt.plot(np.exp(rsltsKalman['simulations']['mean']), lin

    #plt.plot(np.exp(residuals_RAW) - 4, c=[0.5, 0.5, 0.5], a
    #plt.plot(np.exp(residual_) - 4, c = '#ff7f00')
    #plt.plot(np.exp(1.96*stdRes_RAW) - 4, '--', c=[0.3, 0.3,
    #plt.plot(np.exp(-1.96*stdRes_RAW) - 4, '--', c=[0.3, 0.3

    plt.xticks(zz, [str(idxLabel[j]) for j in zz]);
    plt.legend(loc='upper left')
```

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```
                                        plt.twinx()
                                        plt.plot(2. * tblOffline[region].values / np.max(tblOffli

                                        title_ = '_'.join(runParams['folders']) + '__' + filterTy
                                        plt.title('RAW: ' + title_)

                                        plt.tight_layout()

                                        plt.savefig(os.path.join(WORKSPACE_PATH, 'RLS', 'model_RLS
                                        plt.close()

                        tblTemp_RAW.drop('u', level=0, axis=1, inplace=True)
                        # 14. Divide the data in results holders by the number of epoch to get the averag
                        tblTemp_SA = tblTemp_SA / maxEpochs
                        tblTemp_RAW = tblTemp_RAW / maxEpochs
                        if includeOffline:
                            tblTemp_RAW.to_csv(os.path.join(WORKSPACE_PATH, 'RLS', 'fit_RLS_RAW__with_off]
                            tblTemp_SA.to_csv(os.path.join(WORKSPACE_PATH, 'RLS', 'fit_RLS_SA__with_offlin
                        else:
                            tblTemp_RAW.to_csv(os.path.join(WORKSPACE_PATH, 'RLS', 'fit_RLS_RAW__no_offlin
                            tblTemp_SA.to_csv(os.path.join(WORKSPACE_PATH, 'RLS', 'fit_RLS_SA__no_offline
```

```
STARTING: RLS Estimations
    STARTING: EPOCH 1
    0 :  Transactions\New Visitors\Brand\Organic Central Scotland
          seasonally_adjusted__Whole_Central Scotland
          var(out) = 0.1730425067894006
    1 :  Transactions\New Visitors\Brand\Organic East Of England
          seasonally_adjusted__Whole_East Of England
          var(out) = 0.15507835249759097
    2 :  Transactions\New Visitors\Brand\Organic HTV Wales
          seasonally_adjusted__Whole_HTV Wales
          var(out) = 0.28047995301010714
    3 :  Transactions\New Visitors\Brand\Organic HTV West
          seasonally_adjusted__Whole_HTV West
          var(out) = 0.3027464951508597
    4 :  Transactions\New Visitors\Brand\Organic London
          seasonally_adjusted__Whole_London
          var(out) = 0.1071749907902796
    5 :  Transactions\New Visitors\Brand\Organic Meridian (exc. Channel Islands)
          seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
          var(out) = 0.14990137975705675
    6 :  Transactions\New Visitors\Brand\Organic Midlands
          seasonally_adjusted__Whole_Midlands
          var(out) = 0.09907178371402543
    7 :  Transactions\New Visitors\Brand\Organic North East
          seasonally_adjusted__Whole_North East
          var(out) = 0.3540737626265682
```

```
8 :  Transactions\New Visitors\Brand\Organic North Scotland
        seasonally_adjusted__Whole_North Scotland
        var(out) = 0.5583733026013257
9 :  Transactions\New Visitors\Brand\Organic North West
        seasonally_adjusted__Whole_North West
        var(out) = 0.10966783198626476
10 :  Transactions\New Visitors\Brand\Organic South West
        seasonally_adjusted__Whole_South West
        var(out) = 0.6354936612852943
11 :  Transactions\New Visitors\Brand\Organic Ulster
        seasonally_adjusted__Whole_Ulster
        var(out) = 0.48612887451021186
12 :  Transactions\New Visitors\Brand\Organic Yorkshire
        seasonally_adjusted__Whole_Yorkshire
        var(out) = 0.13295819317417115
13 :  Transactions\New Visitors\Brand\PPC Central Scotland
        seasonally_adjusted__Whole_Central Scotland
        var(out) = 0.14819181092921999
14 :  Transactions\New Visitors\Brand\PPC East Of England
        seasonally_adjusted__Whole_East Of England
        var(out) = 0.12397642586708613
15 :  Transactions\New Visitors\Brand\PPC HTV Wales
        seasonally_adjusted__Whole_HTV Wales
        var(out) = 0.20354460634958962
16 :  Transactions\New Visitors\Brand\PPC HTV West
        seasonally_adjusted__Whole_HTV West
        var(out) = 0.2670906201090068
17 :  Transactions\New Visitors\Brand\PPC London
        seasonally_adjusted__Whole_London
        var(out) = 0.10628071390773032
18 :  Transactions\New Visitors\Brand\PPC Meridian (exc. Channel Islands)
        seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
        var(out) = 0.13890292730144593
19 :  Transactions\New Visitors\Brand\PPC Midlands
        seasonally_adjusted__Whole_Midlands
        var(out) = 0.08540565554973677
20 :  Transactions\New Visitors\Brand\PPC North East
        seasonally_adjusted__Whole_North East
        var(out) = 0.265655571928900807
21 :  Transactions\New Visitors\Brand\PPC North Scotland
        seasonally_adjusted__Whole_North Scotland
        var(out) = 0.43383807241065026
22 :  Transactions\New Visitors\Brand\PPC North West
        seasonally_adjusted__Whole_North West
        var(out) = 0.1377601875787911
23 :  Transactions\New Visitors\Brand\PPC South West
        seasonally_adjusted__Whole_South West
        var(out) = 0.31174602393473666
```

```
24 :  Transactions\New Visitors\Brand\PPC Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.3691126788113858
25 :  Transactions\New Visitors\Brand\PPC Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 0.09181833721852976
26 :  Transactions\New Visitors\Brand\Direct Central Scotland
       seasonally_adjusted__Whole_Central Scotland
       var(out) = 0.542350009134015
27 :  Transactions\New Visitors\Brand\Direct East Of England
       seasonally_adjusted__Whole_East Of England
       var(out) = 0.45855184356372486
28 :  Transactions\New Visitors\Brand\Direct HTV Wales
       seasonally_adjusted__Whole_HTV Wales
       var(out) = 0.6923423616070956
