Time series data

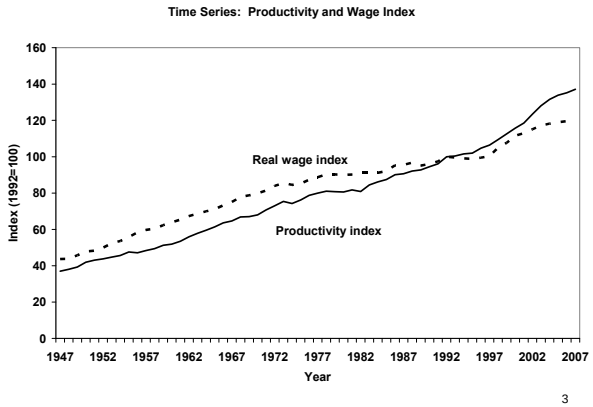
The Benefits and Problems of Persistence

1

Key time series property: Persistence

- Persistence over time (trends)
- Persistence in cycle
- Both allow for excellent explanatory power of time series data
- Also produce persistence in errors
  - $\text{Cov}(\varepsilon_{t-1}, \varepsilon_t) \neq 0$
- Persistence can produce spurious correlation

2



3

```
* generate ln of outcomes
. gen rwagel=ln(rwage)

. gen prodl=ln(productivity)

.
. * run a model of productivity
. * on just a time trend
. * see how well it fits
. reg prodl time

      Source |       SS       df       MS              Number of obs =      61
-------------+------------------------------           F(  1,    59) = 4128.39
       Model |  7.79439507     1  7.79439507            Prob > F      =  0.0000
    Residual |    .1113919    59  .001887998           R-squared     =  0.9859
-------------+------------------------------           Adj R-squared =  0.9857
       Total |  7.90578697    60  .131763116           Root MSE      =  .04345

------------------------------------------------------------------------------
       prodl |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0203023   .000316    64.25   0.000       .01967    .0209346
       _cons |   3.684954   .0112649   327.12   0.000     3.662413    3.707495
------------------------------------------------------------------------------
```

Look at the R-squared

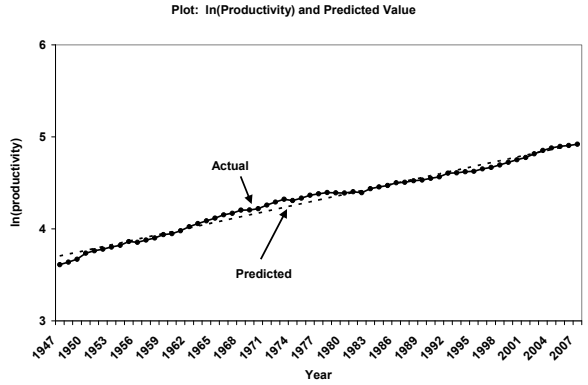
Interpret coefficient

4

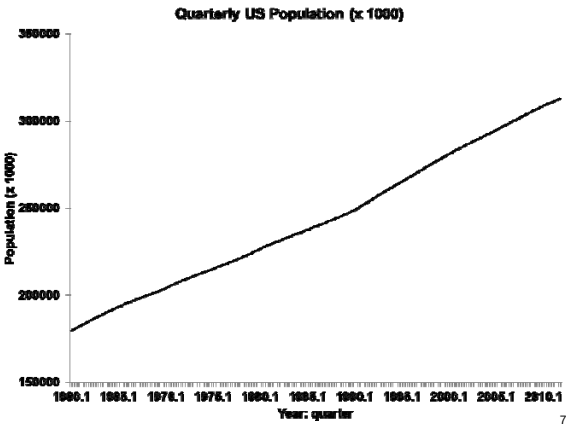
```
. * output predicted value
. predict prodl_pred
(option xb assumed; fitted values)
.
. *output predicted values to csv
. * file to graph in pretty graph
. outsheet time year prodl prodl_pred using predict_value.csv, comma
```

Output the predicted values from the regression, then Output them to a csv file to be used in excel

5



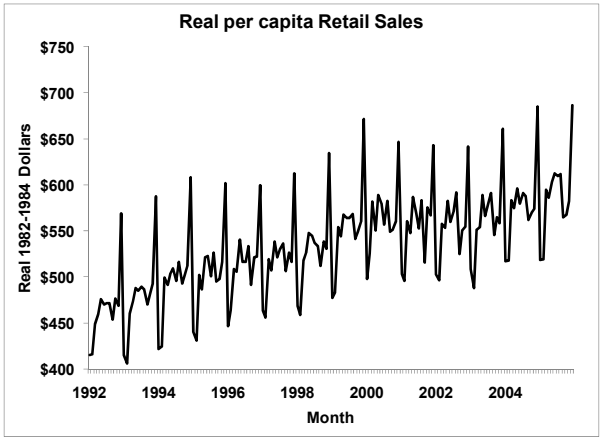
6



7

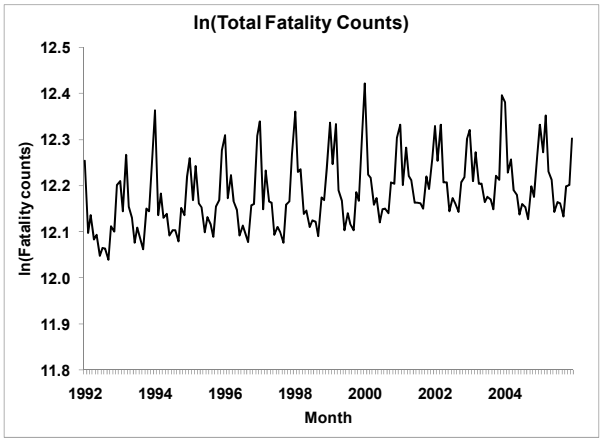
```
. reg population time

      Source |       SS       df       MS              Number of obs =     208
-------------+------------------------------           F(  1,   206) =40948.07
       Model |  3.0705e+11     1  3.0705e+11           Prob > F      =  0.0000
    Residual |  1.5447e+09   206  7498534.91           R-squared     =  0.9950
-------------+------------------------------           Adj R-squared =  0.9950
       Total |  3.0860e+11   207  1.4908e+09           Root MSE      =  2738.3

------------------------------------------------------------------------------
  population |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   639.8904   3.162196   202.36   0.000      633.656    646.1248
       _cons |   176784.8   381.1136   463.86   0.000     176033.4    177536.2
------------------------------------------------------------------------------

.
```

