Nonstationary Panel Time Series Using NPT 1.2 - A User Guide

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Abstract

This is a user's guide for nonstationary panel time series package 1.2 (NPT 1.2) written in GUASS.

1 Introduction

This is a user's guide for nonstationary panel time series package 1.2 (NPT 1.2) [1] written in GUASS. One of the most exciting econometric developments of the last few years have been the nonstationary panel time series models. With the growing use of cross-country data over time to study purchasing power parity, growth convergence, and international R&D spillovers, the focus of panel data econometrics has shifted towards studying the asymptotics of macro panels with large N (number of countries) and large T (length of the time series) rather than the usual asymptotics of micro panels with large N and small T. Adding the cross-section dimension to the time-series dimension offers an advantage in the testing for non-stationarity and cointegration. The hope of the econometrics of non-stationary panel data is to combine the best of both worlds: the method of dealing with non-stationary data from the time series and the increased data and power from the cross-section. The addition of the cross-section dimension, under certain assumptions, can act as repeated draws from the same distribution. Thus as the time and cross-section dimensions increase, panel test statistics and estimators can be derived which converge in distribution to normally distributed

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[1] NTP is designed for our own research and teaching, as well as a service to the econometrics community. NPT 1.2 is completely free: it may be downloaded and distributed freely. If you use NPT 1.2 for research, proper reference to it in your paper as follows:

Chiang, M-H., and Kao., C. (2000), "Nonstationary Panel Time Series Using NPT 1.2 - A User Guide," Center for Policy Research, Syracuse University.

random variables. Baltagi and Kao (2000), Banerjee (1999) and Phillips and Moon (1999) surveyed some of the developments in nonstationary panel models that have occurred since the middle of the 1990s.

Due to the popularity and flexibility of the GAUSS[2], the NPT was written in GAUSS. In addition, the NPT needs some procedures in the COINT[3] library to do kernel estimation and other functions. In the next version, the NPT should be executable without dependence on other package.

This guide introduces features and usage of the NPT 1.2. A particular attractive feature of NPT is that it includes panel unit root tests, panel cointegration tests, and panel cointegration estimation. The NPT 1.2 introduces three new panel unit root procedures by Im, Pesaran, and Shin (1997), Breitung (2000), and Hadri (2000). In addition, most errors existing in procedures of the previous version and found by users have been modified.

The structure of this guide is as follows: Section 2 describes how NPT can be installed while Section 3 describes how data should be organized and the important global variables. Section 4 contains the econometrics methods employed by NPT. Section 5 presents an example. Section 6 concludes. The sample program, sample1.prg, is in the Appendix A. Appendix B contains the NPT procedures.

2 Installation

Before installation of the NPT 1.2, GAUSS version 3.2 (or higher) is required, since the NPT 1.2 was developed using a GAUSS version which allows the length of a symbol name up to 32 characters. The downloadable file is `npt1.2.zip`, which contains three directories: SRC, LIB, and EXAMPLES; one executable file: chkargs.exe, and a DOS batch file: ginstall.bat. You should unzip `npt1.2.zip` before installation. Then, the NPT 1.1 can be installed manually or by running the DOS batch file, ginstall.bat.

Manual installation: (Assuming GAUSS is in c:\GAUSS and the platform is Windows[4] 95, 98, 2000 or NT)

1. Copy all files in SRC*.* to C:\GAUSS\SRC directory.
2. Copy all files in LIB*.* to C:\GAUSS\LIB directory.
3. Copy all files in EXAMPLES*.* to C:\GAUSS\EXAMPLES

[2] GAUSS™ is a trademark of Aptech Systems, Inc.

[3] The COINT 2.0 in GAUSS is developed by Ouliaris and Phillips (1994). Those who are interested in the COINT 2.0 should contact PREDICTA SOFTWARE Inc.

[4] Windows™ is a trademark of Microsoft Company.

Run ginstall.bat: (Assuming GAUSS is in c:\GAUSS and the platform is Windows 95, 98, 2000 or NT)

1. In the DOS prompt, type: GINSTALL [source directory (or drive)] [destination drive]. The source directory (or drive) is where the unzipped `npt1.2.zip` files are stored while the destination drive indicates the drive in which GAUSS is installed. For example, the current prompt is in C: drive. In the mean time, your source files are in C:\UNZIPPED and the destination drive is C:. Therefore, the proper command should be written as follows:

   C:\> `C:\UNZIPPED\GINSTALL C:\UNZIPPED C:`

3 DATA

The requirement for running NPT is a suitable GAUSS data set. This is normally created from an ASCII data file. Since variables are panel types, the arrangement of input variables in data files becomes an important issue. In the NPT, we require that the input variables, including dependent and independent variables, be arranged as $T \times (N \times k)$ where T represents time periods, N is the number of cross-sectional units, and k indicates the number of variables. For the current version, there should be only one dependent variable. As for the explanatory variables, there is no such restriction. For example, in Kao et al. (1999), the data comprised of one dependent variable, $\log TFP$ (total factor productivity) and two explanatory variables, domestic R&D capital stocks, $\log S^d$, and foreign R&D capital stocks, $\log S^f$. Moreover, we have annual data for 22 countries from 1971 to 1990. Therefore, these three input variables should be arranged as follows in your data files:

The dependent variable, $\log TFP$:

Year	U.S.	Japan	...	Switz.
1971	-0.0223	-0.0964	...	-0.0119
1972	-0.0155	-0.0846	...	-0.0061
.	.	.	...	.
.	.	.	...	.
.	.	.	...	.
1990	0.0095	0.0737	...	0.0249

The independent variables, $\log S^d$ and $\log S^f$:

	$\log S^d$				$\log S^f$			
Year	U.S.	Japan	...	Switz.	U.S.	Japan	...	Switz.
1971	-0.1993	-0.4609	...	-0.0575	-0.3737	-0.1656	...	-0.1898
1972	-0.1838	-0.4157	...	-0.0506	-0.3401	-0.1891	...	-0.2083
.	.	.	...	.	.	.	...	.
.	.	.	...	.	.	.	...	.
.	.	.	...	.	.	.	...	.
1990	0.0924	0.1649	...	0.0465	0.1596	0.0592	...	0.0899

The years and country names should not be included in the data files unless they are explanatory variables in the fitted equations. When the preparation of data files is done, you are ready to call procedures in the NPT to process your work.

There are 5 major global variables, `_panel_kernel_lag_hom`, `_panel_kernel_lag_het`, `_pc_kao_t_lag`, `_pcs_adf_lag`, and `_pcs_kernel_lag`, which control the number of lagged terms. The default values and the corresponding procedures are listed as follows:

Global Variable	Default Value	Procedure
`_panel_kernel_lag_hom`	5	**ols_rd**, **fm_rd**, **dols_rd**
`_panel_kernel_lag_het`	5	**ols_hrd**, **fm_hrd**, **dols_hrd**
`_pc_kao_t_lag`	2	**kao_t**
`_pcs_adf_lag`	2	**pcs_4**, **pcs_7**
`_pcs_kernel_lag`	5	**pcs_1**, **pcs_2**, **pcs_3**, **pcs_4**, **pcs_5**, **pcs_6**

`_panel_kernel_lag_hom`, `_panel_kernel_lag_het`, and `_pcs_kernel_lag` determine the number of lagged windows in kernel estimation. `_pc_kao_t_lag` and `_pcs_adf_lag` control the lagged terms in the ADF type equations of **kao_t**, **pcs_4**, and **pcs_7**.

4 Nonstationary Panel Time Series

This section provides brief descriptions of the procedures in the NPT 1.1 package to implement nonstationary panel time series described in Baltagi and Kao (2000).

4.1 Panel Unit Root Tests

punit.src contains procedures for the panel unit root tests. In particular **punit.src** contains routines for

1. Levin and Lin (1992, 1993).
2. Im, Pesaran, and Shin (1995, 1997).
3. Harris and Tzavalis (1999).
4. Breitung (2000)
5. Hadri (2000)

The null hypothesis for these unit root tests is that the data series is nonstationary. The procedures from **ll_1** to **ll_7** are for Levin and Lin (1992) and the procedures from **ll_8** to **ll_10** are for Levin and Lin (1993). The associated models with procedures are listed as follows:

Procedure	Levin and Lin (1992)
ll_1	Model 1: $y_{it} = \rho y_{it-1} + \epsilon_{it}$
ll_2	Model 2: $y_{it} = \rho y_{it-1} + \delta_0 + \varepsilon_{it}$
ll_3	Model 3: $y_{it} = \rho y_{it-1} + \delta_0 + \delta_1 t + \varepsilon_{it}$
ll_4	Model 4: $y_{it} = \rho y_{it-1} + v_t + \varepsilon_{it}$
ll_5	Model 5: $y_{it} = \rho y_{it-1} + \eta_i + \varepsilon_{it}$
ll_6	Model 6: $y_{it} = \rho y_{it-1} + \eta_{i0} + \eta_{i1} t + \varepsilon_{it}$
ll_7	Model 7: $y_{it} = \rho y_{it-1} + \epsilon_{it}$, with serial correlation
	Levin and Lin (1993)
ll_8	Model 1: $\Delta y_{it} = \delta_i y_{it-1} + \zeta_{it}$
ll_9	Model 2: $\Delta y_{it} = \alpha_{0i} + \delta_i y_{it-1} + \zeta_{it}$
ll_10	Model 3: $\Delta y_{it} = \alpha_{0i} + \alpha_{1i} t + \delta_i y_{it-1} + \zeta_{it}$

The major difference between Levin and Lin (1992) and Levin and Lin (1993) is that Levin and Lin (1993) allow heterogeneous coefficients in y_{it-1} and persistence and heterogeneity in error terms of considered models.

The **ips_95** procedure preforms the average of ADF t test proposed by Im, Pesaran, and Shin (1995). IPS allows for a heterogeneous coefficient of y_{it-1} and considers the case that error terms are serially correlated with different serial correlation coefficients across cross-sectional units. On the other hand, the **ips_97** and **ips_LM** are for ADF t and LM-bar tests suggested in Im, Pesaran, and Shin (1997), respectively.

The procedures of **ht_1**, **ht_2**, and **ht_3** carry out the panel unit root tests suggested by Harris and Tzavalis (1999) under the fixed time dimension. The corresponding models are as follows:

Procedure	Harris and Tzavalis (1999)
ht_1	Model 1a: $y_{it} = \varphi y_{it-1} + \upsilon_{it}$
ht_2	Model 1b: $y_{it} = \alpha_i + \varphi y_{it-1} + \upsilon_{it}$
ht_3	Model 1c: $y_{it} = \alpha_i + \beta_i t + \varphi y_{it-1} + \upsilon_{it}$

The **ub** procedure executes the panel unit root test proposed by Breitung (2000) who found the losses of power due to bias correction terms in Levin and Lin (1993) and detrending bias in Im, Pesaran and Shin (1997). Therefore, he suggested a new test without bias corrections.

