平滑转换模型

王群勇（南开大学数量经济研究所，教授、博士生导师, QunyongWang@outlook.com）

内容

平滑转换模型

$$y_t = x_t\beta + G(s_t; c, \gamma) z_t \alpha + \epsilon_t.$$

条件期望 $\mathrm{E}(y_t|x_t)$ 包括两部分：

- 线性部分 $x_t\beta$，
- 非线性部分$G(s_t; c, \gamma) z_t \alpha$.

x_t与z_t可以相同，也可以不同。

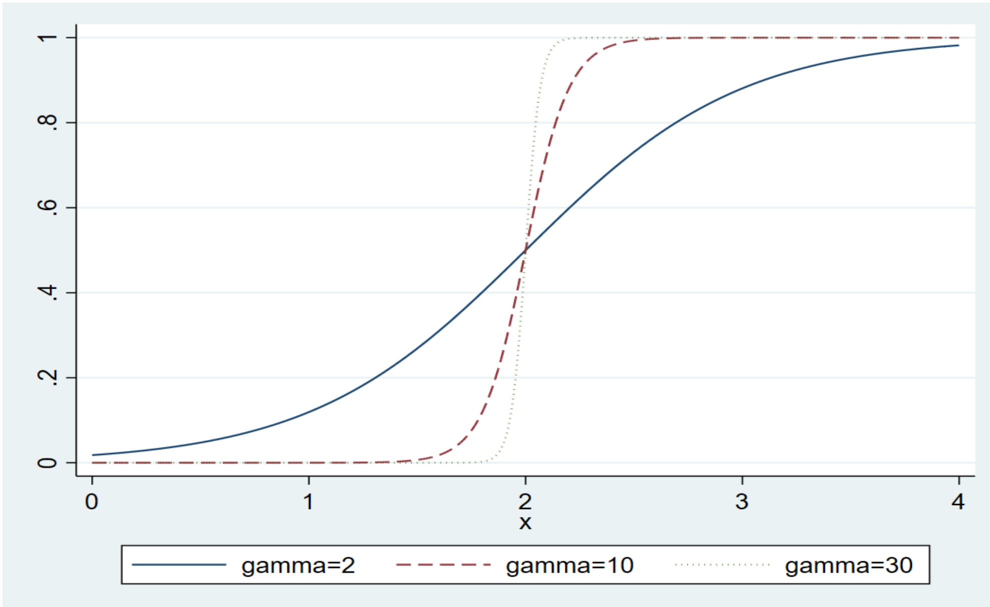
模型设定

$G(s_t; c, \gamma)$为平滑函数，常见的包括：logistic, normal, and exponential

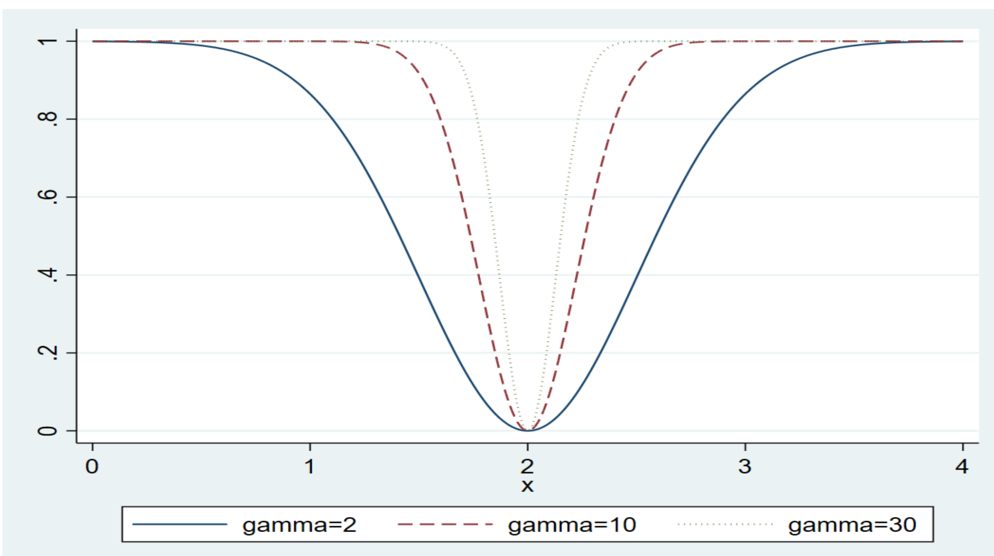
$$G(s_t; c, \gamma) = \begin{cases} [1 + \exp(-\gamma(s_t - c))]^{-1} & \text{Logistic, or LSTR} \\ 1 - \exp(-\gamma(s_t - c)^2) & \text{Exponential, or ESTR} \\ \Phi(\gamma(s_t - c)) & \text{Normal CDF} \end{cases}$$

其中，$\gamma > 0$，控制转换的速度。

模型设定



模型设定



边际效应

设$x_t = z_t$，那么x_t对$\mathrm{E}(y_t|x_t)$的边际效应：$\beta + G(s_t; c, \gamma)\alpha$.