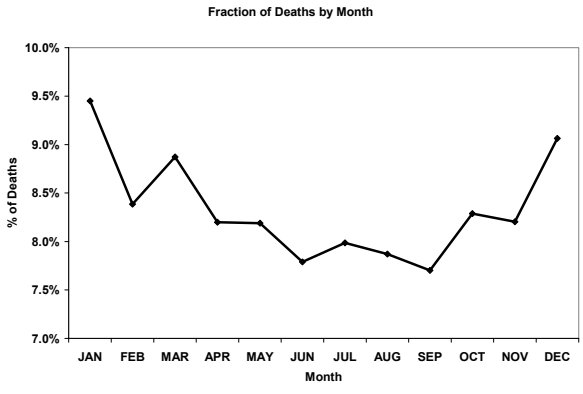
8



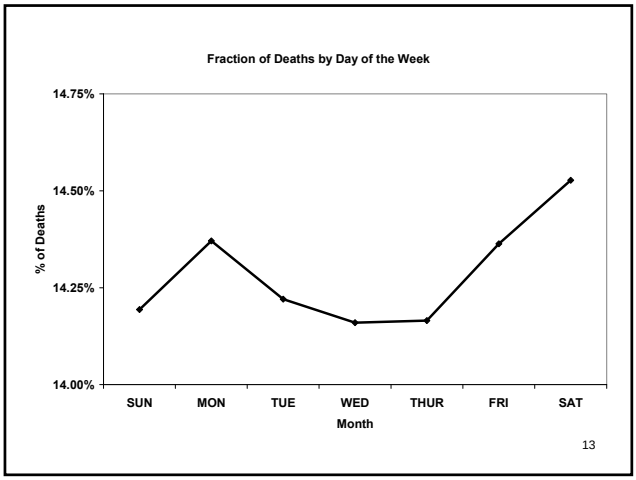

```
. reg lr_retail_capita _I* time unrate

      Source |       SS       df       MS              Number of obs =     168
-------------+------------------------------           F( 13,   154) =  514.11
       Model |  2.06236449    13  .158643422           Prob > F      =  0.0000
    Residual |  .047521099   154  .000308579           R-squared     =  0.9775
-------------+------------------------------           Adj R-squared =  0.9756
       Total |  2.10988559   167  .012634045           Root MSE      =  .01757

------------------------------------------------------------------------------
lr_retail_~a |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   _Imonth_2 |  -.0202347   .0066395    -3.05   0.003     -.033351   -.0071183
   _Imonth_3 |   .0899394   .0066398    13.55   0.000     .0768226    .1030562
   _Imonth_4 |   .0861822     .00664    12.98   0.000      .073065    .0992995
   _Imonth_5 |   .1351768   .0066405    20.36   0.000     .1220585    .1482952
   _Imonth_6 |   .1094872    .006641    16.49   0.000     .0963681    .1226064
   _Imonth_7 |   .1074848   .0066416    16.18   0.000     .0943643    .1206053
   _Imonth_8 |   .1316515   .0066427    19.82   0.000      .118529     .144774
   _Imonth_9 |   .0720061   .0066434    10.84   0.000     .0588821    .0851301
  _Imonth_10 |   .1109814   .0066449    16.70   0.000     .0978546    .1241082
  _Imonth_11 |   .1427717   .0066459    21.48   0.000     .1296427    .1559006
  _Imonth_12 |   .3417103   .0066471    51.41   0.000      .328579    .3548416
        time |   .0013152   .0000319    41.24   0.000     .0012522    .0013782
      unrate |  -.0049376    .001584    -3.12   0.002    -.0080668   -.0018083
       _cons |   8.11711   .0112221   723.31   0.000     8.094941    8.139279
------------------------------------------------------------------------------
```

10

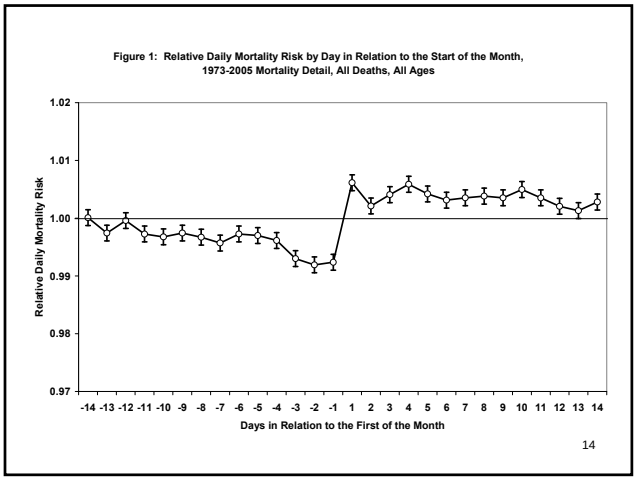




12



13



14

```
. * get log of counts
. gen lcounts=ln(counts)

. * construct month and weekday dummy variables
. xi i.month i.weekday
i.month           _Imonth_1-12        (naturally coded; _Imonth_1 omitted)
i.weekday         _Iweekday_1-7       (naturally coded; _Iweekday_1 omitted)

. * construct variable for the 1st week of the month
. gen firstweek=(day>=1&day<=7)

. gen sept911=(month==9&day==11&year==2001)
```

Given a variable x that has k unique values,
the xi command in STATA will generate a series of
k-1 dummy variables, one for each unique value
With the smallest value set as the reference group

15

```
. reg lcounts trend sept911 firstweek _I*

      Source |       SS       df       MS              Number of obs =   12053
-------------+------------------------------           F( 20, 12032) = 4084.99
       Model |  127.396712    20  6.36983559           Prob > F      =  0.0000
    Residual |  18.7618363 12032  .001559328           R-squared     =  0.8716
-------------+------------------------------           Adj R-squared =  0.8714
       Total |  146.158548 12052  .012127327           Root MSE      =  .03949

------------------------------------------------------------------------------
     lcounts |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       trend |   .0007336   3.15e-06   233.04   0.000      .0007275    .0007398
     sept911 |   .3857986   .0395213     9.76   0.000      .3083306    .4632667
  firstweek  |   .0052759   .0008548     6.17   0.000      .0036003    .0069515
   _Imonth_2 |  -.0260462   .0017882   -14.57   0.000     -.0295514    -.022541
   _Imonth_3 |  -.0638372    .001746   -36.56   0.000     -.0672597   -.0604147

                        DELETE SOME RESULTS
  _Imonth_11 |    -.11388   .0017608   -64.68   0.000     -.1173314   -.1104286
  _Imonth_12 |  -.0493627   .0017464   -28.27   0.000     -.0527859   -.0459396
_Iweekday_2  |   .0113788    .001346     8.45   0.000      .0087405    .0140171

                        DELETE SOME RESULTS
_Iweekday_6  |    .010537    .001346     7.83   0.000      .0078987    .0131753
_Iweekday_7  |   .0225822    .001346    16.78   0.000      .0199439    .0252205
       _cons |   8.641988    .001646  5250.26   0.000      8.638761    8.645214
------------------------------------------------------------------------------
```

16

Great Britain --1947

- Raised compulsory education age from 14-15
- Within a year – education levels for the country increased
- Did this generate better outcomes?

17

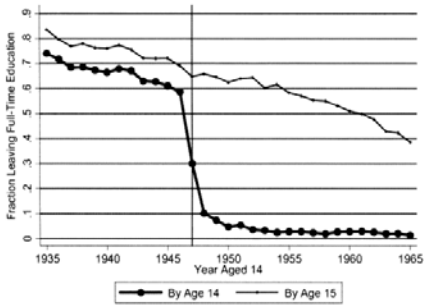


FIGURE 1. FRACTION LEFT FULL-TIME EDUCATION BY YEAR AGED 14 AND 15 (*Great Britain*)

Note: The lower line shows the proportion of British-born adults aged 32 to 64 from the 1983 to 1998 General Household Surveys who report leaving full-time education at or before age 14 from 1935 to 1965. The upper line shows the same, but for age 15. The minimum school-leaving age in Great Britain changed in 1947 from 14 to 15.

18

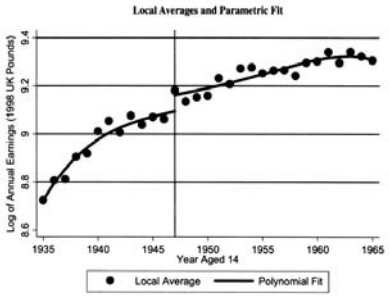
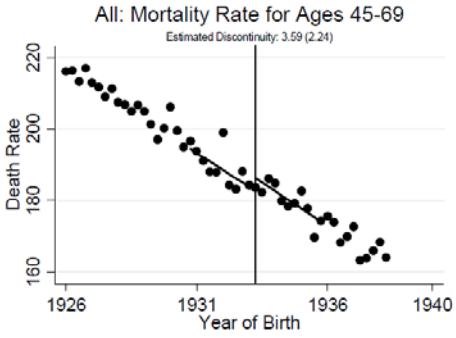


FIGURE 6. AVERAGE ANNUAL LOG EARNINGS BY YEAR AGED 14 (*Great Britain*)

19



20

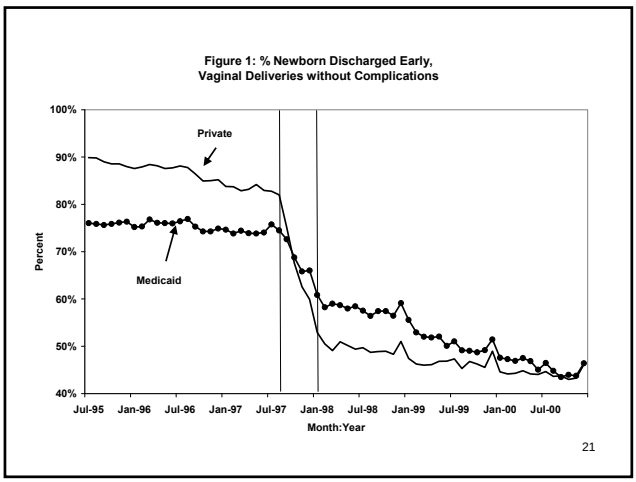


Figure 1: % Newborn Discharged Early,
Vaginal Deliveries without Complications
100%
90%
80%
70%
60%
50%
40%
Percent
Private
Medicaid
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Month:Year
21