The **eta_test** procedure performs the panel unit root test proposed by Hadri (2000). The Hadri's test extends the tests of Hadri (1998) for the *null of stationarity* against the alternative of unit roots in panel data with independent errors over t to the case of heterogeneous and serially correlated errors over t. The **eta_test** procedure produces two test statistics, one from the model without deterministic trend and the other from the model with deterministic trend.

4.2 Panel Cointegration Tests

pcoin_t1.src and **pcoin_t2.src** provide procedures for the panel cointegration tests:

1. Kao (1999).
2. McKoskey and Kao (1998).
3. Pedroni (1995, 1999).

The null hypothesis for the panel cointegration tests, Kao (1999) and Pedroni (1995, 1999) is that the estimated equation is not cointegrated. The LM test in McKoskey and Kao (1998) tests whether the null of the estimated equation is cointegrated. In particular, **pcoin_t1.src** and **pcoin_t2.src** contain:

Procedure	Kao (1999)
kao_t	$DF_\rho = \frac{\sqrt{N}T(\widehat{\rho}-1)+3\sqrt{3}}{\sqrt{10.2}}$ $DF_t = \sqrt{1.25}t_\rho + \sqrt{1.875}N$ $DF_\rho^* = \frac{\sqrt{N}T(\widehat{\rho}-1)+\frac{3\sqrt{N}\widehat{\sigma}_v^2}{\widehat{\sigma}_{0v}^2}}{\sqrt{3+\frac{7.2\widehat{\sigma}_v^4}{\widehat{\sigma}_{0v}^4}}}$ $DF_t^* = \frac{t_\rho+\frac{\sqrt{6N}\widehat{\sigma}_v}{2\widehat{\sigma}_{0v}}}{\sqrt{\frac{\widehat{\sigma}_{0v}^2}{2\widehat{\sigma}_v^2}+\frac{3\widehat{\sigma}_v^2}{10\widehat{\sigma}_{0v}^2}}}$ $ADF = \frac{t_{ADF}+\frac{\sqrt{6N}\widehat{\sigma}_v}{2\widehat{\sigma}_{0v}}}{\sqrt{\frac{\widehat{\sigma}_{0v}^2}{2\widehat{\sigma}_v^2}+\frac{3\widehat{\sigma}_v^2}{10\widehat{\sigma}_{0v}^2}}}$
	McKoskey and Kao (1998)
mkao_lm	$LM^+ = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{\frac{1}{T^2}\sum_{t=1}^{T}S_{it}^{+2}}{\widehat{\varpi}_{1.2}^2}\right)$
	Pedroni (1995)
pedroni_t	$PC_1 = T\sqrt{N}(\widehat{\rho}_{NT}-1)/\sqrt{2}$ $PC_2 = \sqrt{NT(T-1)}(\widehat{\rho}_{NT}-1)/\sqrt{2}$

Moreover, the **pcoin_t2.src** contains the panel cointegration test procedures of Pedroni (1999). The corresponding models are shown as follows:

Procedure	Pedroni (1999)
pcs_1	Panel v-Statistic
pcs_2	Panel $\widetilde{n}$-Statistic
pcs_3	Panel t-Statistic (nonparametric)
pcs_4	Panel t-Statistic (parametric)
pcs_5	Group $\widetilde{n}$-Statistic
pcs_6	Group t-Statistic (nonparametric)
pcs_7	Group t-Statistic (parametric)

The panel cointegration tests proposed by Pedroni (1999) permit heterogeneity in cointegrating vectors and the dynamics of the underlying error process across the cross-sectional units. All test statistics are implemented as residual tests. The first 4 test statistics, **pcs_1**, **pcs_2**, **pcs_3**, and **pcs_4**, are based on pooling along within-dimension. The null hypothesis is $H_0 : \widetilde{a}_i = 1$ (i.e. no cointegration) for all cross-sectional units versus the alternative hypothesis $H_1 : \widetilde{a}_i = \widetilde{a} < 1$ for all cross-sectional units so that a common slope value of lag one residuals is presumed in residual test equations. On the other hand, the last 3 test statistics, **pcs_5**, **pcs_6**, and **pcs_7**, are based on pooling along between-dimension. By contrast, the alternative hypothesis is $H_1 : \widetilde{a}_i < 1$ for all i so that it permits distinct slope values for lag one residuals in residual test equations.