29 :  Transactions\New Visitors\Brand\Direct HTV West
       seasonally_adjusted__Whole_HTV West
       var(out) = 0.5259253556426987
30 :  Transactions\New Visitors\Brand\Direct London
       seasonally_adjusted__Whole_London
       var(out) = 0.5804391478008846
31 :  Transactions\New Visitors\Brand\Direct Meridian (exc. Channel Islands)
       seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
       var(out) = 0.4953147585970106
32 :  Transactions\New Visitors\Brand\Direct Midlands
       seasonally_adjusted__Whole_Midlands
       var(out) = 0.6092191822627571
33 :  Transactions\New Visitors\Brand\Direct North East
       seasonally_adjusted__Whole_North East
       var(out) = 0.5961846436260146
34 :  Transactions\New Visitors\Brand\Direct North Scotland
       seasonally_adjusted__Whole_North Scotland
       var(out) = 0.8011907495199091
35 :  Transactions\New Visitors\Brand\Direct North West
       seasonally_adjusted__Whole_North West
       var(out) = 0.5449639634651948
36 :  Transactions\New Visitors\Brand\Direct South West
       seasonally_adjusted__Whole_South West
       var(out) = 0.7896939987833308
37 :  Transactions\New Visitors\Brand\Direct Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.7385272108934596
38 :  Transactions\New Visitors\Brand\Direct Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 1.1481491288244707
39 :  Transactions\New Visitors\Non Brand\PPC Central Scotland
       seasonally_adjusted__Whole_Central Scotland
       var(out) = 0.5602104109260014
```

```
40 :   Transactions\New Visitors\Non Brand\PPC East Of England
        seasonally_adjusted__Whole_East Of England
        var(out) = 0.22740865185909878
41 :   Transactions\New Visitors\Non Brand\PPC HTV Wales
        seasonally_adjusted__Whole_HTV Wales
        var(out) = 0.49774253305611993
42 :   Transactions\New Visitors\Non Brand\PPC HTV West
        seasonally_adjusted__Whole_HTV West
        var(out) = 0.5271424867325233
43 :   Transactions\New Visitors\Non Brand\PPC London
        seasonally_adjusted__Whole_London
        var(out) = 0.4289378243366618
44 :   Transactions\New Visitors\Non Brand\PPC Meridian (exc. Channel Islands)
        seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
        var(out) = 0.3267617797966498
45 :   Transactions\New Visitors\Non Brand\PPC Midlands
        seasonally_adjusted__Whole_Midlands
        var(out) = 0.2995590859247563
46 :   Transactions\New Visitors\Non Brand\PPC North East
        seasonally_adjusted__Whole_North East
        var(out) = 0.5639146416554536
47 :   Transactions\New Visitors\Non Brand\PPC North Scotland
        seasonally_adjusted__Whole_North Scotland
        var(out) = 0.718873216656739
48 :   Transactions\New Visitors\Non Brand\PPC North West
        seasonally_adjusted__Whole_North West
        var(out) = 0.43780504152869903
49 :   Transactions\New Visitors\Non Brand\PPC South West
        seasonally_adjusted__Whole_South West
        var(out) = 0.6520218906802715
50 :   Transactions\New Visitors\Non Brand\PPC Ulster
        seasonally_adjusted__Whole_Ulster
        var(out) = 0.7899724152916632
51 :   Transactions\New Visitors\Non Brand\PPC Yorkshire
        seasonally_adjusted__Whole_Yorkshire
        var(out) = 0.436255259236948
52 :   Transactions\Returning Visitors\Brand\Organic Central Scotland
        seasonally_adjusted__Whole_Central Scotland
        var(out) = 0.21872734600538696
53 :   Transactions\Returning Visitors\Brand\Organic East Of England
        seasonally_adjusted__Whole_East Of England
        var(out) = 0.12576347923998937
54 :   Transactions\Returning Visitors\Brand\Organic HTV Wales
        seasonally_adjusted__Whole_HTV Wales
        var(out) = 0.18321997922903352
55 :   Transactions\Returning Visitors\Brand\Organic HTV West
        seasonally_adjusted__Whole_HTV West
        var(out) = 0.20809150042618008
```

```
56 :  Transactions\Returning Visitors\Brand\Organic London
       seasonally_adjusted__Whole_London
       var(out) = 0.2136280558305184
57 :  Transactions\Returning Visitors\Brand\Organic Meridian (exc. Channel Islands)
       seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
       var(out) = 0.1384091607621542
58 :  Transactions\Returning Visitors\Brand\Organic Midlands
       seasonally_adjusted__Whole_Midlands
       var(out) = 0.1385252722978822
59 :  Transactions\Returning Visitors\Brand\Organic North East
       seasonally_adjusted__Whole_North East
       var(out) = 0.21671307374438628
60 :  Transactions\Returning Visitors\Brand\Organic North Scotland
       seasonally_adjusted__Whole_North Scotland
       var(out) = 0.17968070980807968
61 :  Transactions\Returning Visitors\Brand\Organic North West
       seasonally_adjusted__Whole_North West
       var(out) = 0.20512799778195162
62 :  Transactions\Returning Visitors\Brand\Organic South West
       seasonally_adjusted__Whole_South West
       var(out) = 0.1771327016185555
63 :  Transactions\Returning Visitors\Brand\Organic Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.29694656105056927
64 :  Transactions\Returning Visitors\Brand\Organic Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 0.17067569694035417
65 :  Transactions\Returning Visitors\Brand\PPC Central Scotland
       seasonally_adjusted__Whole_Central Scotland
       var(out) = 0.14038798968969987
66 :  Transactions\Returning Visitors\Brand\PPC East Of England
       seasonally_adjusted__Whole_East Of England
       var(out) = 0.07977955194264261
67 :  Transactions\Returning Visitors\Brand\PPC HTV Wales
       seasonally_adjusted__Whole_HTV Wales
       var(out) = 0.11329709287367185
68 :  Transactions\Returning Visitors\Brand\PPC HTV West
       seasonally_adjusted__Whole_HTV West
       var(out) = 0.14221079865620392
69 :  Transactions\Returning Visitors\Brand\PPC London
       seasonally_adjusted__Whole_London
       var(out) = 0.15574163636357136
70 :  Transactions\Returning Visitors\Brand\PPC Meridian (exc. Channel Islands)
       seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