$0 \leq G(s_t; c, \gamma) \leq 1$，两种极端状态下的边际效应为$\beta$和$\beta + \alpha$。

LSTR and NSTR:

- 当$s_t \to -\infty$, $G(s_t; c, \gamma) \to 0$, 边际效应为β;
- 当$s_t \to \infty$, $G(s_t; c, \gamma) \to 1$, 边际效应为$\beta + \alpha$.
- 随着s_t 的增加，边际效应从β过渡到$\beta + \alpha$，中心点为c（边际效应为$\beta + \alpha/2$）。

边际效应

ESTR:

- 当$s_t \to c$, $G(s_t; c, \gamma) \to 0$, 边际效应为β.
- 当$s_t \to -\infty$或$s_t \to \infty$, $G(s_t; c, \gamma) \to 1$, 边际效应为$\beta + \alpha$.

转换速度

当$\gamma \to \infty$, $G(s_t; c, \gamma)$变为示性函数。

$$G(s_t; c, \gamma) = \begin{cases} 1 & s_t \geq c \\ 0 & s_t < c \end{cases}$$

模型退化为门限模型。

当$\gamma \to 0$,模型退化为线性模型：

- $G(s_t; c, \gamma) \to 1/2$ in LSTR and NSTR model
- $G(s_t; c, \gamma) \to 0$ in ESTR model

多个状态

LSTR 模型的多个状态的情况

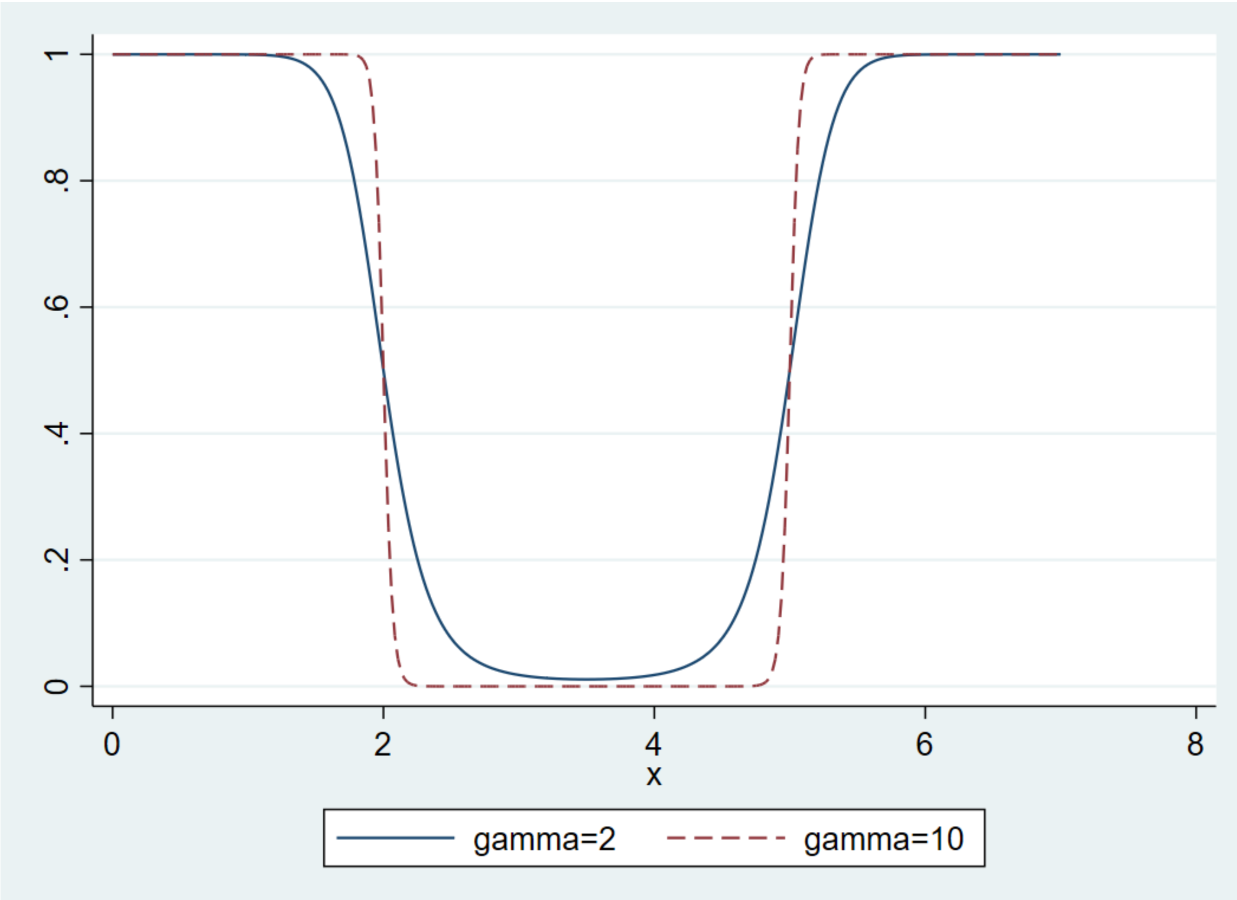
$$G(s_t; c, \gamma) = \left[1 + \exp\left(-\gamma \prod_{j=1}^{m} (s_t - c_j)\right)\right]^{-1},$$