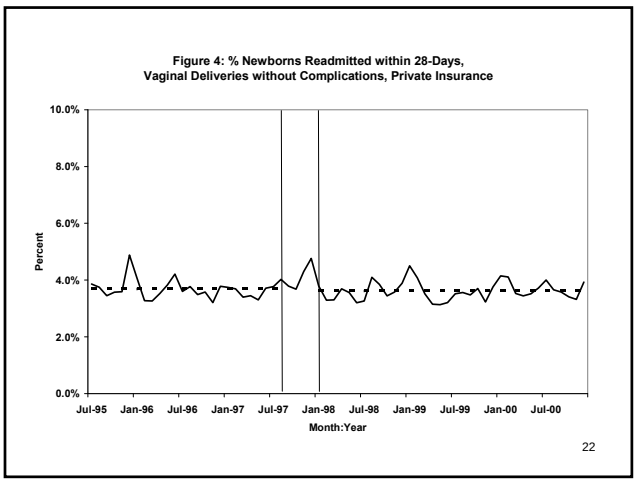
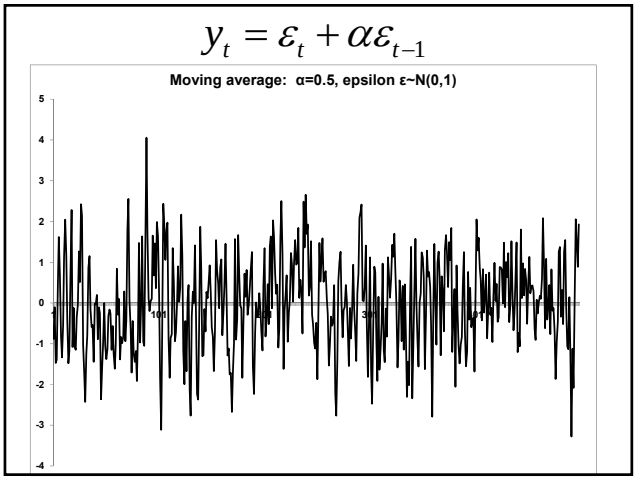
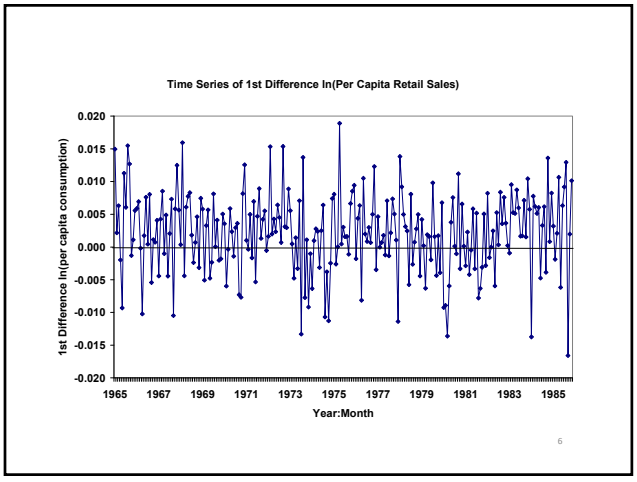
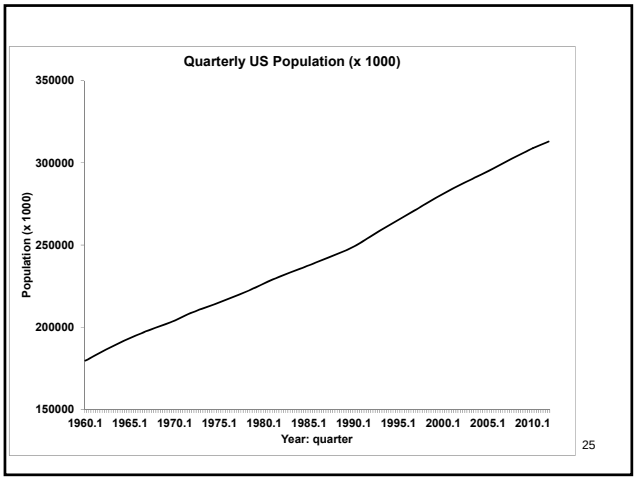


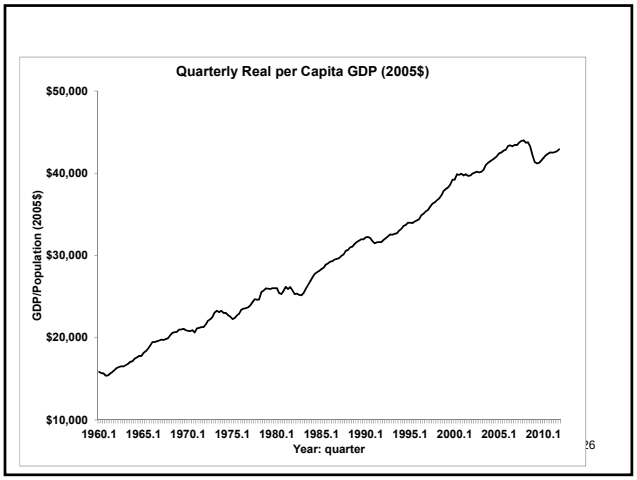
Figure 4: % Newborns Readmitted within 28-Days,
Vaginal Deliveries without Complications, Private Insurance
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
Percent
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Month:Year
22


$y_t = \varepsilon_t + \alpha\varepsilon_{t-1}$
Moving average: α=0.5, epsilon ε~N(0,1)
5
4
3
2
1
0
-1
-2
-3
-4

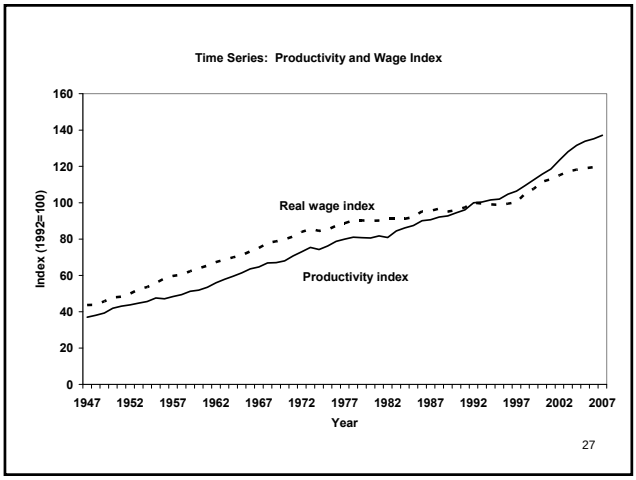

Time Series of 1st Difference ln(Per Capita Retail Sales)
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
1st Difference ln(per capita consumption)
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
Year:Month
6


Quarterly US Population (x 1000)
Population (x 1000)
350000
300000
250000
200000
150000
1960.1 1965.1 1970.1 1975.1 1980.1 1985.1 1990.1 1995.1 2000.1 2005.1 2010.1
Year: quarter

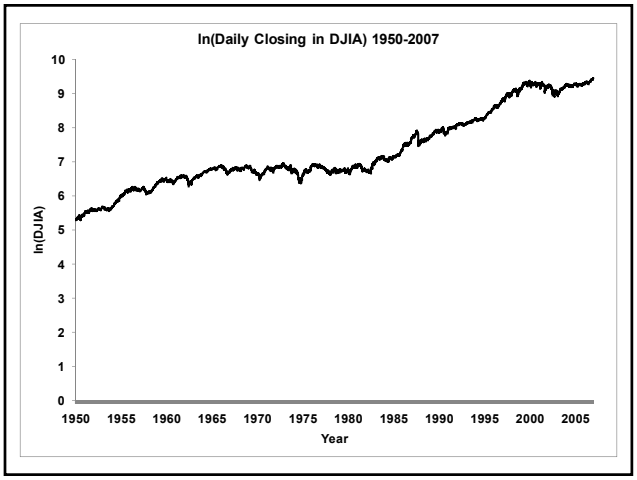
25

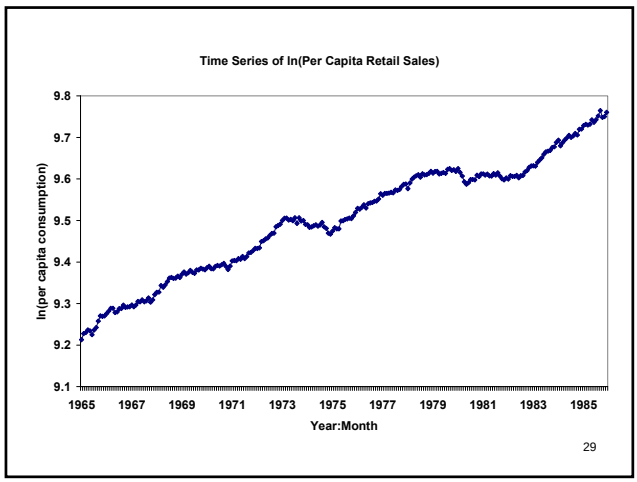

Quarterly Real per Capita GDP (2005$)
GDP/Population (2005$)
$50,000
$40,000
$30,000
$20,000
$10,000
1960.1 1965.1 1970.1 1975.1 1980.1 1985.1 1990.1 1995.1 2000.1 2005.1 2010.1
Year: quarter