       var(out) = 0.093564486114568
71 :  Transactions\Returning Visitors\Brand\PPC Midlands
       seasonally_adjusted__Whole_Midlands
       var(out) = 2.363387390852187
```

```
72 :  Transactions\Returning Visitors\Brand\PPC North East
       seasonally_adjusted__Whole_North East
       var(out) = 0.13689496500626705
73 :  Transactions\Returning Visitors\Brand\PPC North Scotland
       seasonally_adjusted__Whole_North Scotland
       var(out) = 0.12097158096101038
74 :  Transactions\Returning Visitors\Brand\PPC North West
       seasonally_adjusted__Whole_North West
       var(out) = 0.1511784235331867
75 :  Transactions\Returning Visitors\Brand\PPC South West
       seasonally_adjusted__Whole_South West
       var(out) = 0.1301089160253701
76 :  Transactions\Returning Visitors\Brand\PPC Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.18221185198131323
77 :  Transactions\Returning Visitors\Brand\PPC Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 0.211041981293378
78 :  Transactions\Returning Visitors\Brand\Direct Central Scotland
       seasonally_adjusted__Whole_Central Scotland
       var(out) = 0.21536437952132134
79 :  Transactions\Returning Visitors\Brand\Direct East Of England
       seasonally_adjusted__Whole_East Of England
       var(out) = 0.2637350576866841
80 :  Transactions\Returning Visitors\Brand\Direct HTV Wales
       seasonally_adjusted__Whole_HTV Wales
       var(out) = 0.5531222872948326
81 :  Transactions\Returning Visitors\Brand\Direct HTV West
       seasonally_adjusted__Whole_HTV West
       var(out) = 0.3315794902810941
82 :  Transactions\Returning Visitors\Brand\Direct London
       seasonally_adjusted__Whole_London
       var(out) = 0.3134776919579389
83 :  Transactions\Returning Visitors\Brand\Direct Meridian (exc. Channel Islands)
       seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
       var(out) = 0.31879121779353214
84 :  Transactions\Returning Visitors\Brand\Direct Midlands
       seasonally_adjusted__Whole_Midlands
       var(out) = 0.2823763092266039
85 :  Transactions\Returning Visitors\Brand\Direct North East
       seasonally_adjusted__Whole_North East
       var(out) = 0.3153849315237012
86 :  Transactions\Returning Visitors\Brand\Direct North Scotland
       seasonally_adjusted__Whole_North Scotland
       var(out) = 0.6859679201749289
87 :  Transactions\Returning Visitors\Brand\Direct North West
       seasonally_adjusted__Whole_North West
       var(out) = 0.4308890821123294
```

```
88 :  Transactions\Returning Visitors\Brand\Direct South West
       seasonally_adjusted__Whole_South West
       var(out) = 0.5500557262674508
89 :  Transactions\Returning Visitors\Brand\Direct Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.45352830462083293
90 :  Transactions\Returning Visitors\Brand\Direct Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 0.27902625293718203
91 :  Transactions\Returning Visitors\Non Brand\PPC Central Scotland
       seasonally_adjusted__Whole_Central Scotland
       var(out) = 0.3218570822590175
92 :  Transactions\Returning Visitors\Non Brand\PPC East Of England
       seasonally_adjusted__Whole_East Of England
       var(out) = 0.25056032133888034
93 :  Transactions\Returning Visitors\Non Brand\PPC HTV Wales
       seasonally_adjusted__Whole_HTV Wales
       var(out) = 0.2531501405613419
94 :  Transactions\Returning Visitors\Non Brand\PPC HTV West
       seasonally_adjusted__Whole_HTV West
       var(out) = 0.2592429187879257
95 :  Transactions\Returning Visitors\Non Brand\PPC London
       seasonally_adjusted__Whole_London
       var(out) = 0.3441737148234361
96 :  Transactions\Returning Visitors\Non Brand\PPC Meridian (exc. Channel Islands)
       seasonally_adjusted__Whole_Meridian (exc. Channel Islands)
       var(out) = 0.19262048959222508
97 :  Transactions\Returning Visitors\Non Brand\PPC Midlands
       seasonally_adjusted__Whole_Midlands
       var(out) = 0.22174544087750728
98 :  Transactions\Returning Visitors\Non Brand\PPC North East
       seasonally_adjusted__Whole_North East
       var(out) = 0.3103351927567976
99 :  Transactions\Returning Visitors\Non Brand\PPC North Scotland
       seasonally_adjusted__Whole_North Scotland
       var(out) = 0.23844307298454362
100 :  Transactions\Returning Visitors\Non Brand\PPC North West
       seasonally_adjusted__Whole_North West
       var(out) = 0.23972681502677515
101 :  Transactions\Returning Visitors\Non Brand\PPC South West
       seasonally_adjusted__Whole_South West
       var(out) = 0.22203407331320582
102 :  Transactions\Returning Visitors\Non Brand\PPC Ulster
       seasonally_adjusted__Whole_Ulster
       var(out) = 0.4213842719728601
103 :  Transactions\Returning Visitors\Non Brand\PPC Yorkshire
       seasonally_adjusted__Whole_Yorkshire
       var(out) = 0.2609579257094481
```

```
FINISHED in 0.98m

STARTING: EPOCH 2
FINISHED in 0.98m

STARTING: EPOCH 3
FINISHED in 0.80m

STARTING: EPOCH 4
FINISHED in 0.86m

STARTING: EPOCH 5
FINISHED in 0.94m

STARTING: EPOCH 6
FINISHED in 1.03m

STARTING: EPOCH 7
FINISHED in 1.07m

STARTING: EPOCH 8
FINISHED in 0.77m

STARTING: EPOCH 9
FINISHED in 0.80m

STARTING: EPOCH 10
FINISHED in 0.85m

STARTING: EPOCH 11
FINISHED in 0.95m

STARTING: EPOCH 12
FINISHED in 0.77m

STARTING: EPOCH 13
FINISHED in 0.74m

STARTING: EPOCH 14
FINISHED in 1.22m

STARTING: EPOCH 15
FINISHED in 0.77m

STARTING: EPOCH 16
FINISHED in 0.98m

STARTING: EPOCH 17
```

```
        FINISHED in 0.83m

        STARTING: EPOCH 18
        FINISHED in 0.89m

        STARTING: EPOCH 19
        FINISHED in 1.05m

        STARTING: EPOCH 20
        FINISHED in 6.28m

 FINISHED in 23.59m
```

```
In [38]: print(ROOT_PATH[device])
         print(WORKSPACE_PATH)
         includeOffline, DO_TREND_ADJUSTMENT
```

```
C:\Users\bilgin.sherifov\Documents\PYTHON\Jupyter Notebooks\Econometrics\Active\2019\2018 Style
C:\Users\bilgin.sherifov\Documents\PYTHON\Jupyter Notebooks\Econometrics\Active\2019\2018 Style
```

```
Out[38]: (True, True)
```