绝大多数情况下，$m = 1$ 或者 $m = 2$。

$m = 2$时，转移函数以 $(c_1 + c_2)/2$为中心点（最低点）呈对称形状。

当$\gamma \to \infty$，模型变为三状态的门限模型。两端的状态是相同的，中间是一种状态。

多个状态



模型估计

数值最优化方法。

初始值：

- 给定(c,γ)，模型退化为线性模型，可以采用格点搜索法确定(c,γ)的初始值。
- 需要将γ标准化：γ/σ_s^m。或者将s_t标准化。

非线性检验

H_0: $\gamma = 0$ or H_0: $\alpha = 0$.

由于冗余参数问题，检验统计量服从非标准分布。

令$h_t = s_t - c$，对$G(h_t;\gamma)$在$h_t = 0$做 Taylor 级数展开，

$$G(h_t;\gamma) \approx G(0;\gamma) + G'(h_t;\gamma)h_t + G''(h_t;\gamma)h_t^2 + G'''(h_t;\gamma)h_t^3.$$

非线性检验

对于 LSTR 模型，

$$\begin{aligned} G'(h_t;\gamma) &= \frac{e^{-h_t}}{(1+e^{-h_t})^2} = 1/4 \text{ at } h_t = 0 \\ G''(h_t;\gamma) &= \frac{-e^{-h_t}(1-e^{-h_t})}{(1+e^{-h_t})^3} = 0 \text{ at } h_t = 0 \\ G'''(h_t;\gamma) &= \frac{-e^{-h_t}(1-4e^{-h_t}+e^{-2h_t})}{(1+e^{-h_t})^4} = -1/8 \text{ at } h_t = 0 \end{aligned}$$

$$G(h_t;\gamma) \approx h_t/4 - h_t^3/8.$$

平滑转换模型可以写作

$$y_t = x_t\beta + z_t\alpha(s_t/4 - s_t^3/8) + u_t$$

非线性检验

对$G(h_t;\gamma)$在$h_t = 0$做 Taylor 级数展开，对于 ESTR 模型，

$$\begin{aligned} G'(h_t;\gamma) &= 2h_t\exp(-h_t^2) = 0 \text{ at } h_t = 0 \\ G''(h_t;\gamma) &= 2\exp(-h_t^2) - 4h_t^2\exp(-h_t^2) = 2 \text{ at } h_t = 0 \\ G'''(h_t;\gamma) &= -12h_t\exp(-h_t^2) + 8h_t^3\exp(h_t^2) = 0 \text{ at } h_t = 0 \end{aligned}$$

$$G(s_t;\gamma,c) \approx 2s_t^2.$$

平滑转换模型可以写作

$$y_t = x_t\beta + z_t\alpha(2s_t^2) + u_t$$

对于 LSTR （m=2）也可以得到相似的展开式。

非线性检验

Lin and Teräsvirta (1994)建议如下序贯检验步骤：

$$y_t = x_t\beta + z_t s_t\pi_1 + z_t s_t^2\pi_2 + z_t s_t^3\pi_3 + v_t.$$

- $H_{04}: \pi_1 = \pi_2 = \pi_3 = 0$
- $H_{03}: \pi_3 = 0$
- $H_{02}: \pi_2 = 0 | \pi_3 = 0$

- $H_{01}: \pi_1 = 0 | \pi_2 = \pi_3 = 0$

如果H_{02}的检验的 p 值最低，那么 ESTR 模型更适合。

如果H_{01}或H_{03}的检验的 p 值最低，那么 LSTR 模型更适合。

模型选择

Escribano and Jorda (1999)：

- $H_{024}: \pi_2 = \pi_4 = 0$
- $H_{013}: \pi_1 = \pi_3 = 0$

如果H_{024}的检验统计的 p 值更低，则采用 LSTR (m=2)或者 ESTR 模型。如果H_{013}的检验统计的 p 值更低，则采用 LSTR (m=1)模型。

STAR 模型

在时间序列自回归模型中，以某个滞后变量作为作为门限变量，即得到了平滑转换自回归模型，包括 LSTAR (Logistic Smoothing Transition AutoRegressive)、ESTAR (Exponential Smoothing Transition AutoRegressive)模型。

$$y_t = \beta_0 + \sum_{k=1}^{K} \beta_k y_{t-k} + G(y_{t-d}; c, \gamma) \sum_{k=1}^{K} \alpha_k y_{t-k} + \epsilon_t.$$

面板平滑转换模型

model:

$$y_{it} = c + x_{it}\beta + G(s_{it}; c, \gamma) z_{it}\alpha + u_i + \epsilon_{it}.$$