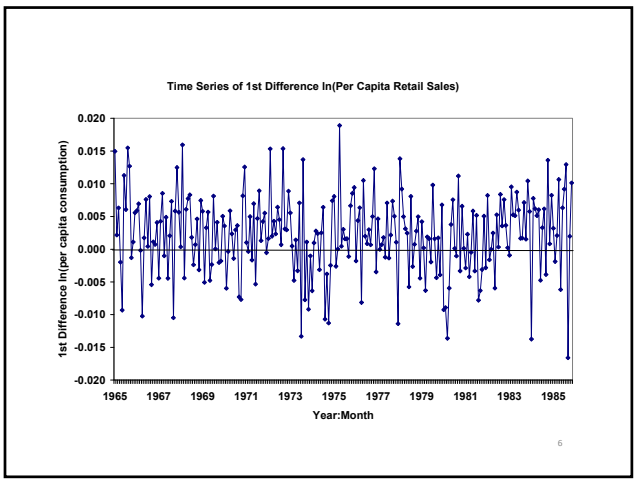
26

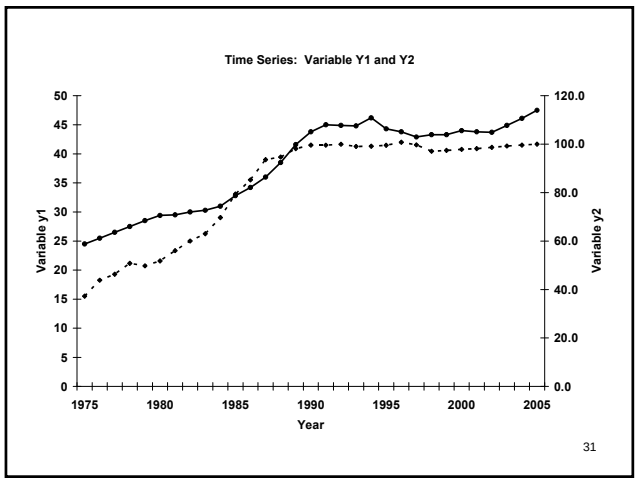

Time Series: Productivity and Wage Index
Index (1992=100)
160
140
120
100
80
60
40
20
0
Real wage index
Productivity index
1947 1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 2002 2007
Year

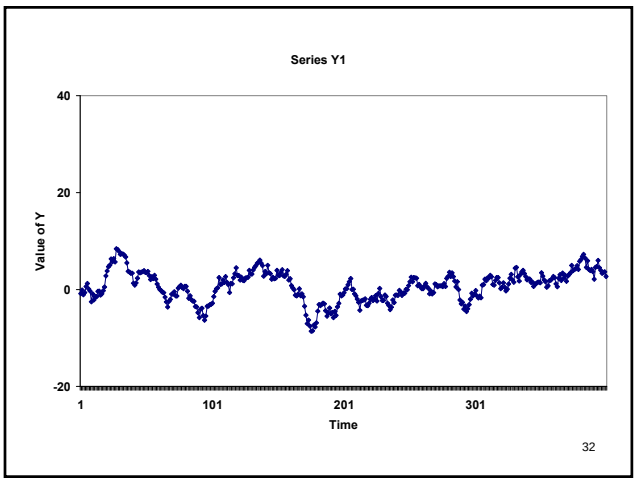
27

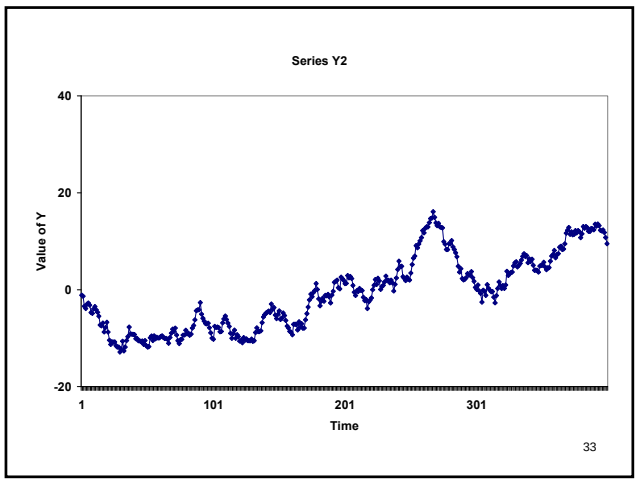

ln(Daily Closing in DJIA) 1950-2007
ln(DJIA)
10
9
8
7
6
5
4
3
2
1
0
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005
Year


Time Series of ln(Per Capita Retail Sales)
ln(per capita consumption)
9.8
9.7
9.6
9.5
9.4
9.3
9.2
9.1
1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985
Year:Month
29

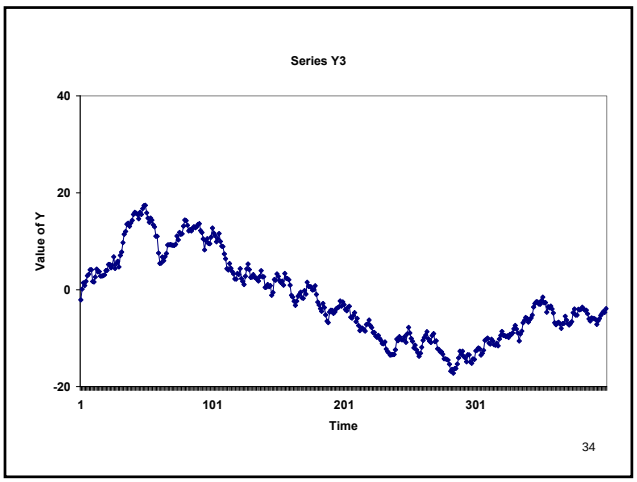

Time Series of 1st Difference ln(Per Capita Retail Sales)
1st Difference ln(per capita consumption)
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985
Year:Month
6


Time Series: Variable Y1 and Y2
Variable y1
Variable y2
50
45
40
35
30
25
20
15
10
5
0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1975 1980 1985 1990 1995 2000 2005
Year
31

