Introducing more flexible modelling of regional household consumption and saving decisions into the dynamic GTAP model

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Recap

- Desire to extend capabilities from comparative static GTAP to dynamic framework to…
  - Trace out the time scale of effects of policy and other economic changes
- GDyn a reasonable starting point
  - Partial adjustment rules for accumulation of capital, rates of return
  - Full accounting of real capital-finance through Regional household wealth, Firm capital accumulation, and Global trust (or clearing house)
- Exploration of GDyn revealed instability – standard model, or variants, do not meet LR stability conditions, limiting application
  - Issue of stability addressed in Gretton (2018) at: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5484

Central review issues and challenges

- What is the theoretic basis of the revised investment rule and is it the ‘true’ source of model instability?
- Does capital accumulation function anchor the growth process of capital when endogenous adjustment costs included?
- Could a top-level utility function be introduced to model saving behaviour that is consistent with a steady state?
- This presentation addresses these issues then provides illustrative simulations that: (1) revisit model stability & simulates BOTE steady-state saving rates (2) projects a base line with varying saving rates (3) models a policy scenario exploiting the new set up

Rate of return measures in focus

- $RORGTARG(r)$ $(rorgt(r))$ – Target rate of return (designated steady-state value)
- $RORGROSS(r)$ $(rorg\ (r))$ – Actual rate of return
- $RORGEXP(r)$ $(rorge(r))$ – Expected rate of return
  - Modelling based on: $RORGEXP\ =\ RORGROSS\ *\ [K(1)/K(0)]\ \hat{}\ -rorgflex$

  (if planned capital, $K(1)$ is above base capital $K(0)$, the expected rate of return is lower relative to base rate of return by parameter rorgflex)

- For equilibrium, investment and capital stocks adjust to achieve steady state:
  - $RORGEXP(r)\ =\ RORGTARG(r)\ =\ RORGROSS(r)$
  - $rorge(r)\ =\ rorgt(r)\ =\ rorg(r)\ =\ 0$, for all regions

Centrality of investment rule to stability

- Investment rule in GDyn follows a lagged adjustment process:

$$ERG\_RORE(r) = LAMBRORGE(r) * log\left(\frac{RORGTARG(r)}{RORGEXP(r)}\right)$$

- Differentiating and expressing in percentage changes:

$$\text{ergrorg}(r) = LAMBRORGE(r)\big(rorgt(r) - rorge(r)\big) + \boldsymbol{dLAMBRORGE(r) * log}\left(\frac{\boldsymbol{RORGTARG(r)}}{\boldsymbol{RORGEXP(r)}}\right)$$

