cvpermute() — Obtain all permutations

Description

`cvpermute()` returns all permutations of the values of column vector V, one at a time. If $V = (1\backslash 2\backslash 3)$, there are six permutations and they are $(1\backslash 2\backslash 3)$, $(1\backslash 3\backslash 2)$, $(2\backslash 1\backslash 3)$, $(2\backslash 3\backslash 1)$, $(3\backslash 1\backslash 2)$, and $(3\backslash 2\backslash 1)$. If $V = (1\backslash 2\backslash 1)$, there are three permutations and they are $(1\backslash 1\backslash 2)$, $(1\backslash 2\backslash 1)$, and $(2\backslash 1\backslash 1)$.

Vector V is specified by calling `cvpermutesetup()`,

```
info = cvpermutesetup(V)
```

info holds information that is needed by `cvpermute()` and it is *info*, not V, that is passed to `cvpermute()`. To obtain the permutations, repeated calls are made to `cvpermute()` until it returns `J(0,1,.)`:

```
info = cvpermutesetup(V)
while ((p=cvpermute(info)) != J(0,1,.)) {
        ... p ...
}
```

Column vector p will contain a permutation of V.

`cvpermutesetup()` may be specified with one or two arguments:

```
info = cvpermutesetup(V)

info = cvpermutesetup(V, unique)
```

unique is usually not specified. If *unique* is specified, it should be 0 or 1. Not specifying *unique* is equivalent to specifying *unique* = 0. Specifying *unique* = 1 states that the elements of V are unique or, at least, are to be treated that way.

When the arguments of V are unique—for instance, $V = (1\backslash 2\backslash 3)$—specifying *unique* = 1 will make `cvpermute()` run faster. The same permutations will be returned, although usually in a different order.

When the arguments of V are not unique—for instance, $V = (1\backslash 2\backslash 1)$—specifying *unique* = 1 will make `cvpermute()` treat them as if they were unique. With *unique* = 0, there are three permutations of $(1\backslash 2\backslash 1)$. With *unique* = 1, there are six permutations, just as there are with $(1\backslash 2\backslash 3)$.

Syntax

info = `cvpermutesetup(`*real colvector V* [, *real scalar unique*]`)`

real colvector `cvpermute(`*info*`)`

where *info* should be declared *transmorphic*.

Remarks and examples

stata.com

▷ Example 1

You have the following data:

v1	v2
22	29
17	33
21	26
20	32
16	35

You wish to do an exact permutation test for the correlation between `v1` and `v2`.

That is, you wish to (1) calculate the correlation between `v1` and `v2`—call that value `r`—and then (2) calculate the correlation between `v1` and `v2` for all permutations of `v1`, and count how many times the result is more extreme than `r`.

For the first step,

```
: X = (22, 29 \
>      17, 33 \
>      21, 26 \
>      20, 32 \
>      16, 35)

:
: correlation(X)
[symmetric]
                  1               2
    +-------------------------------+
  1 |             1                 |
  2 |  -.8468554653               1 |
    +-------------------------------+
```

The correlation is −.846855. For the second step,

```
: V1 = X[,1]

: V2 = X[,2]

: num = den = 0

: info = cvpermutesetup(V1)

: while ((V1=cvpermute(info)) != J(0,1,.)) {
>          rho = correlation((V1,V2))[2,1]
>          if (rho<=-.846 | rho>=.846) num++
>          den++
> }
```

```
: (num, den, num/den)
                 1             2             3
    ┌─────────────────────────────────────────────┐
  1 │           13           120   .1083333333  │
    └─────────────────────────────────────────────┘
```

Of the 120 permutations, 13 (10.8%) were outside .846855 or −.846855.

◁

▷ Example 2

You now wish to do the same thing but using the Spearman rank-correlation coefficient. Mata has no function that will calculate that, but Stata has a command that does—see [R] **spearman**—so we will use the Stata command as our subroutine.

This time, we will assume that the data have been loaded into a Stata dataset:

```
. list

     ┌─────────────┐
     │ var1   var2 │
     ├─────────────┤
  1. │   22     29 │
  2. │   17     33 │
  3. │   21     26 │
  4. │   20     32 │
  5. │   16     35 │
     └─────────────┘
```

For the first step,

```
. spearman var1 var2

 Number of obs =       5
Spearman's rho =      -0.9000

Test of H0: var1 and var2 are independent
    Prob > |t| =       0.0374
```

For the second step,

```
. mata
────────────────────────────────────────────────── mata (type end to exit) ─────
: V1 = st_data(., "var1")

: info = cvpermutesetup(V1)

: num = den = 0

: while ((V1=cvpermute(info)) != J(0,1,.)) {
>         st_store(., "var1", V1)
>         stata("quietly spearman var1 var2")
>         rho = st_numscalar("r(rho)")
>         if (rho<=-.9 | rho>=.9) num++
>         den++
> }

: (num, den, num/den)
                 1             2             3
    ┌─────────────────────────────────────────────┐
  1 │            2           120   .0166666667  │
    └─────────────────────────────────────────────┘
```

Only two of the permutations resulted in a rank correlation of at least .9 in magnitude.

In the code above, we obtained the rank correlation from `r(rho)` which, we learned from [R] **spearman**, is where `spearman` stores it.

Also note how we replaced the contents of `var1` by using `st_store()`. Our code leaves the dataset changed and so could be improved.

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Conformability

`cvpermutesetup(`*V*`,` *unique*`)`:

V:	$n \times 1$	
unique:	1×1	(optional)
result:	$1 \times L$	

`cvpermute(`*info*`)`:

info:	$1 \times L$
result:	$n \times 1$ or 0×1

where

$$L = \begin{cases} 3 & \text{if } n = 0 \\ 4 & \text{if } n = 1 \\ (n+3)(n+2)/2 - 6 & \text{otherwise} \end{cases}$$

The value of L is not important except that the *info* vector returned by `cvpermutesetup()` and then passed to `cvpermute()` consumes memory. For instance,

n	L	Total memory ($8 \times L$)
5	22	176 bytes
10	72	576
50	1,372	10,560
100	5,247	41,976
1,000	502,497	4,019,976

Diagnostics

`cvpermute()` returns `J(0,1,.)` when there are no more permutations.

Also see

[M-4] **Statistical** — Statistical functions