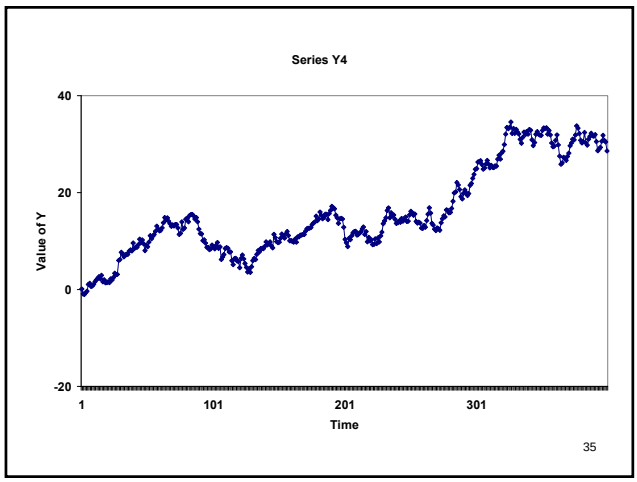

Series Y1
Value of Y
40
20
0
-20
1 101 201 301
Time
32


Series Y2
40
20
0
-20
Value of Y
1
101
201
301
Time

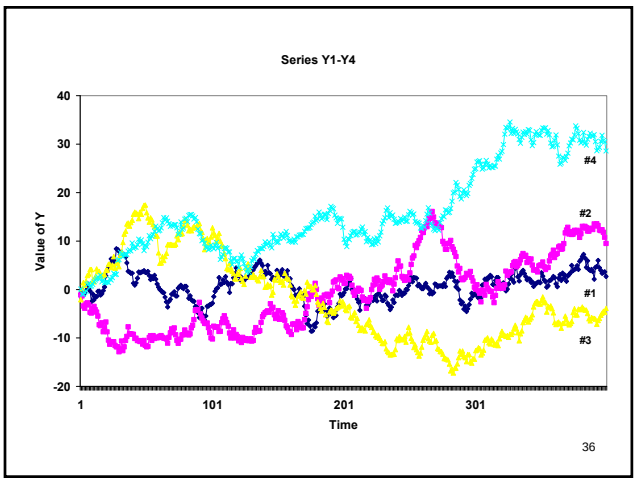
33


Series Y3
40
20
0
-20
Value of Y
1
101
201
301
Time

34


Series Y4
40
20
0
-20
Value of Y
1
101
201
301
Time

35

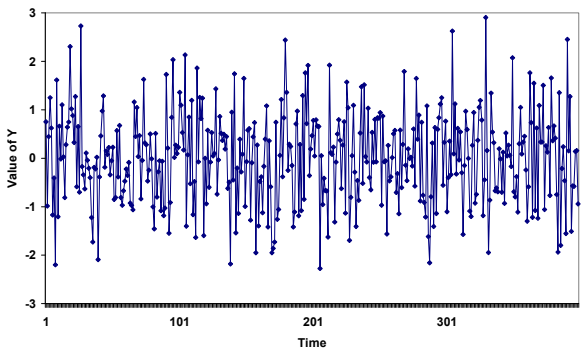

Series Y1-Y4
40
30
20
10
0
-10
-20
Value of Y
#4
#2
#1
#3
1
101
201
301
Time

36

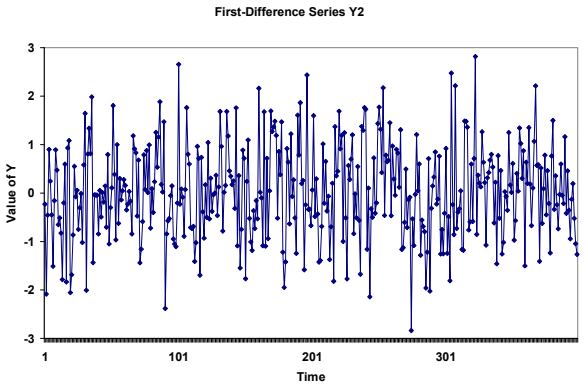
$$y_t = a + \rho y_{t-1} + v_t$$

Series	Coefficient (std error) on ρ	P-value, H_o: ρ=1
Y1		
Y2		
Y3		
Y4		

37



38



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OLS – Levels on Levels

coefficients (standard errors)

Ind. Var.	Dependent Variable			
	y1	y2	y3	y4
y1		0.134 (0.124)	0.274 (0.140)	0.461 (0.149)
y2	0.022 (0.020)		-0.854 (0.037)	0.823 (0.045)
y3	0.034 (0.018)	-0.668 (0.029)		-0.532 (0.047)
y4	0.051 (0.016)	0.559 (0.030)	-0.463 (0.041)	

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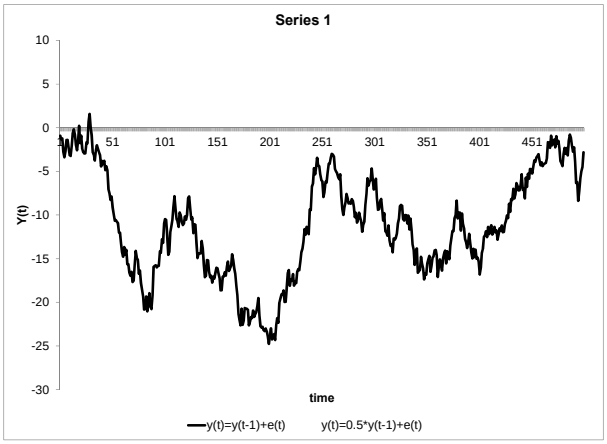
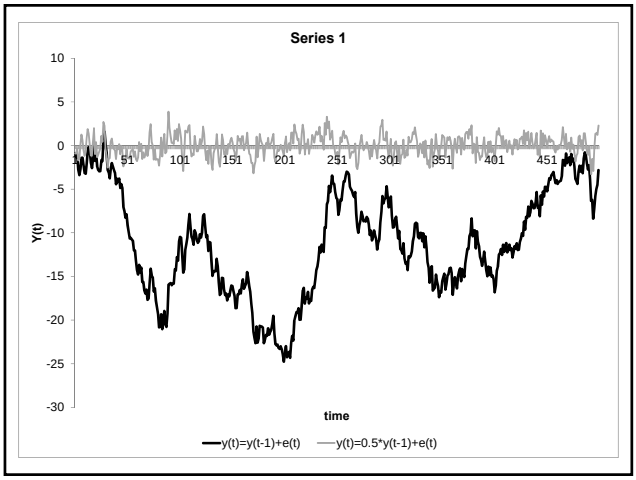
OLS – Differences on Differences

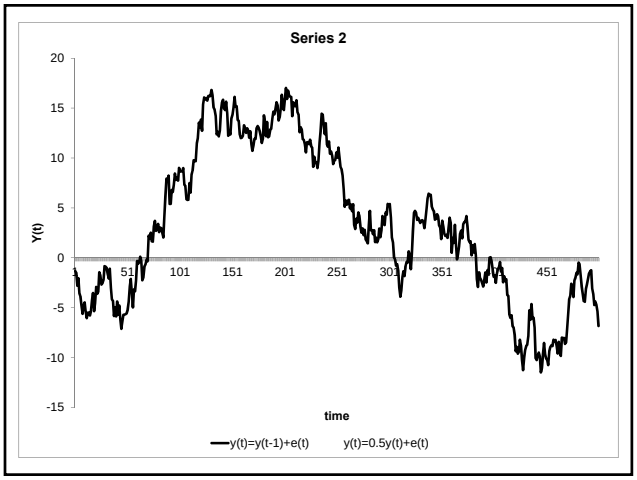
coefficients (standard errors)

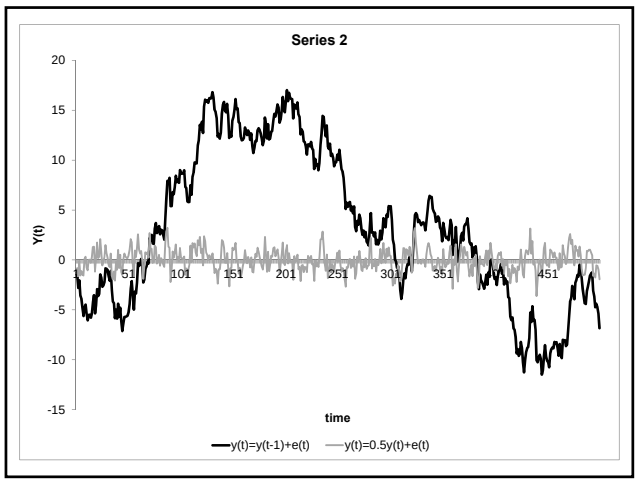
Ind. Var.	Dependent Variable			
	Δy1	Δ y2	Δ y3	Δ y4
Δ y1		-0.046	0.045	0.006
		(0.051)	(0.051)	(0.047)
Δ y2	-0.044		0.011	0.005
	(0.049)		(0.051)	(0.047)
Δ y3	0.043	0.011		-0.003
	(0.049)	(0.049)		(0.047)
Δ y4	0.067	0.006	-0.004	
	(0.052)	(0.053)	(0.054)	