4.3 Panel Cointegration Estimation and Inference

panel.src and **panel_h.src** include procedures performing estimation and inferences in panel cointegration models. The procedures in **panel.src** carry out estimation under the assumption of homogeneous long-run covariance across cross-sectional units while procedures in **panel_h.src** relax the homogeneous assumption to allow for heterogeneous long-run covariance. The associated models with procedures are presented as follows:

Procedure	Homogeneous Panels
ols_rd	$\widehat{\beta}_{OLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)(x_{it}-\overline{x}_i)'\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)(y_{it}-\overline{y}_i)\right]$
fm_rd	$\widehat{\beta}_{FM} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)(x_{it}-\overline{x}_i)'\right]^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it}-\overline{x}_i)\widehat{y}_{it}^{+} - T\widehat{\Delta}_{\varepsilon u}^{+}\right)\right]$
dols_rd	$y_{it} = \alpha_i + x_{it}'\beta + \sum_{j=-q}^{q} c_{ij}\Delta x_{it+j} + \dot{v}_{it}$
	Heterogeneous Panels
fm_hrd	$\widehat{\beta}_{FM} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}^{*}-\overline{x}_i^{*})(x_{it}^{*}-\overline{x}_i^{*})'\right]^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it}^{*}-\overline{x}_i^{*})\widehat{y}_{it}^{*} - T\widehat{\Delta}_{i\varepsilon u}^{*}\right)\right]$
dols_hrd	$y_{it}^{*} = \alpha_i + x_{it}^{*'}\beta + \sum_{j=-q}^{q} c_{ij}\Delta x_{it+j}^{*} + \dot{v}_{it}^{*}$

NPT only reports estimated slope coefficients.

5 An Example

In this section, we demonstrate how to operate some of the procedures in the NPT using the data sets in Kao et al. (1999). The example data set, tfp.dat, r&d.dat, fr&d.dat, and impor.dat, are supplied with NPT.

We present the idea regarding how to implement the NPT using Kao et al.,

$$\log TFP_{it} = \alpha_{it}^{0} + \alpha^{d}\log S_{it}^{d} + \alpha^{f}\log S_{it}^{f}, \tag{1}$$

where i is the country index, t is the time index, S_{it}^{d} represents the domestic R&D capital stock, and S_{it}^{f}

represents the foreign R&D capital stocks defined as the import-share-weighted average of the domestic R&D capital stocks of trade partners.

Listed in the appendix A is the sample program, sample1.prg, containing GAUSS instruction codes used to obtain results of the equation 1. The following two lines should be present in the beginning of your program:

```
library pcoint coint pgraph; @ include NPT and COINT package @

_ker_fun=&fejer; @ set up kernel function @
```

The `LIBRARY` statement includes both NPT and COINT packages and the global variable, `_ker_fun`, is a COINT variable that indicates the kernel function used in kernel estimation.

For the panel unit root tests, we use the model 1a of Harris and Tzavalis (1999). The GAUSS program is:

```
/* Panel Unit Root Tests */

@ Harris and Tzavalis (1999) mode l1a @

''-Panel Unit Root Tests of TFP-'';

ht_1(tfp);

''-Panel Unit Root Tests of domestic R&D capital stocks-'';

ht_1(rd);

''-Panel Unit Root Tests of foreign R&D capital stocks-'';

ht_1(frd);
```

and the results are:

```
-Panel Unit Root Tests of TFP-

----The Harris and Tzavalis(1999) Model 1a Unit Root Test----

----Without Intercept and Time Trend-----

nomalized ht_1_stat -0.00000:critical Probability=0.50000

-Panel Unit Root Tests of domestic R&D capital stocks-

----The Harris and Tzavalis(1999) Model 1a Unit Root Test----

----Without Intercept and Time Trend-----
```

```
nomalized ht_1_stat 0.00000:critical Probability=0.50000

-Panel Unit Root Tests of TFP-

----The Harris and Tzavalis(1999) Model 1a Unit Root Test----

----Without Intercept and Time Trend-----

nomalized ht_1_stat 0.00000:critical Probability=0.50000
```

The results above show that test statistics of all three variables, $\log TFP$, $\log S^d$ and $\log S^f$, are not significant. This means that the null hypothesis of nonstationarity is not rejected for these variables.

The residuals obtained from the OLS are used to test whether the estimated equation is cointegrated or not. The program below runs the panel cointegration tests using Kao (1999) and Pedroni (1995).

```
/*Kao(1999) and Pedroni(1995) Panel Cointegration Tests*/

kao_t(ols_res,y,x,1);@Kao(1999) panel cointegration tests@

pedroni_t(ols_res,y,x);@Pedroni(1995) panel cointegration tests@
```

and the results are:

```
= ======== The Panel Cointegration Test(Homogeneous)=========

  *******Kao(1999) Panel Cointegration Test********

  *****************************************************

          DF_Rho Test  =  -0.1169 Prob:0.4535

        DF_t_Rho Test  =  -0.4204 Prob:0.3371

     DF_Rho_Star Test  =  -5.4501 Prob:0.0000

   DF_t_Rho_Star Test  =  -2.2489 Prob:0.0123

= ======== The Panel Cointegration Test(Homogeneous)=========

  *******Kao(1999)ADFPanelCointegrationTest********

  *********************************************************

    lags  ADF test stat  prob:   AIC      SC

    1     -2.3661        0.0090  -9.2410  -9.2209
```

```
= ======== The Panel Cointegration Test(Homogeneous)=========

  *******Pedroni(1995) Panel Cointegration Test********

  ****************************************************

  rho_NT_minus_1 = -0.1864

       t_rho_NT = -249.3833 Prob:0.0000

        TN1_rho = -12.3667 Prob:0.0000

        TN2_rho = -12.0535 Prob:0.0000
```

