Using GEMPACK Runge-Kutta solution methods with the GTAP model

By Erwin Corong, Michael Jerie and Florian Schiffmann

Abstract:

The release of GEMPACK 12.2 (December 2024) added Runge-Kutta (RK) solution methods to the set of methods that the user may choose from when running a simulation. The RK methods are of higher order than the older Euler, Gragg and Midpoint methods. While each step of an RK method is computationally more expensive than the older methods, the higher order convergence of RK results in faster times to solution. Furthermore, some of the new RK methods offer error estimation and adaptive step sizes.

The RK methods provide improved solution times to accurate solutions and better diagnostics for simulations that solve with low accuracy. These characteristics make the RK methods very useful for the user.

However, the RK methods are less tolerant of coding and data errors which lead to non-smooth behaviour. One manifestation of this is the RK methods do not allow a change of sign in percent change variables. This leads to a fatal error for %-changes of more than -100%. Therefore, when switching to the RK methods the user may be frustrated by a seemingly more-difficult-to-use solution method. In fact, understanding and fixing the problems exposed by RK methods leads to a model which is better behaved and indeed more robust for simulations with large shocks, as the latter result in non-linear model responses.

In this paper we demonstrate the use of the RK solution methods using the GTAP model in various forms. We present several worked examples, involving common problems, which the reader may encounter:

- GTAP Tuning the solution method for accuracy and solution time
- GTAP-RD Using RK with adaptive step sizes and modifying default control parameters where necessary
- GTAP Using RK error estimates to identify a coding or data error
- GTAP-E Industry output falls by -100%
- GTAP Dealing with divide by zero problems
- GTAP-Power Identifying solution problems related to the energy nest

All examples, code and data, are available for download.

JEL codes: D58; C68

Key Words: GTAP; computational solution methods; Runge-Kutta; convergence; Computable General Equilibrium (CGE); error estimation