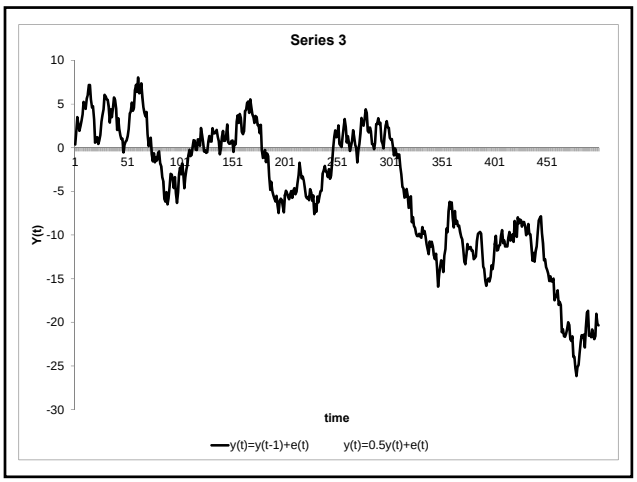
41

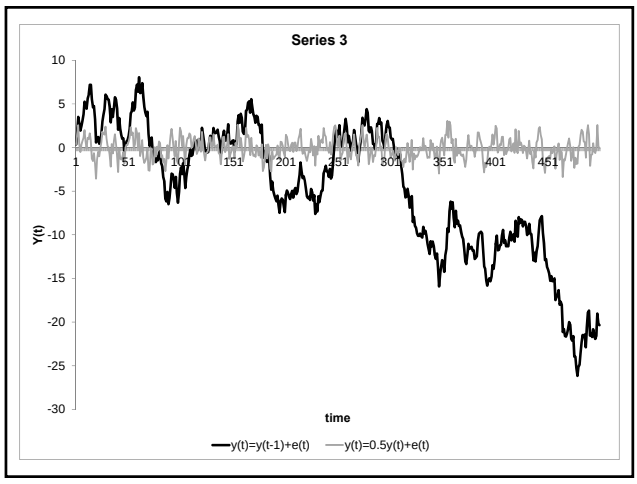


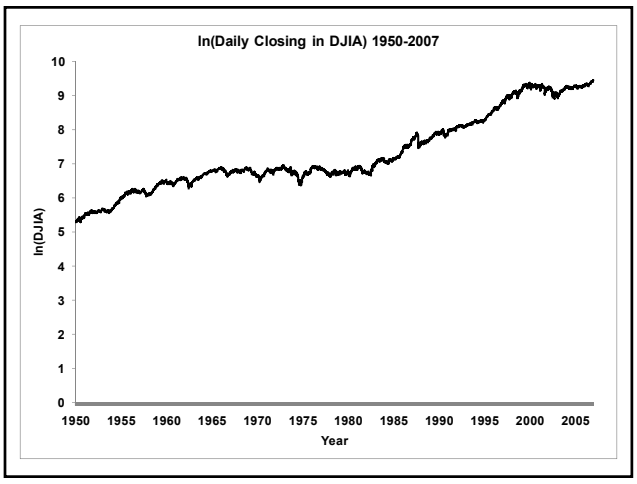


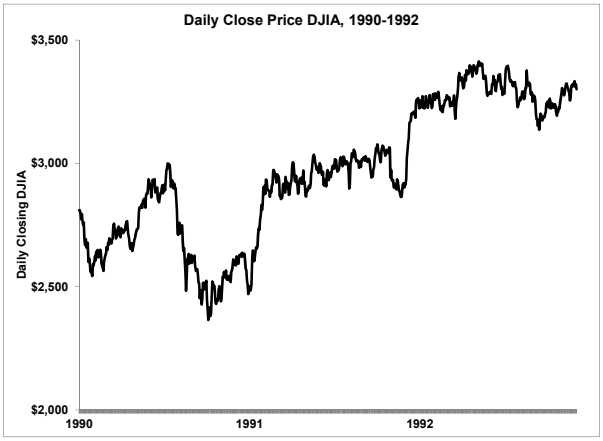



Series 2
Y(t)
time
y(t)=y(t-1)+e(t)
y(t)=0.5y(t)+e(t)


Series 3
Y(t)
time
y(t)=y(t-1)+e(t)
y(t)=0.5y(t)+e(t)


Series 3
Y(t)
time
y(t)=y(t-1)+e(t)
y(t)=0.5y(t)+e(t)


ln(Daily Closing in DJIA) 1950-2007
ln(DJIA)
Year




```
. * notice the variable time.  the first day is
. * 1, the second day 2, etc.
.
. * define the data as time series
. * the variable time is the index
. tsset time
        time variable:  time, 1 to 14362
                delta:  1 unit
```

50

Generating lags in STATA

- Data set needs to be identified as a time-series (tsset)
- Given variable z
- One period lag

  gen zlag1=z[_n-1]

- Five period lag

  gen zlag5=z[_n-5]

51

Model (1)

$$y_t = \alpha + \rho y_{t-1} + \varepsilon_t$$

$$H_o : \rho = 1$$
$$H_a : \rho < 1$$

Model (2)

$$y_t - y_{t-1} = \alpha + \rho y_{t-1} - y_{t-1} + \varepsilon_t$$

$$\Delta y_t = \alpha + (\rho - 1) y_{t-1} + \varepsilon_t$$

$$\Delta y_t = \alpha + \theta y_{t-1} + \varepsilon_t$$

$$H_0 : \theta = 0$$
$$H_a : \theta < 0$$

52

```
* take the ln of the daily closing price
gen ln_close=ln(close)

* get the 1st difference
gen ln_close_1=ln_close[_n-1]


* get the 1st difference
gen d_ln_close=ln_close-ln_close_1

* get the lag of the 1st difference
gen d_ln_close_1=d_ln_close[_n-1]
```

53

```
. * test for random walk
. * run a regression of change ln(closing price)
. * on one period lag
. reg ln_close ln_close1
      Source |       SS       df       MS              Number of obs =   14361
-------------+------------------------------           F(  1, 14359) =       .
       Model |  18001.7298     1  18001.7298           Prob > F      =  0.0000
    Residual |  1.18771395 14359  .000082716           R-squared     =  0.9999
-------------+------------------------------           Adj R-squared =  0.9999
       Total |  18002.9175 14360  1.25368507           Root MSE      =  .00909

------------------------------------------------------------------------------
   ln_close |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
  ln_close1 |   .9999874   .0000678        .   0.000     .9998545     1.00012
      _cons |   .0003808   .0004995     0.76   0.446    -.0005984      .00136
------------------------------------------------------------------------------

. test ln_close1==1
 ( 1)  ln_close1 = 1
       F(  1, 14359) =    0.03
            Prob > F =    0.8520
```

54

```
. * now run model where null is transformed into 0
. reg d_ln_close ln_close_1

      Source |       SS       df       MS              Number of obs =   14361
-------------+------------------------------           F(  1, 14359) =    0.03
       Model |  2.8777e-06     1  2.8777e-06           Prob > F      =  0.8520
    Residual |  1.18771395 14359  .000082716           R-squared     =  0.0000
-------------+------------------------------           Adj R-squared = -0.0001
       Total |  1.18771682 14360   .00008271           Root MSE      =  .00909

------------------------------------------------------------------------------
  d_ln_close |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_close_1 |  -.0000126   .0000678    -0.19   0.852    -.0001455    .0001202
       _cons |   .0003808   .0004995     0.76   0.446    -.0005984      .00136
------------------------------------------------------------------------------
```

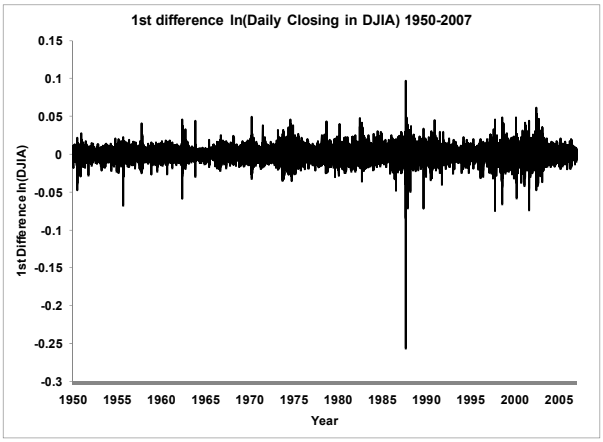
55

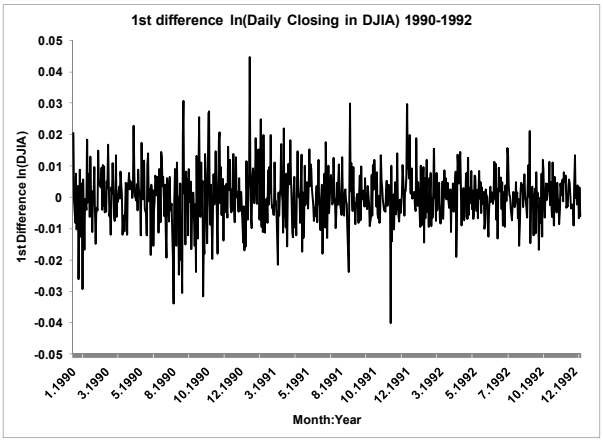
```
. * now get dickey fuller test
. dfuller ln_close

Dickey-Fuller test for unit root                   Number of obs   =     14361

                         ---------- Interpolated Dickey-Fuller ---------
             Test         1% Critical       5% Critical      10% Critical
           Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.187            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9401

.
```