All test statistics are significant, which means that the null hypothesis of no cointegration is rejected. The GAUSS program below runs the panel coefficient estimations using Kao and Chiang (2000):

```
/*Kao and Chiang (2000) Panel Coefficient Estimation*/

 {ols_res,b,c,d,e} = ols_rd(y,x);@OLS estimation@

  {fm_res,b,c,d,e} = fm_rd(y,x);@Fully-Modified estimation@

{dols_res,b,c,d,e} = dols_rd(y,x,1,2);@Dynamic OLS estimation@
```

and the results are:

```
              The Conventional T test and OLS estimator

        The beta1 is : 0.0972

     The t-ratio1 is : 10.9801 probabiltiy(t)=0.0000 probability(N)=0.0000

        The beta2 is : 0.0921

     The t-ratio2 is : 6.0048 probabiltiy(t)=0.0000 probability(N)=0.0000

         R square is : 0.5584

Adjusted R square is : 0.5564

                   THE ADJUSTED T RATIO AND VALUES

    The adjusted beta1 is : 0.0836

 The adjusted t-ratio1 is : 4.5711 probabiltiy(t)=0.0000 probability(N)=0.0000
```

```
    The adjusted beta2 is  :  0.1254

The adjusted t-ratio2 is  :  4.0709 probabiltiy(t)=0.0000 probability(N)=0.0000

     The bias of beta1 is  :  0.2707

     The bias of beta2 is  :  -0.6652

              R square is  :  0.5584

     Adjusted R square is  :  0.5517

                     The Fully-Modified Estimators


       The FM_beta1 is  :  0.0842

       The t-ratio1 is  :  4.3715 probabiltiy(t)=0.0000 probability(N)=0.0000

       The FM_beta2 is  :  0.1033

       The t-ratio2 is  :  3.1842 probabiltiy(t)=0.0008 probability(N)=0.0007

           R square is  :  0.5560

  Adjusted R square is  :  0.5540

                      The Dynamic OLS Estimators


     The DOLS_beta1 is  :  0.1069

       The t-ratio1 is  :  4.6721 probabiltiy(t)=0.0000 probability(N)=0.0000

     The DOLS_beta2 is  :  0.0558

       The t-ratio2 is  :  1.4503 probabiltiy(t)=0.0740 probability(N)=0.0735

           R square is  :  0.5114

  Adjusted R square is  :  0.3054
```

6 Concluding Remarks

The NPT 1.2 offers researchers a useful tool to implement the econometrics of nonstationary panel time series. The NPT contains GAUSS procedures performing (1) panel unit root tests, (2) panel cointegration tests, and (3) panel cointegration estimation and inference.

Appendix

A The Sample Program

```
/* sample1.prg
**
** The Program is to include the data sets used in the paper listed below
** and provide an example to demonstrate how to use Nonstationary Panel
** Time Series (NPT) 1.2 procedures.
**
** ''International R&D Spillovers Revisited:  An Applicati on of Estimation
** and Inference in Panel Cointegration''
**
** Author:  Chihwa Kao, Min-Hsien Chiang, Bangtian Chen
**
** Program Developers:  Chihwa Kao and Min-Hsien Chiang
**
** Please Address any comments to Professor Kao at
**
** Center for Policy Research
** Eggers 426
** Syracuse University
** Syracuse, NY 13244
** E-mail:cdkao@maxwell.syr.edu
****************************************************************** */
library pcoint coint pgraph; @ include NPT and COINT package @
_ker_fun=&fejer; @ set up kernel function @
/* Change the data source directory if data are not in c:\examples */
loadm f[20,23]=c:\examples\tfp.dat; @total facor productivity@
loadm rd[20,23]=c:\examples\r&d.dat; @domestic r&d capital stock@
loadm frd[20,23]=c:\examples\fr&d.dat; @foreign r&d capital stock@
loadm m[20,23]=c:\examples\impor.dat; @imports as a share of gnp@
@ ========= some adjustments on data corresponding to Coe and Helpman (1995) ========= @
tfp =f[.,1:9]~f[.,20]~f[.,10]~f[.,12:17]~f[.,19]~f[.,18]
```

```
 ~f[.,21:23]~f[.,11];
impt=m[.,1:9]~m[.,20]~m[.,10]~m[.,12:17]~m[.,19]~m[.,18]
 ~m[.,21:23]~m[.,11];
impt1={1970 0.0552 0.0958 0.1914 0.1528 0.1560 0.2145 0.2001 0.1475 0.3081
 0.4387 0.3090 0.2678 0.1700 0.4212 0.5002 0.4513 0.2548 0.4535 0.3359
 0.1466 0.2282 0.3907};
impt_m=impt1|impt[1:19,.];
@ ============================================================== @
 tfp=log(tfp[.,2:23]);
 rd =log(rd[.,2:23]);
 frd=log(frd[.,2:23]);
 y=tfp;x=rd~frd; @ Data Set for Equation 1 @
/* Panel Unit Root Tests */
@ Harris and Tzavalis (1999) mode l1a @
''-Panel Unit Root Tests of TFP-'';
ht_1(tfp);
''-Panel Unit Root Tests of domestic R&D capital stocks-'';
ht_1(rd);
''-Panel Unit Root Tests of foreign R&D capital stocks-'';
ht_1(frd);
/*Kao and Chiang (2000) Panel Coefficient Estimation*/
 {ols_res,b,c,d,e}= ols_rd(y,x); @ OLS estimation @
 {fm_res,b,c,d,e}=fm_rd(y,x); @ Fully-Modified estimation @
 {dols_res,b,c,d,e}=dols_rd(y,x,1,2); @ Dynamic OLS estimation @

/*Kao(1999) and Pedroni(1995) Panel Cointegration Tests*/
kao_t(ols_res,y,x,1);@Kao(1999) panel cointegration tests@
pedroni_t(ols_res,y,x);@Pedroni(1995) panel cointegration tests@
end;
```

B NPT 1.2 Procedures

PUNIT.SRC

Panel Unit Root Procedures

ETA_**test(y,num_kernel)**

PURPOSE:

Compute the unit root test of Hadri (2000) for the null hypothesis that y is stationary.