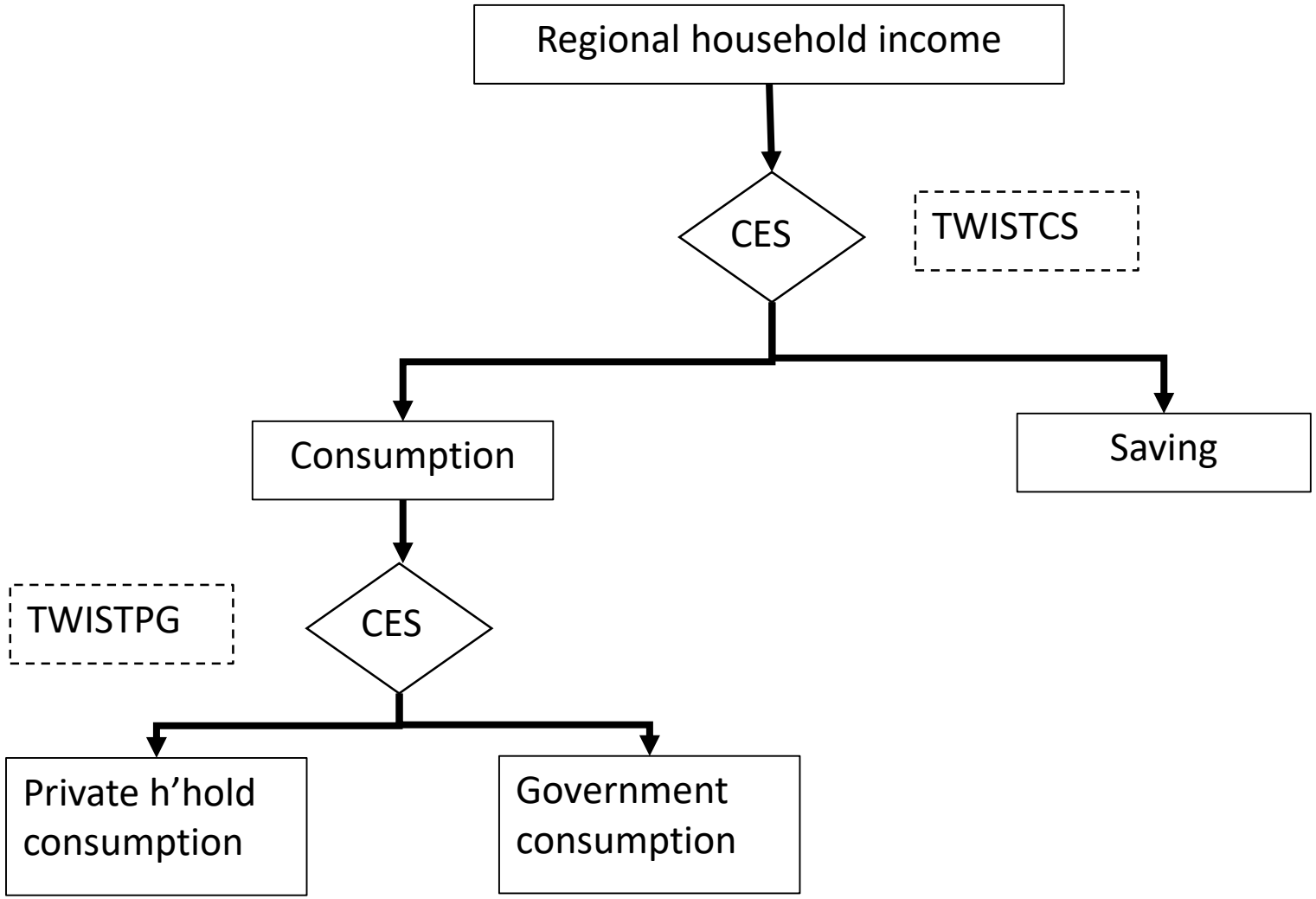
- In GDyn the second term (**bold**) is dropped, eliminating the level term
- Revision retains this term by
  - (i) defining: $dLAMBRORGE(r) = LAMBRORGE(r)^2$
  - (ii) setting RORGTARG as exogenous
- The revision **central** to attaining stability

The growth process of capital is anchored to the accumulation function

- Investment in period t adds to beginning capital stocks available in period $t + 1$
  - that is, $VK(r) * qk(r) = 100 * NETINV(r) * time + VK(r) * [sqk(r) + sqkworld\ ]$
- Growth in capital services as a productive input is conceived as equal to real capital accumulation, that is, $kserv(r) = qk(r)$
  - Assumes new capital becomes **instantaneously** productive
  - … but, capital enters production in the period **after** the investment occurs — via $NETINV(r)$
  - The time lag between investment and capital services introduces adjustment costs
- Only by coincidence that the nexus between saving, dep'n, factor shares in the database consistent with a LR equilibrium, creating friction
- An adjustment cost term:
  - Recognises that investment does not become immediately productive, entailing a capital 'cost'
  - Avoids forcing accumulating cost in a key structural variable (eg rate of saving or rate of return)
  - Provides a measure of data inconsistency
- Adjustment costs allowed via term $sqkworld$ in the accumulation equation, above

Introduce more flexible top-level indirect utility function

- Relax Cobb-Douglas assumption
- Introduce TWIST terms to model disequilibria and preference changes