56

```
. gen d_ln_close_1=d_ln_close[_n-1]
(1 missing value generated)

. reg d_ln_close d_ln_close_1

      Source |       SS       df       MS              Number of obs =   14361
-------------+------------------------------           F(  1, 14359) =   69.45
       Model |  .005717215     1  .005717215           Prob > F      =  0.0000
    Residual |  1.18199961 14359  .000082318           R-squared     =  0.0048
-------------+------------------------------           Adj R-squared =  0.0047
       Total |  1.18771682 14360   .00008271           Root MSE      =  .00907

------------------------------------------------------------------------------
  d_ln_close |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
d_ln_close_1 |   .0693792    .008325     8.33   0.000     .0530611    .0856972
       _cons |   .0002687   .0000757     3.55   0.000     .0001202    .0004171
------------------------------------------------------------------------------
```

57



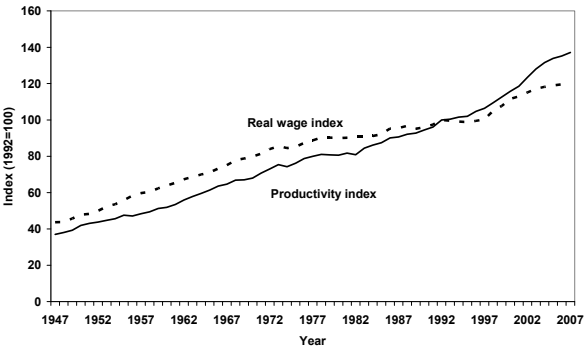


productivity.dta

- Annual data on productivity index and mean real wages, 1947-2007
- Index variable time =1 in 1947, 2=1948….
- Need to "tsset" time series data and identify the index that orders time

```
. tsset time
        time variable:  time, 1 to 61
                delta:  1 unit
```

60



61

```
. * generate ln of outcomes
. gen rwagel=ln(rwage)
. gen prodl=ln(productivity)

. reg rwagel time prodl

      Source |       SS       df       MS              Number of obs =      61
-------------+------------------------------           F(  2,    58) = 2083.25
       Model |  4.65023272     2  2.32511636           Prob > F      =  0.0000
    Residual |   .06473372    58  .001116099          R-squared     =  0.9863
-------------+------------------------------           Adj R-squared =  0.9858
       Total |  4.71496644    60  .078582774          Root MSE      =  .03341

------------------------------------------------------------------------------
      rwagel |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |  -.0147661   .0020467    -7.21   0.000     -.018863   -.0106692
       prodl |   1.479204   .1000978    14.78   0.000     1.278837    1.679572
       _cons |  -1.531055   .3689574    -4.15   0.000    -2.269604   -.7925068
------------------------------------------------------------------------------
```

Notice the excellent fit

Interpret the coef. on prodl

62

```
. * regress levels on 1st differences
. reg rwagel time rwagel1

      Source |       SS       df       MS              Number of obs =      60
-------------+------------------------------           F(  2,    57) =12947.36
       Model |  4.32027231     2  2.16013616           Prob > F      =  0.0000
    Residual |  .009509872    57   .00016684          R-squared     =  0.9978
-------------+------------------------------           Adj R-squared =  0.9977
       Total |  4.32978218    59  .073386139          Root MSE      =  .01292

------------------------------------------------------------------------------
      rwagel |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0004911   .0003717     1.32   0.192    -.0002532    .0012354
     rwagel1 |   .9446265   .0233767    40.41   0.000     .8978154    .9914375
       _cons |   .2443952   .0912928     2.68   0.010     .0615845    .4272059
------------------------------------------------------------------------------

. reg prodl time prodl1

      Source |       SS       df       MS              Number of obs =      60
-------------+------------------------------           F(  2,    57) =18572.67
       Model |  7.39083745     2  3.69541873           Prob > F      =  0.0000
    Residual |  .011341335    57  .000198971          R-squared     =  0.9985
-------------+------------------------------           Adj R-squared =  0.9984
       Total |  7.40217879    59  .125460657          Root MSE      =  .01411

------------------------------------------------------------------------------
       prodl |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .001841   .0008647     2.13   0.038     .0001095    .0035726
      prodl1 |   .9011966   .0422653    21.32   0.000     .8165617    .9858315
       _cons |    .389113   .1549295     2.51   0.015     .0788721     .699354
------------------------------------------------------------------------------
```

63

```
. * regress 1st differences on lags and a trend
. reg drwagel time rwagel1

      Source |       SS       df       MS              Number of obs =      60
-------------+------------------------------           F(  2,    57) =    9.77
       Model |  .003258489     2  .001629244           Prob > F      =  0.0002
    Residual |  .009509872    57   .00016684          R-squared     =  0.2552
-------------+------------------------------           Adj R-squared =  0.2291
       Total |  .012768361    59  .000216413          Root MSE      =  .01292

------------------------------------------------------------------------------
    drwagel1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0004911   .0003717     1.32   0.192    -.0002532    .0012354
     rwagel1 |  -.0553735   .0233767    -2.37   0.021    -.1021846   -.0085625
       _cons |   .2443952   .0912928     2.68   0.010     .0615845    .4272059
------------------------------------------------------------------------------

. reg dprodl time prodl1

      Source |       SS       df       MS              Number of obs =      60
-------------+------------------------------           F(  2,    57) =    3.97
       Model |  .001579428     2  .000789714           Prob > F      =  0.0243
    Residual |  .011341335    57  .000198971          R-squared     =  0.1222
-------------+------------------------------           Adj R-squared =  0.0914
       Total |  .012920763    59  .000218996          Root MSE      =  .01411

------------------------------------------------------------------------------
      dprodl |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .001841   .0008647     2.13   0.038     .0001095    .0035726
      prodl1 |  -.0988034   .0422653    -2.34   0.023    -.1834383   -.0141685
       _cons |    .389113   .1549295     2.51   0.015     .0788721     .699354
------------------------------------------------------------------------------
```

64

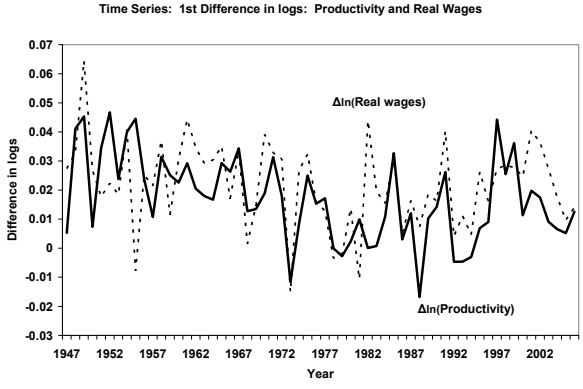
```
. * now get dickey fuller tests with a trend
. dfuller rwagel, trend

Dickey-Fuller test for unit root                   Number of obs   =        60

                         ---------- Interpolated Dickey-Fuller ---------
             Test        1% Critical       5% Critical      10% Critical
           Statistic          Value             Value            Value
------------------------------------------------------------------------------
 Z(t)          -2.369           -4.128            -3.490           -3.174
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3964

. dfuller prodl, trend

Dickey-Fuller test for unit root                   Number of obs   =        60

                         ---------- Interpolated Dickey-Fuller ---------
             Test        1% Critical       5% Critical      10% Critical
           Statistic          Value             Value            Value
------------------------------------------------------------------------------
 Z(t)          -2.338           -4.128            -3.490           -3.174
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.4132
```