FORMAT:

eta_test(y,num_kernel);

INPUT:

y	panel series variable $T \times N$.
num_kernel	the number of autocovariance terms in the kernel

ps. You have to choose a kernel function by setting a global of **_ker_fun** in COINT 2.0.

OUTPUTS:

Print computational outcomes with no output variables.

REFERENCE:

Hadri, K. (2000), "Testing for stationarity in Heterogenous Panel Data," *Econometrics Journal* 3:2, 148-161.

HT_1(y)

PURPOSE:

Compute the unit root test of Harris and Tzavalis (1999) Model 1a with time dimension fixed for the null hypothesis that y has a unit root.

FORMAT:

ht_1(y);

INPUT:

y panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ht_2, **ht_3**

REFERENCE:

Harris, Richard D.F. and Tzavalis, E. (1999), "Inference for Unit Roots in Dynamic Panels Where the Time Dimension is Fixed," Journal of Econometrics, 91, 201-226.

HT_2(y)

PURPOSE:

Compute the unit root test of Harris and Tzavalis (1999) Model 1b with time dimension fixed for the null hypothesis that y has a unit root.

FORMAT:

ht_2(y);

INPUTS:

y   panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ht_1, **ht_3**

REFERENCE:

Harris, Richard D.F. and Tzavalis, E. (1999), "Inference for Unit Roots in Dynamic Panels Where the Time Dimension is Fixed," Journal of Econometrics, 91, 201-226.

HT_3(y)

PURPOSE:

Compute the unit root test of Harris and Tzavalis (1999) Model 1c with time dimension fixed for the null hypothesis that y has a unit root.

FORMAT:

ht_3(y);

INPUT:

y   panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ht_1, **ht_2**

REFERENCE:

Harris, Richard D.F. and Tzavalis, E. (1999), "Inference for Unit Roots in Dynamic Panels Where the Time Dimension is Fixed," Journal of Econometrics, 91, 201-226.

IPS_95**(y,num_lag)**

PURPOSE:

Test the null hypothesis that y has a unit root using Im, Pesaran, and Shin (1995) ADF type test statistic.

FORMAT:

ips_95(y,num_lag);

INPUTS:

y	panel series variable $T \times N$.
num_lag	a $N \times 1$ vector of the number of lagged first difference terms of residuals in theADFequation

OUTPUTS:

Print computational outcomes with no output variables.

REFERENCE:

Im, K. Pesaran, H., and Shin, Y. (1995), "Testing for Unit Roots in Heterogeneous Panels," Manuscript, University of Cambridge.

IPS_97**(y,num_lag)**

PURPOSE:

Test the null hypothesis that y has a unit root using Im, Pesaran, and Shin (1997) ADF type test statistic.

FORMAT:

ips_97(y,num_lag);

INPUTS:

y	panel series variable $T \times N$.
num_lag	a $N \times 1$ vector of the number of lagged first difference terms of residuals in theADFequation

OUTPUTS:

Print computational outcomes with no output variables.

REFERENCE:

Im, K. Pesaran, H., and Shin, Y. (1997), "Testing for Unit Roots in Heterogeneous Panels," Manuscript, University of Cambridge.

IPS_LM(**y,num_lag**)

PURPOSE:

Test the null hypothesis that y has a unit root using Im, Pesaran, and Shin (1997) LM-bar type test statistics.

FORMAT:

ips_LM(y,num_lag);

INPUTS:

y	panel series variable $T \times N$.
num_lag	a $N \times 1$ vector of the number of lagged first difference terms of residuals in theADFequation

OUTPUTS:

Print computational outcomes with no output variables.

REFERENCE:

Im, K. Pesaran, H., and Shin, Y. (1997), "Testing for Unit Roots in Heterogeneous Panels," Manuscript, University of Cambridge.

LL_1(y)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 1 for the null hypothesis that y has a unit root.

FORMAT:

ll_1(y);

INPUT:

y   panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_2, **ll_3**, **ll_4**, **ll_5**, **ll_6**, **ll_7**, **ll_8, ll_9, ll_10**

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_2(y)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 2 for the null hypothesis that y has a unit root.

FORMAT:

ll_2(y);

INPUT:

y panel series variable with $T \times N$.

OUTPUTS:

Print computation outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_3, ll_4, ll_5, ll_6, ll_7, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_3(y)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 3 for the null hypothesis that y has a unit root.

FORMAT:

ll_3(y);

INPUT:

y panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_4, ll_5, ll_6, ll_7, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_4(y)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 4 for the null hypothesis that y has a unit root.

FORMAT:

ll_4(y);

INPUT:

y   panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_5, ll_6, ll_7, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_5(y)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 5 for the null hypothesis that y has a unit root.

FORMAT:

ll_5(y);

INPUT:

y   panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_4, ll_6, ll_7, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_**6(y)**

PURPOSE:

Computes the unit root test of Levin and Lin (1992) Model 6 for the null hypothesis that y has a unit root.