令$sz(c,\gamma)_{it} = G(s_{it}; c, \gamma) z_{it}$

$$y_{it} - \bar{y}_{i.} = (x_{it} - \bar{x}_{i.})\beta + (sz_{it} - \overline{sz(c,\gamma)}_{it})\alpha + \epsilon_{it} - \bar{\epsilon}_{i.}$$

内容

平滑转换模型

stregress 与 xtstregress

应用

语法

$$y_t = x_t\beta + G(s_t; c, \gamma)z_t\alpha + \epsilon_t.$$

`stregress` *depvar indep* [*if*] [*in*] , [`lstr`(*spec*) `estr`(*spec*) `nstr`(*spec*) `nolog` *options*]

`lstr`, `estr`, `nstr` 可以重复设定。

spec 的格式：*transition*, *regime-dependents*, [*constant*, *number of states*]

- *constant* 为 0（z）中是否含有常数项（0 或 1）
- *number of states*：默认值为 1

`xtstregress` *depvar indep* [*if*] [*in*] , [`lstr`(*spec*) `estr`(*spec*) [`nstr`(*spec*) `nolog` *options*]

语法

```
estat linear
estat reslinear
estat pconst
estat stplot
estat ic
estat summ
```

内容

平滑转换模型

stregress 与 xtstregress

应用

非对称的货币政策

Taylor 规则 (Enders, 2015, p436)：

$$i_t = \alpha_0 + \alpha\pi_t + \beta y_t + \gamma_1 i_{t-1} + \epsilon_t$$

其中，i_t为名义利率，π_t为通胀率，y_t为产出缺口（实际产出距离潜在产出的百分比）。

在高通胀或低增长时，货币政策的反应强度可能更大。估计如下模型：

$$i_t = \alpha_0 + \gamma_1 i_{t-1} + x_{t-1}\beta + G(\pi_{t-1};\gamma,c)z_{t-1}\alpha + \epsilon_t$$

泰勒规则

```
. use taylor, clear

. stregress ffr l.ffr l.pi l.ygap, lstr(l.pi, l.pi l.ygap,1) nolog

Smoothing transition regression (lstr)

log-likelihood     =       -148.8880          Number of obs    =         113
AIC                =        313.7759          R-squared        =      0.9398
BIC                =        335.5950          Adj R-squared    =      0.9352
HQIC               =        322.6299          Root MSE         =      0.9403
```

ffr	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Linear						
ffr						
L1.	0.7750	0.0439	17.67	0.000	0.6890	0.8609
pi						
L1.	-0.1767	0.3533	-0.50	0.617	-0.8693	0.5158
ygap						
L1.	0.4346	0.1412	3.08	0.002	0.1578	0.7113
_cons	1.1327	0.7372	1.54	0.124	-0.3123	2.5777
L.pi						
pi						
L1.	0.6104	0.3709	1.65	0.100	-0.1165	1.3372
ygap						
L1.	-0.2282	0.1616	-1.41	0.158	-0.5450	0.0885
_cons	-1.0977	0.7782	-1.41	0.158	-2.6228	0.4275
threshold1	2.4867	0.0456	54.56	0.000	2.3974	2.5761
lngamma	4.4934	6.9501	0.65	0.518	-9.1285	18.1154

```
. est store spi
```

泰勒规则

```
. stregress ffr l.ffr l.pi l.ygap, lstr(l.ygap, l.pi l.ygap,1) nolog

Smoothing transition regression (lstr)

log-likelihood  =       -145.3470             Number of obs   =         113
AIC             =        306.6940             R-squared       =      0.9434
BIC             =        328.5131             Adj R-squared   =      0.9391
HQIC            =        315.5480             Root MSE        =      0.9113
```

ffr	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Linear						
ffr						
L1.	0.8194	0.0410	19.96	0.000	0.7390	0.8998
pi						
L1.	0.3721	0.1214	3.06	0.002	0.1341	0.6100
ygap						
L1.	-1.2190	0.4649	-2.62	0.009	-2.1302	-0.3077
_cons	-4.1373	1.1827	-3.50	0.000	-6.4554	-1.8192
L.ygap						
pi						
L1.	0.0112	0.1121	0.10	0.920	-0.2084	0.2309
ygap						
L1.	1.4083	0.4720	2.98	0.003	0.4832	2.3333
_cons	4.1074	1.1957	3.44	0.001	1.7639	6.4509
threshold1	-1.6536	0.1714	-9.65	0.000	-1.9895	-1.3176
lngamma	3.7723	3.0053	1.26	0.209	-2.1181	9.6627

```
. est store sygap
```

