**Background**

Panel unit root tests are divided into two generations by the consideration of cross section dependence, i.e., individual series in the panel are correlated. First generation tests ignore the problem and it leads to size distortion and low power; second generation tests focus on solving dependence.

There are weak and strong forms of cross section dependence. An important special case of the strong form, the long run dependence, occurs when dependence is driven only by common stochastic trend(s) across panel individuals.

Chang (2002) test based on nonlinear instrument variable technique works well with the weak form of dependence. To solve strong dependence Chang and Song (2005) develop the technique, which enables the test to handle any form of dependence including the long run dependence.

**The Problem**

- Poor finite sample performance – size distortion.
- 5% finite sample test sizes of CH and CS tests

<table>
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<th>N</th>
<th>T</th>
<th>CH</th>
<th>CS</th>
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<th>CS</th>
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</table>

(Note: CH: Chang (2002) test; CS: Chang and Song (2005) test.)

- Asymptotic property problem

Im and Pesaran (2003) critique: a much more restrictive condition (as following) is required for the asymptotic property of Chang (2002) to hold – essentially in the panel the number of individuals N must be very small relative to time series length T. The same problem is conjectured to Chang and Song (2005) due to its similar technique to Chang (2002).

\[ \frac{N \ln T}{T} \rightarrow 0 \quad \text{as } N, T \rightarrow \infty \]

**Numerical methods to solve the problem**

- Generate a large amount of data from panel unit root models with different forms of dependence through Monte Carlo simulations.
- Use the artificial data to estimate response surface regressions to analyze the finite sample bias of the two tests.
- Graph numerical distributions under various sample sizes to highlight finite sample properties of the statistics.
- Augment 1%, 5% and 10% critical values computed from Monte Carlo experiments by the randomness resulting from simulations.

**Numerical probability density functions (PDF)**

(Note: numerical PDF computed under general strong form of dependence is chosen as example.)

- Normal
- N10/T
- N50/T
- N100/T

**Results**

- Finite sample bias estimated from response surface regressions

(Note: 5% quantile bias computed under general strong form of dependence is chosen as example; N, number of individuals; T, time length)

**Figure 1**: different scales for N and T according to sample sizes chosen in Monte Carlo experiments

**Figure 2**: same scale for N and T

- As T is much larger than N and increases faster than N, finite sample bias seems to tend to zero;
- As N and T increase at the same pace, finite sample bias moves away from zero.
- Result is consistent with Im and Pesaran (2003) critique.

**Conclusion**

- Numerical results illustrate significant differences between finite sample and large sample properties. The problem makes it essential to compute finite sample critical values for application.
- This paper proposes augmented finite sample critical values of the general panel unit root tests Chang (2002) and Chang & Song (2005) through Monte Carlo simulations. The computation approach is also applicable when error terms in the unit root models fail normality assumption, e.g. experiencing heavy tails.