Key equation (in percentage changes), parameterization and modelling scenarios

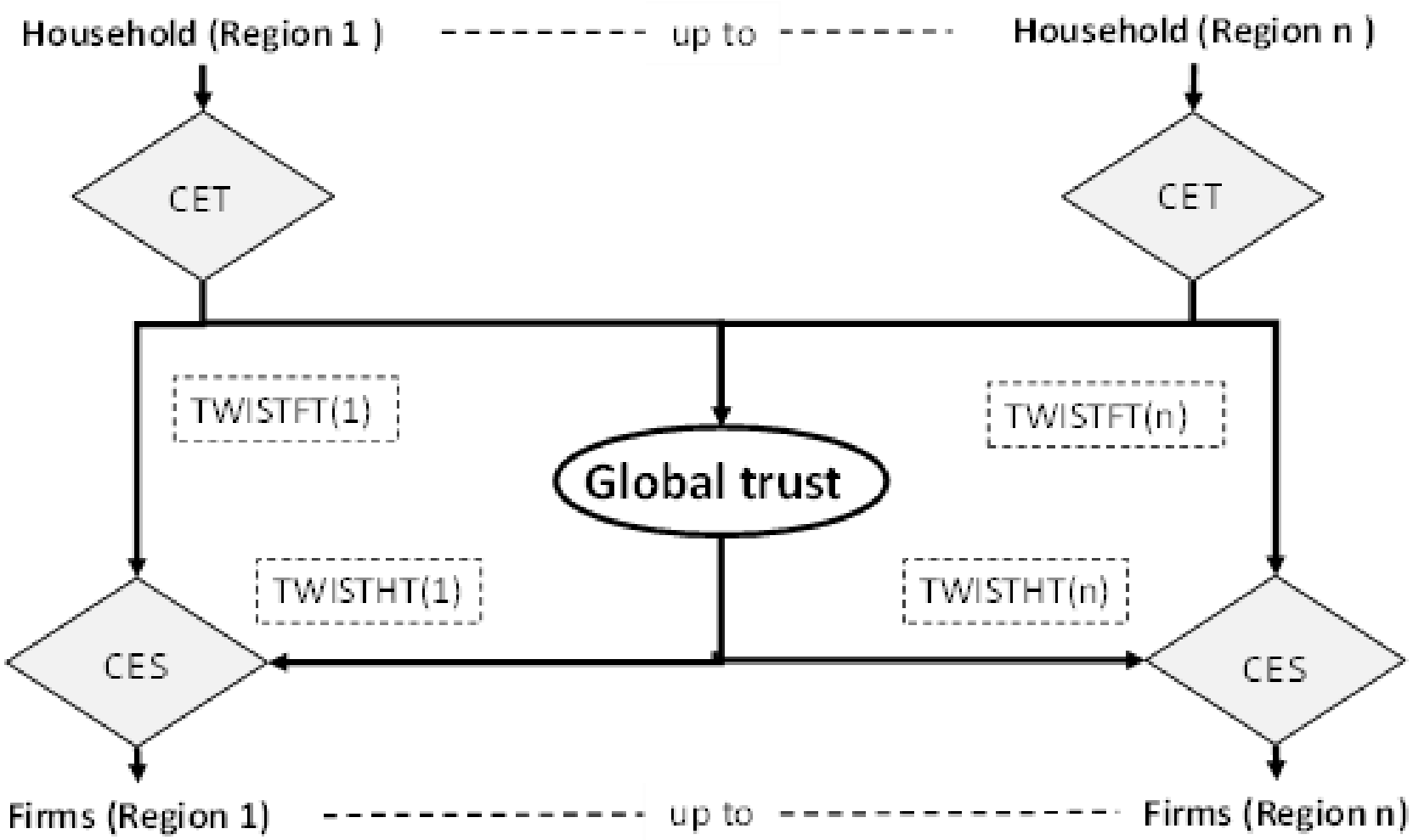
- Consumption-Saving expenditure function in percentage changes

$$s = y - \varphi\left(p_s - \sum_i S_i p_i\right) - (S_c * twistcs)$$

where s is saving, y in regional h'hold income, p_s is the price of savings, $\sum_i S_i p_i$ is the weighted sum of prices such that the expenditure weights, S_i, sum to 1, and φ is the CES parameter