3.2.1 Load results and calculate impact

```
In [44]: years = [2014, 2015, 2016, 2017, 2018, 2019]
         last_month = 4

         visitor_types = ['New Visitors', 'Returning Visitors']
         channels = ['Brand PPC', 'Brand Direct', 'Brand Organic', 'Non Brand PPC']
         result_types = ['actual', 'impact']

         includeOffline_ = [True, False]
         DO_TREND_ADJUSTMENT_ = [True, False]


         for includeOffline in includeOffline_:
             for DO_TREND_ADJUSTMENT in DO_TREND_ADJUSTMENT_:
                 timerText = 'Calculating impact for inputs '
                 if includeOffline:
                     timerText = timerText + 'with TV and '
                 else:
                     timerText = timerText + 'without TV and '
                 if DO_TREND_ADJUSTMENT:
                     timerText = timerText + 'trend adjustment'
                 else:
                     timerText = timerText + 'no trend adjustment'
```

```python
with timer(timerText, n_blanks=4):
    if includeOffline:
        path_ = os.path.join(ROOT_PATH[device], 'WORKSPACE_w_Offline')
        if DO_TREND_ADJUSTMENT:
            tblTemp_RAW = pd.read_csv(os.path.join(path_, 'RLS', 'with_trend_a
            tblTemp_SA = pd.read_csv(os.path.join(path_, 'RLS', 'with_trend_ac
        else:
            tblTemp_RAW = pd.read_csv(os.path.join(path_, 'RLS', 'no_trend_adj
            tblTemp_SA = pd.read_csv(os.path.join(path_, 'RLS', 'no_trend_adju
    else:
        path_ = os.path.join(ROOT_PATH[device], 'WORKSPACE_wo_Offline')
        if DO_TREND_ADJUSTMENT:
            tblTemp_RAW = pd.read_csv(os.path.join(path_, 'RLS', 'with_trend_a
            tblTemp_SA = pd.read_csv(os.path.join(path_, 'RLS', 'with_trend_ac
        else:
            tblTemp_RAW = pd.read_csv(os.path.join(path_, 'RLS', 'no_trend_adj
            tblTemp_SA = pd.read_csv(os.path.join(path_, 'RLS', 'no_trend_adju

    if includeOffline:
        dctResults = {
            'model': [],
            'inputs include offline': [],
            'has manual adjustment': [],
            'visitor type': [],
            'channel': [],
            'year': [],
            'month': [],
            'actual': [],
            'impact': [],
            'adjusted impact': [],
        }
    else:
        dctResults = {
            'model': [],
            'inputs include offline': [],
            'has manual adjustment': [],
            'visitor type': [],
            'channel': [],
            'year': [],
            'month': [],
            'actual': [],
            'impact': []
        }

    for year in years:
        cnt = 0
        for visitor_type in visitor_types:
            for channel in channels:
```

```python
                cnt += 1
                column_name = visitor_type + '; ' + channel
                results_actual = get_values_by_year_and_month(tblTemp_RAW, tbl
                results_impact = get_values_by_year_and_month(tblTemp_RAW, tbl
                if includeOffline:
                    results_adjusted_impact = get_values_by_year_and_month(tbl
                if cnt == 1:
                    dfResultsByChannel_actual = pd.DataFrame({column_name: res
                    dfResultsByChannel_impact = pd.DataFrame({column_name: res
                    if includeOffline:
                        dfResultsByChannel_adjusted_impact = pd.DataFrame({col
                else:
                    dfResultsByChannel_actual[column_name] = copy.deepcopy(res
                    dfResultsByChannel_impact[column_name] = copy.deepcopy(res
                    if includeOffline:
                        dfResultsByChannel_adjusted_impact[column_name] = cop

                n_rows = len(results_actual)
                dctResults['year'].extend(list(results_actual.index.get_level
                dctResults['month'].extend(list(results_actual.index.get_level
                dctResults['actual'].extend(list(results_actual.values.astype
                dctResults['impact'].extend(list(results_impact.values.astype
                if includeOffline:
                    dctResults['adjusted impact'].extend(list(results_adjusted
                dctResults['channel'].extend([channel for j in range(n_rows)]
                dctResults['visitor type'].extend([visitor_type for j in range
                dctResults['has manual adjustment'].extend([DO_TREND_ADJUSTME
                dctResults['inputs include offline'].extend([includeOffline fo
                dctResults['model'].extend(['recursive' for j in range(n_rows]

    print(8*' ' + "len(dctResults['year'])", len(dctResults['year']))
    print(8*' ' + "len(dctResults['month'])", len(dctResults['month']))
    print(8*' ' + "len(dctResults['impact'])", len(dctResults['impact']))
    print(8*' ' + "len(dctResults['channel'])", len(dctResults['channel']))
    print(8*' ' + "len(dctResults['visitor type'])", len(dctResults['visitor t
    print(8*' ' + "len(dctResults['has manual adjustment'])", len(dctResults[
    print(8*' ' + "len(dctResults['inputs include offline'])", len(dctResults
    print(8*' ' + "len(dctResults['model'])", len(dctResults['model']))

    dfResults = pd.DataFrame(dctResults)

    file_name = 'econ__Results_RLS__'
    if includeOffline:
        file_name = file_name + 'w_offline__'
    else:
        file_name = file_name + 'wo_offline__'
    if DO_TREND_ADJUSTMENT:
        file_name = file_name + 'w_mnl_adj'
```

```
            else:
                file_name = file_name + 'wo_mnl_adj'
            file_name = file_name + '.csv'

            dfResults.to_csv(os.path.join(RESULTS_PATH,file_name), index=False)

    dfResults.head()
```