FORMAT:

ll_6(y);

INPUT:

y panel series variable with $T \times N$.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_4, ll_5, ll_7, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_7(y,num_lag)

PURPOSE:

Computes the unit root test of Levin and Lin (1992) model with serial correlation across time for the null hypothesis that y has a unit root.

FORMAT:

ll_7(y,num_lag);

INPUTS:

y	panel series variable $T \times N$.
num_lag	number of lags for serial correlation across time periods.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_3, ll_4, ll_5, ll_6, ll_8, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1992), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Working Paper, University of California, San Diego.

LL_8(y,p)

PURPOSE:

Computes the unit root test of Levin and Lin (1993) Model 1 for the null hypothesis that y has a unit root.

FORMAT:

ll_8(y,p);

INPUTS:

y	panel series variable $T \times N$.
p	=-1,the number of lags for each cross-sectional unit is 4. =a vector of $N \times 1$ specifies N numbers of lags for each cross-sectional unit.

OUTPUTS:

Print computation outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_4, ll_5, ll_6, ll_7, ll_9, ll_10

REFERENCE:

Levin, A and C-F Lin (1993), "Unit Root Tests in Panel Data: New Results," Working Paper, University of California, San Diego.

LL_9(y,p)

PURPOSE:

Computes the unit root test of Levin and Lin (1993) Model 2 for the null hypothesis that y has a unit root.

FORMAT:

ll_9(y,p);

INPUTS:

y	panel series variable $T \times N$.
p	=-1,the number of lags for each cross-sectional unit is 4. =a vector of $N \times 1$ specifies N numbers of lags for each cross-sectional unit.

OUTPUTS:

Print computational outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_4, ll_5, ll_6, ll_7, ll_8, ll_10

REFERENCE:

Levin, A and C-F. Lin (1993), "Unit Root Tests in Panel Data: New Results," Working Paper, University of California, San Diego.

LL_10(y,p)

PURPOSE:

Computes the unit root test of Levin and Lin (1993) Model 3 for the null hypothesis that y has a unit root.

FORMAT:

ll_10(y,p);

INPUTS:

y	panel series variable $T \times N$.
p	=-1,the number of lags for each cross-sectional unit is 4. =a vector of $N \times 1$ specifies N numbers of lags for each cross-sectional unit.

OUTPUTS:

Print computation outcomes with no output variables.

RELATED PROCEDURES:

ll_1, ll_2, ll_3, ll_4, ll_5, ll_6, ll_7, ll_8, ll_9

REFERENCE:

Levin, A and C-F Lin (1993), "Unit Root Tests in Panel Data: New Results," Working Paper, University of California, San Diego.

UB(**y**)

PURPOSE:

Computes the unit root test of Breitung (2000) for the null hypothesis that y has a unit root.

FORMAT:

ub(y);

INPUTS:

y panel series variable with $T \times N$.

OUTPUTS:

Print computation outcomes with no output variables.

REFERENCE:

Breitung, J. (2000), "The Local Power of Some Unit Root Tests for Panel Data," *Advances in Econometrics* 15, 161-178.

PCOIN_T1.SRC

Panel Cointegration Test Procedures

KAO_T(u,**y,x,num_lag)**

PURPOSE:

Test the null hypothesis that the estimated system is not cointegrated using Kao (1999) panel cointegration tests.

FORMAT:

kao_t(u,y,x,num_lag);

INPUTS:

u	residuals from the estimated cointegration equation.
y	dependent variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables
num_lag	the number of lagged first difference terms of residuals in the ADF test.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

mkao_lm, pedroni_t

REFERENCE:

Kao, C. (1999), "Spurious Regression and Residual-Based Tests for Cointegration in Panel Data," Journal of Econometrics, 90, 1-44.

MKAO_LM(u,omega12,num_ind,N)

PURPOSE:

Compute the LM type panel cointegration test of McCoskey and Kao (1998).

FORMAT:

mkao_lm(u,omega,num_ind,N);

INPUTS:

u	residuals from the estimated cointegration equation.
omega12	the estimated long-run conditional variance.
num_ind	the number of distinct explanatory variables.
N	the number of cross-sectional units.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

kao_t, pedroni_t

REFERENCES:

McCoskey, S. and Kao, C. (1998), "A Residual-Based Test of the Null of Cointegration in Panel Data," Econometric Reviews, 17, 57-84.

PEDRONI_T**(u,y,x)**

PURPOSE:

Compute the Pedroni (1995) panel cointegration tests.

FORMAT:

pedroni_t(u,y,x);

INPUTS:

u residuals from the estimated cointegration equation.

y dependent variable with $T \times N$.

x independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

kao_t, mako_lm

REFERENCES:

Pedroni, P. (1995), "Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis," Manuscript, Department of Economics, Indiana University.