- Parameter choices
  - Elasticity of intertemporal substitution is widely regarded as low
  - Assessment reflected by φ = 0.10 (direct function equivalent is 1.13) - allows some changes in expenditure share due to relative price change
  - Retain C-D for pvte-govt – all changes in expenditure shares modelled though twist terms (while flexible form allows more to be done)

Approach to modelling capital-finance has not been seen as unreasonable (so far)



Stability test - steady state with zero growth, common target rate of return

- Test – consider back-of-the-envelope view of global steady state saving rate for Cobb-Douglas case:
  - $s^* = \alpha * (x + n + \delta)/(\delta + \rho + \theta x)$ (Barro and Sala-i-Martin, 1995, p. 78) where α is the capital share in output, δ is the depreciation rate and ρ is the net returns on capital (rate of time preference), x is the rate of technological change, θ is the (inverse) of the intertemporal rate of substitution
  - With zero growth (x = 0); common target rate (RORGTARG = 0.104)

Impiled S*	alpha	delta	rho
0.15	0.37	0.04	0.06

- Target saving rate by region via successive shocks to regional TWISTCS

Illustrative database aggregation captures diversity of region, reference year 2011

6 regions

Australia (AUS)
China (CHN)
Japan (JPN)
United States (USA)
European Union (EU28)
Rest of the World (ROW)

13 industry sectors

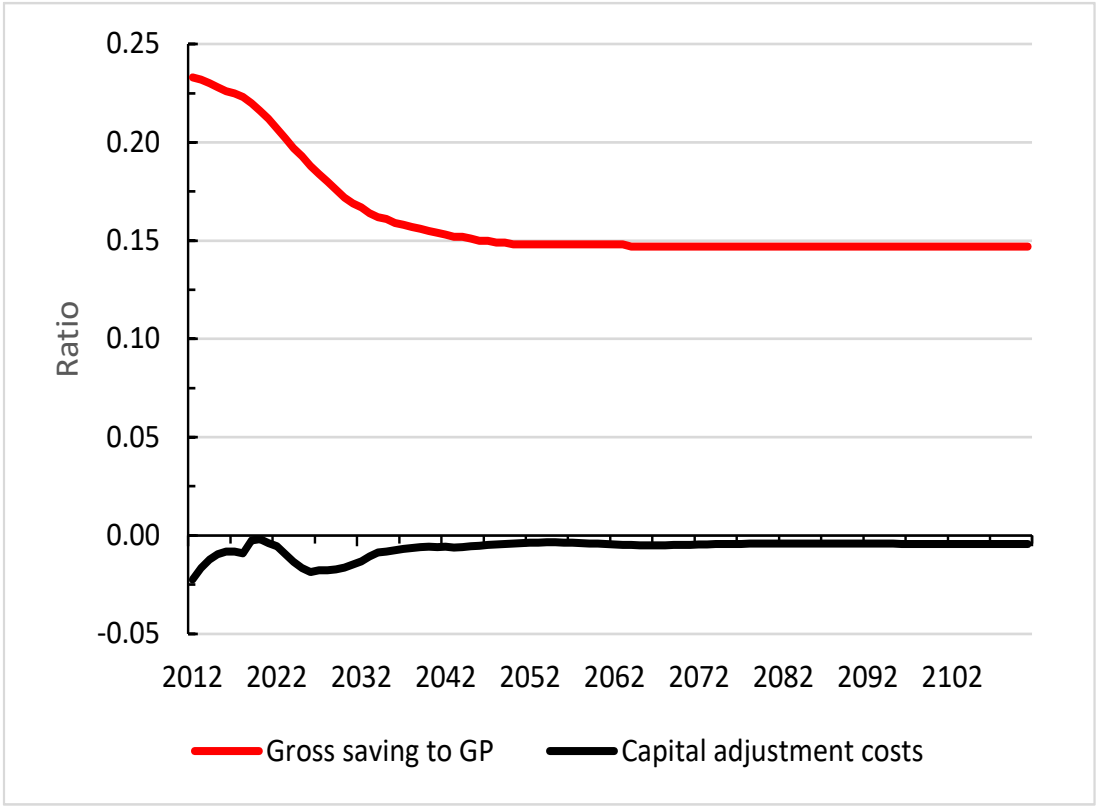
Grains, Crops, Forestry
Livestock, fishing
Mining
Processed food
Textiles and clothing
Light manufacturing
Heavy manufacturing
Utilities
Construction
Transport and communication
Financial services
Other services
Ownership of dwellings