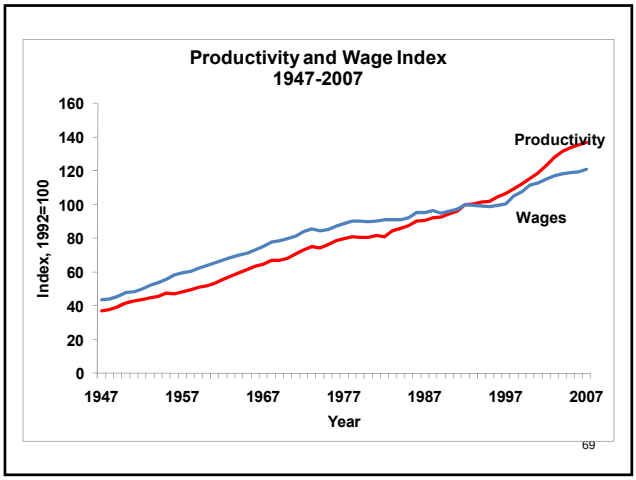


```
. * now difference data
.
. gen drwagel=rwagel-rwagel1
(1 missing value generated)

. gen dprodl=prodl-prodl1
(1 missing value generated)
```

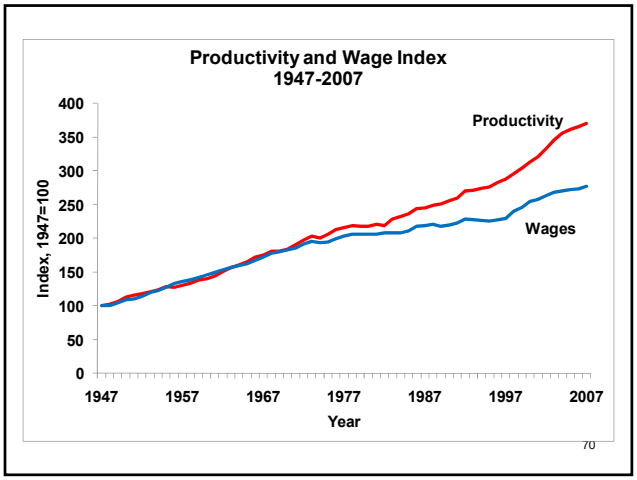


```
. * run regression of diff on diff
. reg drwagel time dprodl

      Source |       SS       df       MS              Number of obs =      60
-------------+------------------------------           F(  2,    57) =   17.71
       Model |  .004894165     2  .002447082           Prob > F      =  0.0000
    Residual |  .007874197    57  .000138144           R-squared     =  0.3833
-------------+------------------------------           Adj R-squared =  0.3617
       Total |  .012768361    59  .000216413           Root MSE      =  .01175

------------------------------------------------------------------------------
    drwagel |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       time |   -.000284   .0000893    -3.18   0.002    -.0004629   -.0001051
     dprodl |   .4548905   .1054274     4.31   0.000     .2437759    .6660052
      _cons |   .0159993   .0042484     3.77   0.000     .0074921    .0245065
------------------------------------------------------------------------------
```



69



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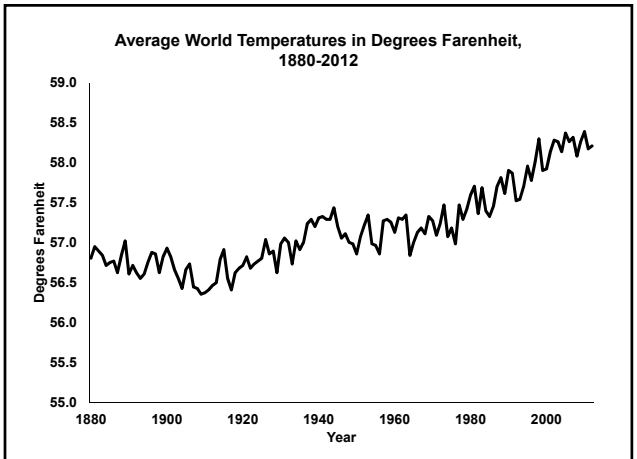
Global Warming

71



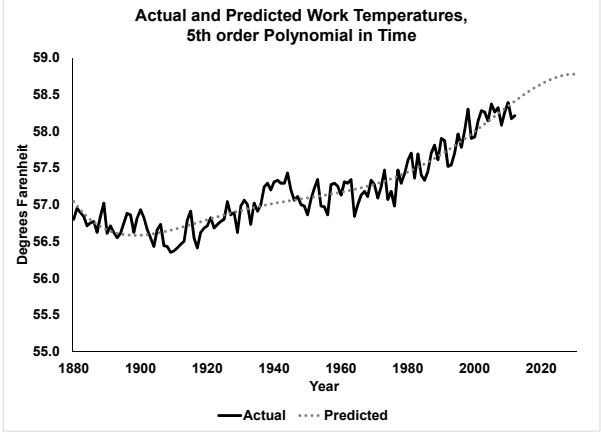
Two variables:

year
avg_temp_f

```
* set the time series
tsset year

* generate some time trends
gen time=year-1979
gen time2=time*time
gen time3=time2*time/1000
gen time4=time3*time/1000000
gen time5=time4*time/100000000

* run high-order polynomial
reg avg_temp_f time*
```



```
      Source |       SS           df       MS      Number of obs   =       133
-------------+----------------------------------   F(5, 127)       =    197.40
       Model |  31.4589038         5  6.29178077   Prob > F        =    0.0000
    Residual |  4.04789829       127  .031873215   R-squared       =    0.8860
-------------+----------------------------------   Adj R-squared   =    0.8815
       Total |  35.5068021       132  .268990925   Root MSE        =    .17853

------------------------------------------------------------------------------
  avg_temp_f |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0195374   .0022199     8.80   0.000     .0151447    .0239301
       time2 |   .0003794   .0000608     6.24   0.000      .000259    .0004998
       time3 |   .0016513    .002339     0.71   0.481    -.0029771    .0062797
       time4 |  -84.83526   52.42066    -1.62   0.108    -188.5663    18.89576
       time5 |  -7.97e+07   3.11e+07    -2.56   0.012    -1.41e+08   -1.81e+07
       _cons |   57.42266   .0309648  1854.45   0.000     57.36139    57.48394
------------------------------------------------------------------------------
```


```
dfuller avg_temp_f

Dickey-Fuller test for unit root                   Number of obs   =       132

---------- Interpolated Dickey-Fuller ---------
Test         1% Critical       5% Critical      10% Critical
Statistic           Value             Value             Value

Z(t)             -1.652            -3.499            -2.888            -2.578

MacKinnon approximate p-value for Z(t) = 0.4558
```

```
* get lag
gen avg_temp_f_1=avg_temp_f[_n-1]

* get 1st different
gen d_avg_temp_f=avg_temp_f-avg_temp_f_1

* get dickey_fuller of 1st difference
dfuller d_avg_temp_f

* run regression
reg d_avg_temp_f time
```

```
. * get dickey_fuller of 1st difference
. dfuller d_avg_temp_f

Dickey-Fuller test for unit root                   Number of obs   =       131

                         ---------- Interpolated Dickey-Fuller ---------
               Test         1% Critical       5% Critical      10% Critical
             Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)           -15.129           -3.500            -2.888           -2.578
------------------------------------------------------------------------------
```

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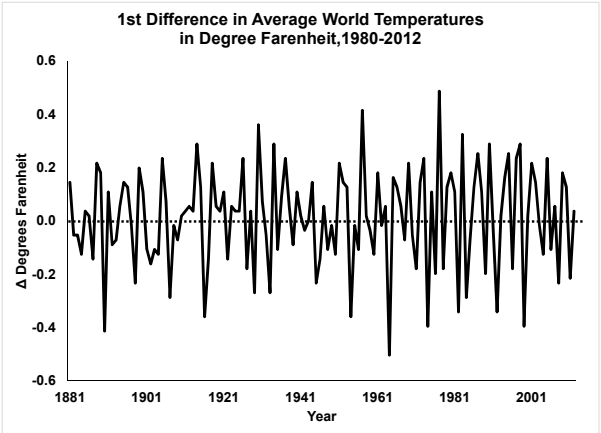

Question

What does it mean if temperatures follow a random walk?

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