泰勒规则

```
. est table spi sygap, stat(N aic bic) star(.1 .05 .01) eq(1,2)
```

Variable	spi	sygap
#1		
ffr		
L1.	.77498173***	.81939891***
pi		
L1.	-.17672544	.3720814***
ygap		
L1.	.43456372***	-1.2189682***
_cons	1.1326753	-4.1373013***
#2		
pi		
L1.	.61038749*	.01124651
ygap		
L1.	-.22821481	1.4082912***
_cons	-1.0976931	4.107365***
threshold1	2.4867259***	-1.6535736***
lngamma	4.493442	3.7722966
Statistics		
N	113	113
aic	315.7759	308.69403
bic	340.32239	333.24052

legend: * p<.1; ** p<.05; *** p<.01

泰勒规则

```
. estat linear
```

Linearity (homegeneity) test for all nonlinear parts:

Ho	chi2	df1	df2	prob
b1=0	1.6483	2	107	.1972
b1=b2=0	1.2192	4	105	.3071
b1=b2=b3=0	1.6241	6	103	.1479
b1=b2=b3=b4=0	1.6473	8	101	.1208

Escribano-Jorda linearity test (based on 4th Taylor expansion):

Ho	chi2	df1	df2	prob
b1=b3=0(HoL)	1.1760	4	101	.3259
b2=b4=0(HoE)	1.2574	4	101	.2918

Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:

Ho	chi2	df1	df2	prob
b1=0|b2=b3=0	1.6483	2	107	.1972
b2=0|b3=0	0.7965	2	105	.4536
b3=0	2.3702	2	103	.09854

泰勒规则

```
. estat reslinear, l.pi
```

Linearity (homegeneity) test for all nonlinear parts:

Ho	chi2	df1	df2	prob
b1=0	0.3559	3	107	.7849
b1=b2=0	0.3121	5	105	.9047
b1=b2=b3=0	1.4461	7	103	.1951
b1=b2=b3=b4=0	1.5648	9	101	.136

Escribano-Jorda linearity test (based on 4th Taylor expansion):

Ho	chi2	df1	df2	prob
b1=b3=0(HoL)	2.0869	6	101	.06122
b2=b4=0(HoE)	2.1948	6	101	.0495

Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:

Ho	chi2	df1	df2	prob
b1=0|b2=b3=0	0.3559	3	107	.7849
b2=0|b3=0	0.3749	3	105	.7713
b3=0	2.9986	3	103	.03408

泰勒规则

```
. est restore sygap
(results sygap are active now)

. lincom [#1]_b[l.pi]+[#2]_b[l.pi]

 ( 1)  [Linear]L.pi + [L.ygap]L.pi = 0
```

ffr	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
(1)	0.3833	0.0843	4.55	0.000	0.2181	0.5486

```
. lincom [#1]_b[l.ygap]+[#2]_b[l.ygap]

 ( 1)  [Linear]L.ygap + [L.ygap]L.ygap = 0
```

ffr	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
(1)	0.1893	0.0929	2.04	0.041	0.0073	0.3713

泰勒规则

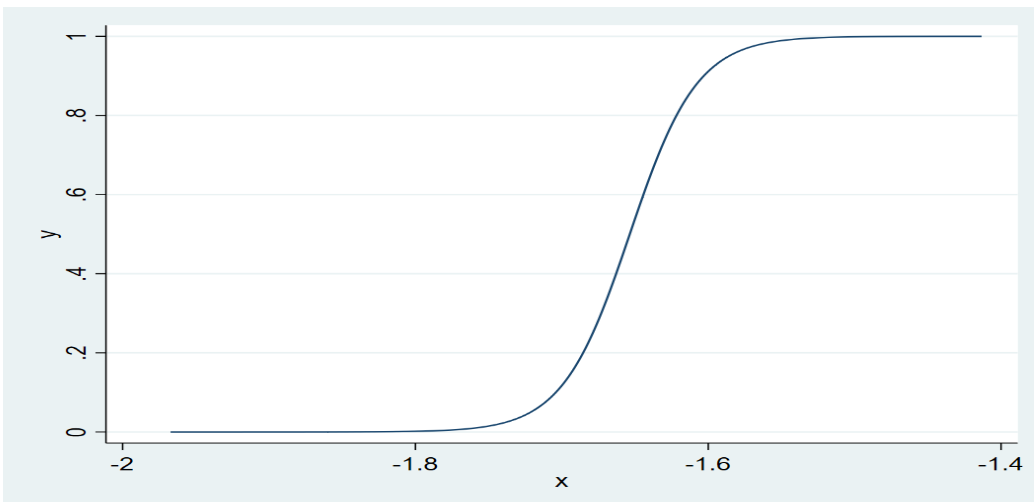
```
. estat stcoef

Transformed coefficient confidence interval (level=95):
```

	Coef	se	z	P>|z|	CILower	CIUpper
L.ygap						
gamma	43.4798	130.6720	0.33	0.7393	-212.6326	299.5922