PCOIN_T2.SRC

Panel Cointegration Test Procedures

PCS_1(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 1 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_1(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
eq_spec	=0,	the estimated cointegration equation without intercepts and trends.
	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_2, pcs_3, pcs_4, pcs_5, pcs_6, pcs_7

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_2(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 2 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_2(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
	=0,	the estimated cointegration equation without intercepts and trends.
eq_spec	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_3, pcs_4, pcs_5, pcs_6, pcs_7

REFERENCES:

Pedroni, P. (1999) “Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors.” *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_3(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 1 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_3(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
	=0,	the estimated cointegration equation without intercepts and trends.
eq_spec	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_2, pcs_4, pcs_5, pcs_6, pcs_7

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_4(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 4 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_4(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
	=0,	the estimated cointegration equation without intercepts and trends.
eq_spec	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_2, pcs_3, pcs_5, pcs_6, pcs_7

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_5(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 1 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_5(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
	=0,	the estimated cointegration equation without intercepts and trends.
eq_spec	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_2, pcs_3, pcs_4, pcs_6, pcs_7

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_6(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 6 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_6(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
eq_spec	=0,	the estimated cointegration equation without intercepts and trends.
	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_2, pcs_3, pcs_4, pcs_5, pcs_7

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PCS_7(y,x,u,eq_spec)

PURPOSE:

Compute the panel cointegration test of Pedroni (1999) Model 7 for the null hypothesis that the estimated equation is not cointegrated

FORMAT:

pcs_7(y,x,u,eq_spec);

INPUTS:

y	dependent variable with $T \times N$.	
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.	
u	residuals from the estimated cointegration equation.	
eq_spec	=0,	the estimated cointegration equation without intercepts and trends.
	=1,	the estimated cointegration equation with intercepts but without trends.
	=2,	the estimated cointegration equation with both intercepts and trends.

OUTPUTS:

Print the computational outputs with no output variables.

RELATED PROCEDURES:

pcs_1, pcs_2, pcs_3, pcs_4, pcs_5, pcs_6

REFERENCES:

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*,61, 653-678.

PANEL.SRC

Panel Estimation Procedures

DOLS_RD(y,x,num_lead,num_lag)

PURPOSE:

Estimate the cointegration coefficients using Kao and Chiang (2000) dynamic ordinary least squares method (DOLS) under the homogeneous covariance structure.

FORMAT:

{resid1,resid2,omega12,N,k}=dols_rd(y,x,num_lead,num_lag);

INPUT:

y	panel series variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.
num_lead	the number of lead terms for the error structure in the fitted equation.
num_lag	the number of lagged terms for the error structure in the fitted equation.

OUTPUTS:

resid1	the residuals from the original equation.
resid2	the residuals from the dynamic ols equation.
omega12	the estimated long-run conditional variance.
N	the number of cross-sectional units.
k	the number of distinct explanatory variables.

RELATED PROCEDURES:

fm_rd, ols_rd

REFERENCE:

Kao, C. and M.H. Chiang (2000), “On the Estimation and Inference of a Cointegrated Regression in Panel Data,” *Advances in Econometrics* 15, forthcoming.

FM_RD(y,x)

PURPOSE:

Estimate the cointegration coefficients using Kao and Chiang (2000) fully modified method under the homogeneous covariance structure.

FORMAT:

{resid1,resid2,omega12,N,k}=fm_rd(y,x);

INPUT:

y	panel series variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.

OUTPUTS:

resid1	the residuals from the original equation.
resid2	the residuals from the fully-modified equation.
omega12	the estimated long-run conditional variance.
N	the number of cross-sectional units.
k	the number of distinct explanatory variables.

RELATED PROCEDURES:

dols_rd, ols_rd

REFERENCE:

Kao, C. and M.H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data," *Advances in Econometrics* 15, forthcoming.

OLS_RD(y,x)

PURPOSE:

Estimate the cointegration coefficients using Kao and Chiang (2000) adjusted ordinary least squares method under the homogeneous covariance structure.

FORMAT:

{resid1,resid2,omega12,N,k}=ols_rd(y,x);

INPUT:

y	panel series variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.

OUTPUTS:

resid1	the residuals from the original equation.
resid2	the residuals from the adjusted OLS equation.
omega12	the estimated long-run conditional variance.
N	the number of cross-sectional units.
k	the number of distinct explanatory variables.

RELATED PROCEDURES:

dols_rd, fm_rd

REFERENCE:

Kao, C. and M.H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data," *Advances in Econometrics* 15, forthcoming.

PANEL_H.SRC

Panel Estimation Procedures

DOLS_HRD(y,x,num_lead,num_lag)

PURPOSE:

Estimate the cointegration coefficients using Kao and Chiang (2000) dynamic ordinary least squares method under the heterogeneous covariance structure.

FORMAT:

{resid1,resid2,omega12,N,k}=dols_hrd(y,x,num_lead,num_lag);

INPUT:

y	panel series variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.

OUTPUTS:

resid1	the residuals from the original equation.
resid2	the residuals from the dynamic OLS equation.
omega12	the estimated long-run conditional variance.
N	the number of cross-sectional units.
k	the number of distinct explanatory variables.

RELATED PROCEDURES:

fm_hrd

REFERENCE:

Kao, C. and M.H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data," *Advances in Econometrics* 15, forthcoming.

FM_HRD(y,x)

PURPOSE:

Estimate the cointegration coefficients using Kao and Chiang (2000) fully modified method under the heterogeneous covariance structure.

FORMAT:

{resid1,resid2,omega12,N,k}=fm_hrd(y,x);

INPUT:

y	panel series variable with $T \times N$.
x	independent variable with $T \times (N \times k)$. k is the number of distinct explanatory variables.

OUTPUTS:

resid1	the residuals from the original equation.
resid2	the residuals from the fully modified equation.
omega12	the estimated long-run conditional variance.
N	the number of cross-sectional units.
k	the number of distinct explanatory variables.

RELATED PROCEDURES:

dols_hrd

REFERENCE:

Kao, C. and M.H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data," *Advances in Econometrics* 15, forthcoming.

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