STARTING: Calculating impact for inputs with TV and trend adjustment
    len(dctResults['year']) 192
    len(dctResults['month']) 192
    len(dctResults['impact']) 192
    len(dctResults['channel']) 192
    len(dctResults['visitor type']) 192
    len(dctResults['has manual adjustment']) 192
    len(dctResults['inputs include offline']) 192
    len(dctResults['model']) 192
FINISHED in 0.01m

STARTING: Calculating impact for inputs with TV and no trend adjustment
    len(dctResults['year']) 192
    len(dctResults['month']) 192
    len(dctResults['impact']) 192
    len(dctResults['channel']) 192
    len(dctResults['visitor type']) 192
    len(dctResults['has manual adjustment']) 192
    len(dctResults['inputs include offline']) 192
    len(dctResults['model']) 192
FINISHED in 0.01m

STARTING: Calculating impact for inputs without TV and trend adjustment
    len(dctResults['year']) 192
    len(dctResults['month']) 192
    len(dctResults['impact']) 192
    len(dctResults['channel']) 192
    len(dctResults['visitor type']) 192
    len(dctResults['has manual adjustment']) 192
    len(dctResults['inputs include offline']) 192
    len(dctResults['model']) 192
FINISHED in 0.01m

STARTING: Calculating impact for inputs without TV and no trend adjustment
    len(dctResults['year']) 192
    len(dctResults['month']) 192
    len(dctResults['impact']) 192
    len(dctResults['channel']) 192
    len(dctResults['visitor type']) 192
    len(dctResults['has manual adjustment']) 192

```
        len(dctResults['inputs include offline']) 192
        len(dctResults['model']) 192
    FINISHED in 0.01m
```

```
Out[44]:     actual        channel  has manual adjustment  impact  \
        0     2439       Brand PPC                  False       0
        1     1506       Brand PPC                  False       0
        2     1786       Brand PPC                  False       0
        3     2520       Brand PPC                  False       6
        4     3939    Brand Direct                  False      34

           inputs include offline       model  month  visitor type  year
        0                    False  recursive      1  New Visitors  2014
        1                    False  recursive      2  New Visitors  2014
        2                    False  recursive      3  New Visitors  2014
        3                    False  recursive      4  New Visitors  2014
        4                    False  recursive      1  New Visitors  2014
```

```
In [45]: temp = copy.deepcopy(dctIO['output']['values'].flatten())
         idxToAdjust = np.arange(0, 109)
         estimatedAdj, estimatedSmth, actualSmth, trend_ = adjust_to_trend(
             temp,
             temp*0,
             idxToAdjust,
             arr_trend = None)
```

```
In [47]: l1, l2, l3
```

```
Out[47]: ('Returning Visitors', 'Non Brand PPC', 'Yorkshire')
```

```
In [48]: tblTemp_RAW.columns.get_level_values(3).unique()
```

```
Out[48]: Index(['actual', 'estimated', 'residual', 'impact'], dtype='object')
```

```
In [49]: l1 = 'Returning Visitors'
         l2 = 'Non Brand PPC'
         l3 = 'South West'

         plt.close('all')
         plt.figure(figsize=(24,6))
         plt.plot(tblTemp_SA[(l1, l2, l3, 'actual')].values, label= 'actual')
         plt.plot(tblTemp_SA[(l1, l2, l3, 'estimated')].values, label= 'estimated')
         plt.plot(tblTemp_SA[(l1, l2, l3, 'residual')].values, label= 'residual')
         plt.plot(tblOffline[l3].values*.1, label= 'offline impact')
         plt.legend(loc='upper left')
         plt.show()
```

```
plt.close('all')
plt.figure(figsize=(24,6))
plt.plot(tblTemp_RAW[(l1, l2, l3, 'actual')].values, label= 'actual')
plt.plot(tblTemp_RAW[(l1, l2, l3, 'estimated')].values, label= 'estimated')
plt.plot(tblTemp_RAW[(l1, l2, l3, 'impact')].values, label= 'offline contribution')
plt.plot(tblOffline[l3].values*.1, label= 'offline impact')
plt.legend(loc='upper left')
plt.show()
```
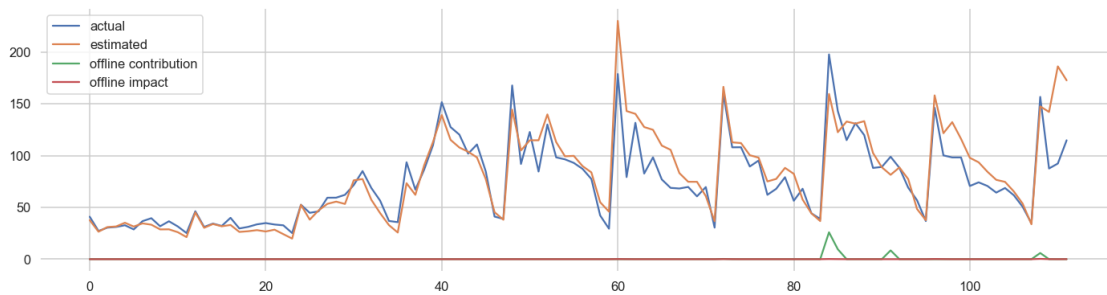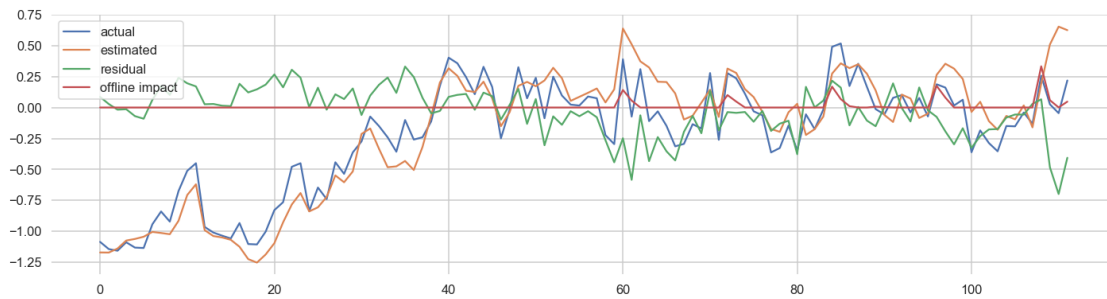


```
In [50]: rsltsKalman['outputCenteringParams'], dctIO['output']['scales'][0], dctIO['output']['c
```

```
Out[50]: ({'mean': -7.93016446160826e-18, 'scale': 3.7560463460434588},
          0.3954526597219493,
          -0.2249959226743523)
```

```
In [51]: inpNoOffline = copy.deepcopy(dctIO['inputs']['values'])
         inpAll = copy.deepcopy(dctIO['inputs']['values'])
         inpNoOffline[:,idx_offline_otb] *= 0

         # estimate w/ ALL inputs
         estAll = np.sum((rsltsKalman['coefs']['smoothed'] * inpAll),axis=1) * rsltsKalman['out
         estAll = estAll * dctIO['output']['scales'][0] + dctIO['output']['centers'][0]
         # estimate w/o OFFLINE
         estNoOffline = np.sum((rsltsKalman['coefs']['smoothed'] * inpNoOffline),axis=1) * rslt
```

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```
estNoOffline = estNoOffline * dctIO['output']['scales'][0] + dctIO['output']['centers
# estimate OFFLINE Only
estOffline = estAll - estNoOffline
estOffline -= np.mean(estOffline[:24])

estNoOffline_2 = estAll - estOffline

plt.close('all')
plt.figure(figsize=(16,6))
plt.plot(dctIO['output']['values'] * dctIO['output']['scales'][0] + dctIO['output']['c
#plt.plot(estNoOffline, label='est no offline', alpha=0.5)
plt.plot(estOffline, label='est offline')
plt.plot(estNoOffline_2, label='est no offline 2', alpha=0.5)
plt.plot(estAll, label='est all', alpha=0.5)