例子

```
. estat stplot
```



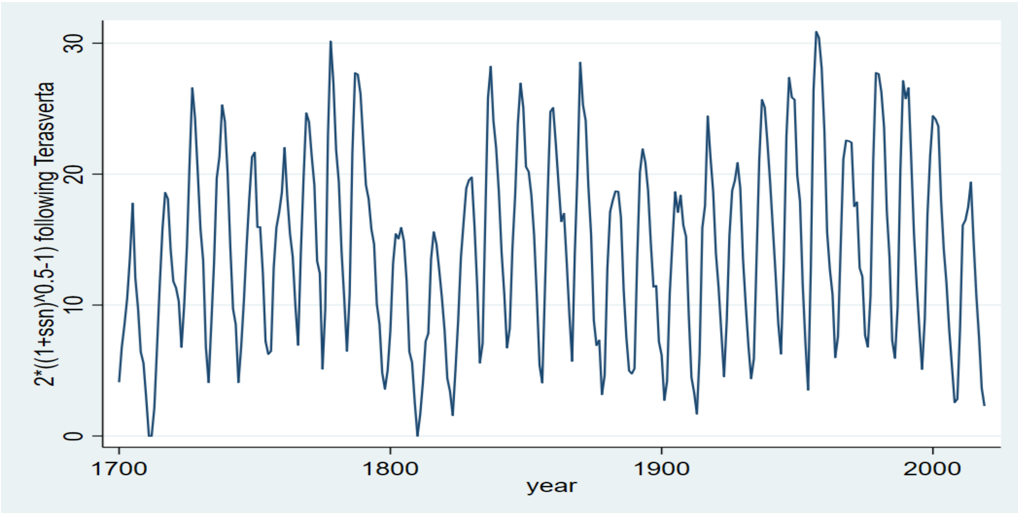
smooth transition plot

sunspot

根据 Ghaddar and Tong (1981), $y_t = 2[(1+x_t)^{1/2} - 1]$,

```
. use sunspot, clear
```

```
. tsline y
```



sunspot

sunspot

```
. frame reset

. use sunspot, clear

. frame create sim aic bic

. forvalues i=1/12 {
  2. qui arima y, ar(1/`i')
  3. qui estat ic
  4. matrix ic = r(S)
  5. local aic=el(ic,1,5)
  6. local bic=el(ic,1,6)
  7. frame post sim (`aic') (`bic')
  8. }

. frame sim: list aic bic

     +---------------------+
     |      aic        bic |
     |---------------------|
  1. | 1811.399   1822.704 |
  2. | 1588.852   1603.925 |
  3. | 1586.573   1605.415 |
  4. | 1588.544   1611.154 |
  5. |  1589.92   1616.298 |
     |---------------------|
  6. | 1579.446   1609.593 |
  7. | 1565.558   1599.473 |
```

```
  8. | 1558.999   1596.682 |
  9. | 1530.128   1571.579 |
 10. | 1531.946   1577.166 |
     |---------------------|
 11. | 1533.887   1582.875 |
 12. | 1535.541   1588.297 |
     +---------------------+
```

sunspot

```
. stregress y l(1/9).y, lstr(l2.y, l(1/9).y, 1) nolog

Smoothing transition regression (lstr)

log-likelihood  =       -699.3807             Number of obs   =        311
AIC             =       1440.7614             R-squared       =     0.8999
BIC             =       1519.2971             Adj R-squared   =     0.8927
HQIC            =       1472.1532             Root MSE        =     2.3756

-------------------------------------------------------------------------------------
            y |     Coef.   Std. Err.      z    P>|z|      [95% Conf. Interval]
--------------+----------------------------------------------------------------------
Linear        |
            y |
          L1. |    1.5063     0.1145    13.15   0.000       1.2819       1.7307
          L2. |   -1.0784     0.3170    -3.40   0.001      -1.6997      -0.4570
          L3. |    0.1443     0.2993     0.48   0.630      -0.4424       0.7309
          L4. |   -0.5632     0.2680    -2.10   0.036      -1.0885      -0.0380
          L5. |    0.4776     0.2673     1.79   0.074      -0.0464       1.0015
          L6. |    0.0370     0.2274     0.16   0.871      -0.4086       0.4827
          L7. |    0.1734     0.2274     0.76   0.446      -0.2723       0.6191
          L8. |    0.1027     0.2291     0.45   0.654      -0.3465       0.5518
          L9. |    0.1390     0.1248     1.11   0.265      -0.1056       0.3835
              |
        _cons |   -3.9351     1.5248    -2.58   0.010      -6.9236      -0.9465
--------------+----------------------------------------------------------------------
L2.y          |
            y |
          L1. |   -0.4495     0.1280    -3.51   0.000      -0.7004      -0.1985
          L2. |    0.8574     0.3295     2.60   0.009       0.2117       1.5032
          L3. |   -0.4732     0.3188    -1.48   0.138      -1.0981       0.1517
          L4. |    0.8559     0.2819     3.04   0.002       0.3033       1.4084
          L5. |   -0.7475     0.2820    -2.65   0.008      -1.3002      -0.1948
          L6. |   -0.0173     0.2447    -0.07   0.944      -0.4969       0.4623
          L7. |    0.0031     0.2454     0.01   0.990      -0.4779       0.4841
          L8. |   -0.3929     0.2445    -1.61   0.108      -0.8721       0.0863
          L9. |    0.1729     0.1362     1.27   0.204      -0.0941       0.4400
              |
```