plt.legend(loc='upper left')
```

Out[51]: <matplotlib.legend.Legend at 0xc9c85f4d68>
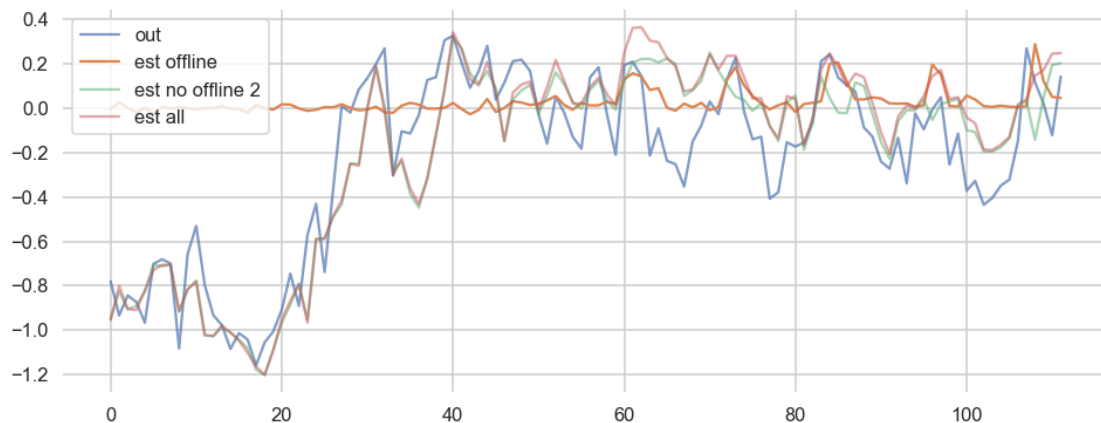

```
In [55]: l1 = 'New Visitors'
         l2 = 'Brand Organic'
         l3 = 'East Of England'

         idxToAdjust = np.arange(60, 109)

         plt.close('all')
         plt.figure(figsize=(24,6))
         plt.plot(tblTemp_SA[(l1, l2, l3, 'actual')].values, label= 'actual')
         plt.plot(tblTemp_SA[(l1, l2, l3, 'estimated')].values, label= 'estimated')

         estimatedAdj, estimatedSmth, actualSmth, trend_ = adjust_to_trend(
             tblTemp_SA[(l1, l2, l3, 'actual')].values,
```

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```
        tblTemp_SA[(l1, l2, l3, 'estimated')].values,
        idxToAdjust,
        arr_trend = None)

    plt.plot(estimatedAdj, label= 'estimatedAdj')
    plt.plot(estimatedSmth, label= 'estimatedSmth')
    plt.plot(actualSmth, label= 'actualSmth')
    plt.legend(loc='upper left')
    plt.show()
```
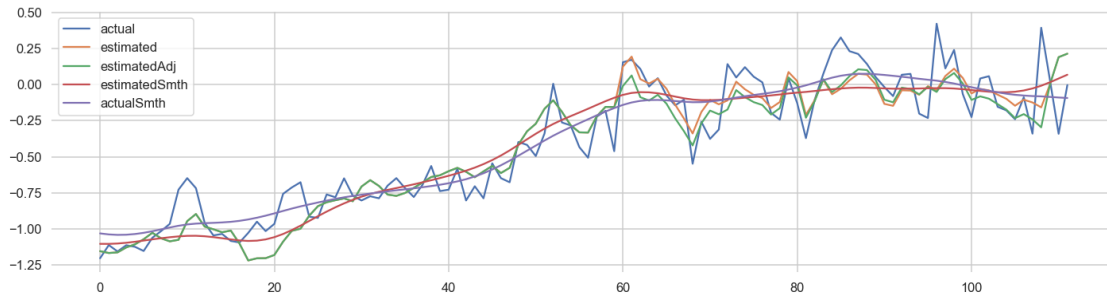


```
In [56]: dctIO['inputs']['newInputLabels']

Out[56]: ['Keyword Position_0',
         'Keyword Position_1',
         'Keyword Position per CPC_0',
         'Keyword Position per CPC_1',
         'CPC per Keyword Position_0',
         'CPC per Keyword Position_1',
         'Inverse Hotel Margin_0',
         'Inverse Hotel Margin_1',
         'Inverse Flight Margin_0',
         'Inverse Flight Margin_1',
         'GbpEur_0',
         'Competitor Advantage_0',
         'Employment_0',
         'CCI_0',
         'Offline Spent Competitors_0',
         'Offline Spent Competitors_1',
         'Offline Spent Competitors_2',
         'Offline Spent OTB_0',
         'Offline Spent OTB_1',
         'Offline Spent OTB_2',
         'Offline Spent OTB_3',
         'Offline Spent OTB_4']
```

3.2.2 Get Results

```
In [61]: DO_TREND_ADJUSTMENT

Out[61]: False

In [62]: year

Out[62]: 2019

In [ ]: year = 2018
        last_month = 6

        cnt = 0
        for visitor_type in visitor_types:
            for result_type in result_types:
                cnt += 1
                column_name = visitor_type + '; ' + channel + '; ' + result_type
                results = get_values_by_year_and_month(tblTemp_RAW, tblRescaleFactors, year, la
                if cnt == 1:
                    dfTemp = pd.DataFrame({column_name: results})
                else:
                    dfTemp[column_name] = copy.deepcopy(results)

        plt.close('all')
        ax = dfTemp.plot.bar()
        plt.title('Number of bookings due to offline')

        print('Total impact = ', (impact_nv + impact_rv).sum())
        dfTemp.astype(int)

In [44]: year = 2018
         last_month = 6

In [45]: ((
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(a
                /
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(a
                *
                tblTotalTransactions['New Visitors']
            )
            +
            (
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')]
                /
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')]
                *
                tblTotalTransactions['Returning Visitors']
```

```
                )
        ).loc[(year,1):(year, last_month)].sum()
         /
         (
             tblTotalTransactions.loc[(year,1):(year, last_month),'Returning Visitors'].sum()
             +
             tblTotalTransactions.loc[(year,1):(year, last_month),'New Visitors'].sum()
         ))
```