_cons	7.5126	1.7000	4.42	0.000	4.1806	10.8446
threshold1	6.7660	0.0388	174.47	0.000	6.6900	6.8420
lngamma	4.1741	1.5604	2.67	0.007	1.1157	7.2325

sunspot

```
. estat linear
```

Linearity (homegeneity) test for all nonlinear parts:

Ho	chi2	df1	df2	prob
b1=0	5.9791	9	292	1.091e-07
b1=b2=0	4.2127	18	283	6.578e-08
b1=b2=b3=0	3.0344	27	274	2.221e-06
b1=b2=b3=b4=0	2.5701	36	265	9.624e-06

Escribano-Jorda linearity test (based on 4th Taylor expansion):

Ho	chi2	df1	df2	prob
b1=b3=0(HoL)	1.2790	18	265	.201
b2=b4=0(HoE)	0.9487	18	265	.5201

Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:

Ho	chi2	df1	df2	prob
b1=0|b2=b3=0	5.9791	9	292	1.091e-07
b2=0|b3=0	2.2213	9	283	.02087
b3=0	0.7459	9	274	.6666

sunspot

```
. estat reslinear, l2.y

Linearity (homegeneity) test for all nonlinear parts:
```

Ho	chi2	df1	df2	prob
b1=0	1.4058	10	292	.1768
b1=b2=0	1.1394	19	283	.3109
b1=b2=b3=0	1.1415	28	274	.2894
b1=b2=b3=b4=0	1.1091	37	265	.3141

```
Escribano-Jorda linearity test (based on 4th Taylor expansion):
```

Ho	chi2	df1	df2	prob
b1=b3=0(HoL)	1.0028	20	265	.4591
b2=b4=0(HoE)	0.9804	20	265	.4864

```
Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:
```

Ho	chi2	df1	df2	prob
b1=0|b2=b3=0	1.4058	10	292	.1768
b2=0|b3=0	0.7830	10	283	.6452
b3=0	1.0232	10	274	.4239

sunspot

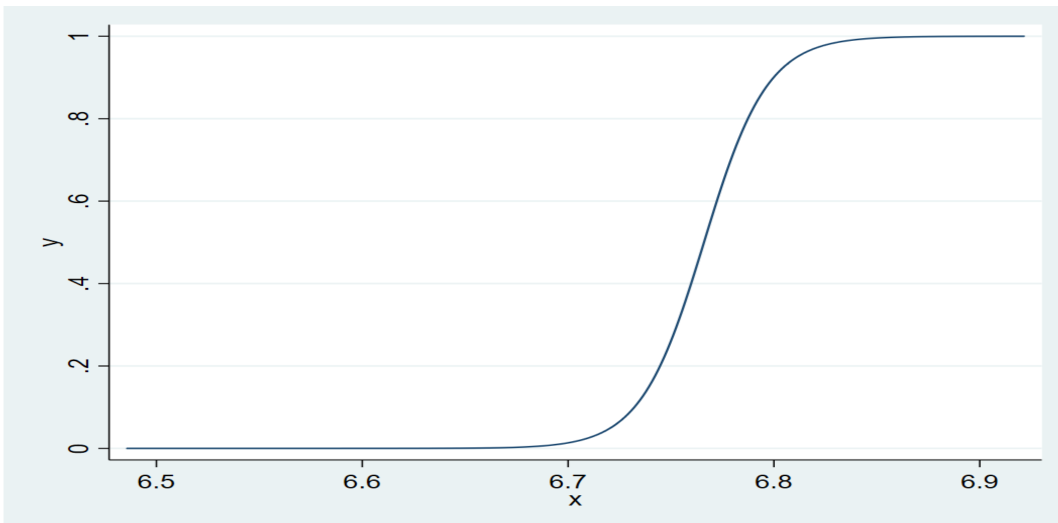
```
. estat stcoef

Transformed coefficient confidence interval (level=95):
```

	Coef	se	z	P>|z|	CILower	CIUpper
L2.y						
gamma	64.9784	101.3946	0.64	0.5216	-133.7514	263.7082