Out[45]: 0.1735008194948842

```
In [ ]: year = 2018
        last_month = 6

        pd.DataFrame(
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(ax:
                /
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(ax:
                *
                tblTotalTransactions['New Visitors']
            )
            +
            (
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')].s
                /
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')].s
                *
                tblTotalTransactions['Returning Visitors']
            )
        ).loc[(year,1):(year, last_month)]
```

```
In [ ]: pd.DataFrame(tblTotalTransactions['New Visitors'] + tblTotalTransactions['Returning Vis
```

```
In [ ]: (
            tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(axis=1)
            tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')].sum(a
        )
```

```
In [ ]: (
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(ax:
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')].s
            ).loc[(year,1):(year, last_month)]
            /
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(ax:
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')].s
            ).loc[(year,1):(year, last_month)]
        )
```

```
In [ ]: tblRescaleFactors

In [ ]: (
            get_values_by_year_and_month(tblTemp_RAW, tblRescaleFactors, year, last_month, 'imp
            + get_values_by_year_and_month(tblTemp_RAW, tblRescaleFactors, year, last_month, '
        )

In [ ]: (
            tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(axis=1
            tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')].sum(a
        ).loc[(2018,1):(2018,last_month)]

In [ ]: (
            tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(axis=1
            tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')].sum(a
        ).loc[(year,1):(year,last_month)]

In [ ]: (
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'impact')].sum(ax
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'impact')].s
            ).loc[(year,1):(year, last_month)].sum()
            /
            (
                tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(ax
                tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')].s
            ).loc[(year,1):(year, last_month)].sum()
        ) * 251000

In [ ]: (
            tblTemp_RAW.loc[:,('New Visitors', slice(None), slice(None) ,'actual')].sum(axis=1
            tblTemp_RAW.loc[:,('Returning Visitors', slice(None), slice(None) ,'actual')].sum(a
        )

In [ ]: year = 2018
        last_month = 6
        (
            (
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Brand Organic', slice(None) ,'impact')]
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Brand Organic', slice(None) ,'imp
                ).loc[(year,1):(year,last_month)].sum()
                /
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Brand Organic', slice(None) ,'actual')]
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Brand Organic', slice(None) ,'act
                ).loc[(year,1):(year,last_month)].sum()
                * 64200
            )
```

```
            +

            (
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Brand PPC', slice(None) ,'impact')].sum
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Brand PPC', slice(None) ,'impact
                ).loc[(year,1):(year,last_month)].sum()
                /
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Brand PPC', slice(None) ,'actual')].sum
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Brand PPC', slice(None) ,'actual
                ).loc[(year,1):(year,last_month)].sum()
                * 95700
            )


            +

            (
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Non Brand PPC', slice(None) ,'impact')]
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Non Brand PPC', slice(None) ,'im
                ).loc[(year,1):(year,last_month)].sum()
                /
                (
                    tblTemp_RAW.loc[:,('New Visitors', 'Non Brand PPC', slice(None) ,'actual')]
                    tblTemp_RAW.loc[:,('Returning Visitors', 'Non Brand PPC', slice(None) ,'act
                ).loc[(year,1):(year,last_month)].sum()
                * 43200
            )
        )
```

```python
In [99]: plt.figure(figsize = (12,4))
         tblTemp_SA[(l1, l2, l3, 'estimated')].plot()
         tblTemp_SA[(l1, l2, l3, 'actual')].plot()
         idxData = np.arange(len(tblTemp_SA[(l1, l2, l3, 'actual')]))

         xFit = np.concatenate([idxData[-16:-12], idxData[-3:]])
         yFit = tblTemp_SA.iloc[xFit][(l1, l2, l3, 'actual')]
         f = interpolate.interp1d(xFit, yFit, kind = 'linear')

         xNew = idxData[-12:]
         yNew = f(xNew)
         tblTemp_SA[(l1, l2, l3, 'estimated 2')] = copy.deepcopy(tblTemp_SA[(l1, l2, l3, 'estim
         yTemp = tblTemp_SA[(l1, l2, l3, 'estimated')].iloc[xNew] - tblTemp_SA[(l1, l2, l3, 'es
         tblTemp_SA[(l1, l2, l3, 'estimated 2')].iloc[xNew] = yNew + yTemp
         tblTemp_SA[(l1, l2, l3, 'estimated 2')].plot()
```

```
Out[99]: <matplotlib.axes._subplots.AxesSubplot at 0x7be04fcac8>
```