sunspot

```
. estat stplot
```



smooth transition plot

面板平滑转换

```
. use hansen1999, clear
(The Value and Performance of U.S.Corporations (B.H.Hall & R.E.Hall, 1993))

. xtstregress i c1 q1 q2 q3 d1 qd1, estr(d1, c1) nolog
Grid search initial values with range:  1 = ( .0063   , .4719   ) ......

Smoothing transition regression (estr)

log-likelihood   =      12896.8579             Number of obs    =         7910
AIC              =     -25775.7157             R2-within        =       0.0961
BIC              =     -25712.9328             R2-between       =       0.0549
HQIC             =     -25754.2140             R2-overall       =       0.0570
------------------------------------------------------------------------------
           i |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Linear       |
          c1 |     0.0853      0.0076    11.28   0.000       0.0705      0.1001
```

```
          q1 |   0.0103    0.0009   11.53   0.000      0.0086     0.0121
          q2 |  -0.0214    0.0026   -8.37   0.000     -0.0264    -0.0164
          q3 |   0.0012    0.0002    6.08   0.000      0.0008     0.0016
          d1 |  -0.0153    0.0048   -3.18   0.001     -0.0247    -0.0059
         qd1 |   0.0028    0.0014    1.96   0.050      0.0000     0.0056
       _cons |   0.0612    0.0011   56.29   0.000      0.0591     0.0634
-------------+-------------------------------------------------------------
d1           |
          c1 |  -0.2770    0.0674   -4.11   0.000     -0.4091    -0.1449
  threshold1 |   0.5186    0.1458    3.56   0.000      0.2329     0.8044
     lngamma |  -1.7627    0.4668   -3.78   0.000     -2.6777    -0.8477
---------------------------------------------------------------------------

. est store estr
```

面板平滑转换

```
. est restore estr
(results estr are active now)

. estat linear

Linearity (homegeneity) test for all nonlinear parts:

-----------------------------------------------------------------
               Ho |          F       df1       df2          prob
------------------+----------------------------------------------
             b1=0 |    23.4854         2      7338     6.807e-11
          b1=b2=0 |    18.1613         4      7336     7.425e-15
       b1=b2=b3=0 |    19.9988         6      7334     2.574e-23
    b1=b2=b3=b4=0 |    15.4907         8      7332     8.185e-23
-----------------------------------------------------------------

Escribano-Jorda linearity test (based on 4th Taylor expansion):

-----------------------------------------------------------------
               Ho |          F       df1       df2          prob
------------------+----------------------------------------------
     b1=b3=0(HoL) |    16.5654         4      7332     1.605e-13
     b2=b4=0(HoE) |    16.1777         4      7332     3.383e-13
-----------------------------------------------------------------
Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:

-----------------------------------------------------------------
```

Ho	F	df1	df2	prob
b1=0|b2=b3=0	23.4854	2	7338	6.807e-11
b2=0|b3=0	12.7619	2	7336	2.932e-06
b3=0	23.4515	2	7334	7.040e-11

面板平滑转换

```
. estat reslinear
```

Linearity (homegeneity) test for all nonlinear parts:

Ho	F	df1	df2	prob
b1=0	0.0085	1	7338	.9265
b1=b2=0	0.0047	2	7337	.9953
b1=b2=b3=0	0.0798	3	7336	.971
b1=b2=b3=b4=0	0.0599	4	7335	.9934

Escribano-Jorda linearity test (based on 4th Taylor expansion):

Ho	F	df1	df2	prob
b1=b3=0(HoL)	0.0605	2	7335	.9413
b2=b4=0(HoE)	0.1070	2	7335	.8985

Note: HoL against LSTR, HoE against ESTR

Terasvirta sequential test:

Ho	F	df1	df2	prob
b1=0|b2=b3=0	0.0085	1	7338	.9265
b2=0|b3=0	0.0008	1	7337	.977
b3=0	0.2302	1	7336	.6314

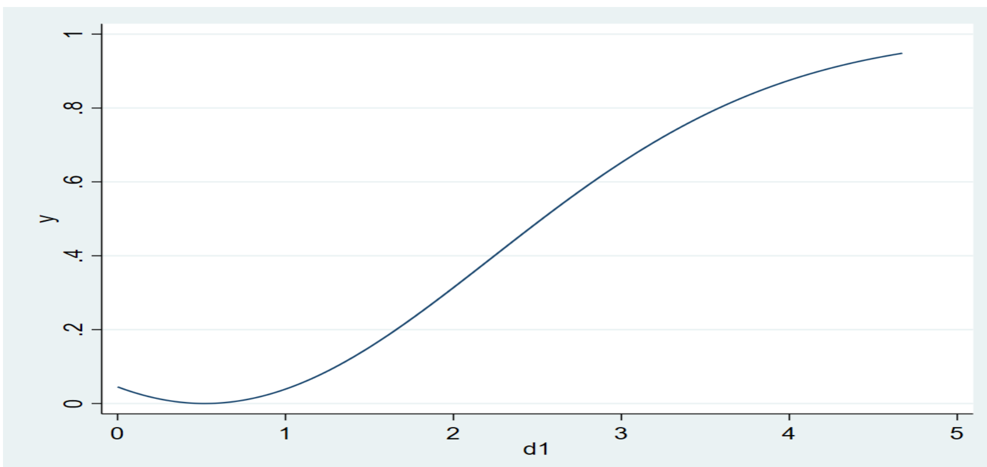
面板平滑转换

```
. estat stcoef

Transformed coefficient confidence interval (level=95):
```

	Coef	se	z	P>|z|	CILower	CIUpper
d1						
gamma	0.1716	0.0801	2.14	0.0322	0.0146	0.3286

```
. estat stplot
```



smooth transition plot

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