Year,Period
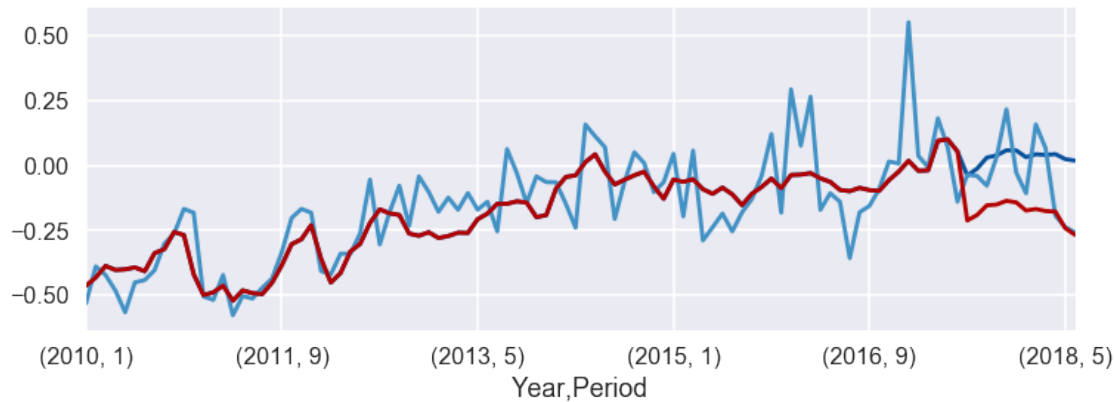
```
In [ ]:  tblTemp_RAW.loc[:,('Returning Visitors', 'Brand PPC', 'London' ,'actual')].groupby(['
```

```
In [19]: [print(j,':', inp_) for j, inp_ in enumerate(dctIO['inputs']['newInputLabels'])];
```

```
0 : Keyword Position_0
1 : Keyword Position_1
2 : Keyword Position per CPC_0
3 : Keyword Position per CPC_1
4 : Inverse Hotel Margin_0
5 : Inverse Hotel Margin_1
6 : Inverse Flight Margin_0
7 : Inverse Flight Margin_1
8 : Competitor Advantage_0
9 : Employment_0
10 : CCI_0
11 : External Shocks_0
```

```
In [110]: [str(j+39) +': ' + '\\'.join(run['folders'])+':'+run['output'] for j,run in enumerate
```

```
Out[110]: ['39: Transactions\\Returning Visitors\\Brand\\Organic:Central Scotland',
           '40: Transactions\\Returning Visitors\\Brand\\Organic:East Of England',
           '41: Transactions\\Returning Visitors\\Brand\\Organic:HTV Wales',
           '42: Transactions\\Returning Visitors\\Brand\\Organic:HTV West',
           '43: Transactions\\Returning Visitors\\Brand\\Organic:London',
           '44: Transactions\\Returning Visitors\\Brand\\Organic:Meridian (exc. Channel Islands
           '45: Transactions\\Returning Visitors\\Brand\\Organic:Midlands',
           '46: Transactions\\Returning Visitors\\Brand\\Organic:North East',
           '47: Transactions\\Returning Visitors\\Brand\\Organic:North Scotland',
           '48: Transactions\\Returning Visitors\\Brand\\Organic:North West',
           '49: Transactions\\Returning Visitors\\Brand\\Organic:South West',
           '50: Transactions\\Returning Visitors\\Brand\\Organic:Ulster',
           '51: Transactions\\Returning Visitors\\Brand\\Organic:Yorkshire',
```

```
    '52: Transactions\\Returning Visitors\\Brand\\PPC:Central Scotland',
    '53: Transactions\\Returning Visitors\\Brand\\PPC:East Of England',
    '54: Transactions\\Returning Visitors\\Brand\\PPC:HTV Wales',
    '55: Transactions\\Returning Visitors\\Brand\\PPC:HTV West',
    '56: Transactions\\Returning Visitors\\Brand\\PPC:London',
    '57: Transactions\\Returning Visitors\\Brand\\PPC:Meridian (exc. Channel Islands)',
    '58: Transactions\\Returning Visitors\\Brand\\PPC:Midlands',
    '59: Transactions\\Returning Visitors\\Brand\\PPC:North East',
    '60: Transactions\\Returning Visitors\\Brand\\PPC:North Scotland',
    '61: Transactions\\Returning Visitors\\Brand\\PPC:North West',
    '62: Transactions\\Returning Visitors\\Brand\\PPC:South West',
    '63: Transactions\\Returning Visitors\\Brand\\PPC:Ulster',
    '64: Transactions\\Returning Visitors\\Brand\\PPC:Yorkshire',
    '65: Transactions\\Returning Visitors\\Non Brand\\PPC:Central Scotland',
    '66: Transactions\\Returning Visitors\\Non Brand\\PPC:East Of England',
    '67: Transactions\\Returning Visitors\\Non Brand\\PPC:HTV Wales',
    '68: Transactions\\Returning Visitors\\Non Brand\\PPC:HTV West',
    '69: Transactions\\Returning Visitors\\Non Brand\\PPC:London',
    '70: Transactions\\Returning Visitors\\Non Brand\\PPC:Meridian (exc. Channel Islands',
    '71: Transactions\\Returning Visitors\\Non Brand\\PPC:Midlands',
    '72: Transactions\\Returning Visitors\\Non Brand\\PPC:North East',
    '73: Transactions\\Returning Visitors\\Non Brand\\PPC:North Scotland',
    '74: Transactions\\Returning Visitors\\Non Brand\\PPC:North West',
    '75: Transactions\\Returning Visitors\\Non Brand\\PPC:South West',
    '76: Transactions\\Returning Visitors\\Non Brand\\PPC:Ulster',
    '77: Transactions\\Returning Visitors\\Non Brand\\PPC:Yorkshire']

In [47]: pathIO = os.path.join(WORKSPACE_PATH, 'S2_IO_Holder')

        for j0, runParams in enumerate(PARAMS['LTI']['runs'][65:78]):
            pathFile = os.path.join(*runParams['folders'])
            print(j0, ': ', pathFile, runParams['output'])
            for filterType, seperator in PARAMS['LTI']['IO Filter Types'].items():
                region = runParams['output']

                #print('- Filter type: ', filterType)
                if filterType == 'None':
                    if runParams['seasonal']:
                        typeSeasonal = 'seasonally_adjusted_'
                    else:
                        typeSeasonal = 'scaled_'

                    # 1. Load data from previous stage
                    with open(os.path.join(pathIO, pathFile,
                                'dctIO'+ seperator + typeSeasonal + region + '.pkl'), 'rb') as
                        dctIO = pickle.load(handle)

                    tblTemp = pd.DataFrame(
```

```python
                    {
                        'Output': dctIO['output']['values'].flatten()
                            * dctIO['output']['scales'][0] + dctIO['output']['centers'][0]
                        ,'Keyword Position': dctIO['inputs']['values'][:,0].flatten()
                            * dctIO['inputs']['scales'][0] + dctIO['inputs']['centers'][0]
                        ,'Keyword Position per CPC': dctIO['inputs']['values'][:,2].flatte
                            * dctIO['inputs']['scales'][2] + dctIO['inputs']['centers'][2]
                        ,'Inverse Hotel Margin': dctIO['inputs']['values'][:,4].flatten()
                            * dctIO['inputs']['scales'][4] + dctIO['inputs']['centers'][4]
                        ,'Inverse Flight Margin': dctIO['inputs']['values'][:,6].flatten()
                            * dctIO['inputs']['scales'][6] + dctIO['inputs']['centers'][6]
                        ,'Competitor Advantage': dctIO['inputs']['values'][:,8].flatten()
                            * dctIO['inputs']['scales'][8] + dctIO['inputs']['centers'][8]
                        ,'Employment': dctIO['inputs']['values'][:,9].flatten()
                            * dctIO['inputs']['scales'][9] + dctIO['inputs']['centers'][9]
                        ,'CCI': dctIO['inputs']['values'][:,10].flatten()
                            * dctIO['inputs']['scales'][10] + dctIO['inputs']['centers'][1
                        ,'Region': region
                    }
                )
                if j0 == 0:
                    tblAll = copy.deepcopy(tblTemp)
                else:
                    tblAll = pd.concat([tblAll, tblTemp], axis=0)

        tblAll[['Region', 'Output']].groupby('Region').agg(['mean', 'std'])

0 :  Transactions\Returning Visitors\Non Brand\PPC Central Scotland
1 :  Transactions\Returning Visitors\Non Brand\PPC East Of England
2 :  Transactions\Returning Visitors\Non Brand\PPC HTV Wales
3 :  Transactions\Returning Visitors\Non Brand\PPC HTV West
4 :  Transactions\Returning Visitors\Non Brand\PPC London
5 :  Transactions\Returning Visitors\Non Brand\PPC Meridian (exc. Channel Islands)
6 :  Transactions\Returning Visitors\Non Brand\PPC Midlands
7 :  Transactions\Returning Visitors\Non Brand\PPC North East
8 :  Transactions\Returning Visitors\Non Brand\PPC North Scotland
9 :  Transactions\Returning Visitors\Non Brand\PPC North West
10 :  Transactions\Returning Visitors\Non Brand\PPC South West
11 :  Transactions\Returning Visitors\Non Brand\PPC Ulster
12 :  Transactions\Returning Visitors\Non Brand\PPC Yorkshire
```

```
Out[47]:                              Output
                                 mean       std
         Region
         Central Scotland       -0.171355  0.381118
         East Of England        -0.366990  0.552267
         HTV Wales              -0.369106  0.524718
```

```
HTV West                              -0.185468   0.440399
London                                -0.212590   0.410015
Meridian (exc. Channel Islands) -0.358464   0.552077
Midlands                              -0.305616   0.457191
North East                            -0.112384   0.359532
North Scotland                        -0.015069   0.436786
North West                            -0.108447   0.466556
South West                            -0.244240   0.453839
Ulster                                -0.067909   0.309120
Yorkshire                             -0.234999   0.408165
```

```
In [48]: plt.figure(figsize=(24,24))
         fig = sns.pairplot(tblAll, hue="Region", size=5, plot_kws={'alpha': 0.2, 's':100, 'li
         plt.savefig(os.path.join(WORKSPACE_COMMON_PATH, 'io_scatter_plots__'+ '_'.join(pathF:
```

```
<matplotlib.figure.Figure at 0x2b244c36a0>
```