5 primary factor inputs

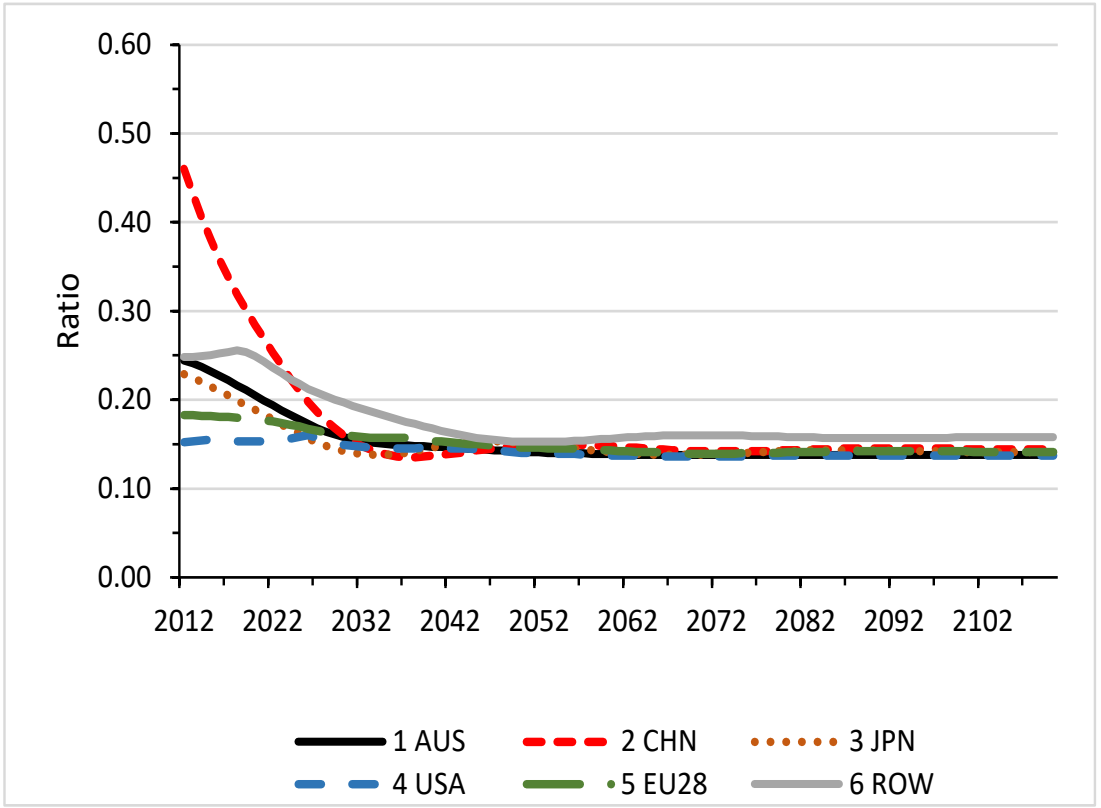
Land
Natural resources
Skilled labour
Unskilled labour
Capital

(1) Projecting BOTE steady state, with zero growth in population and technology

Global gross saving to Global product (ratio) converges to BOTE steady state value; Capital adjustment costs <1%

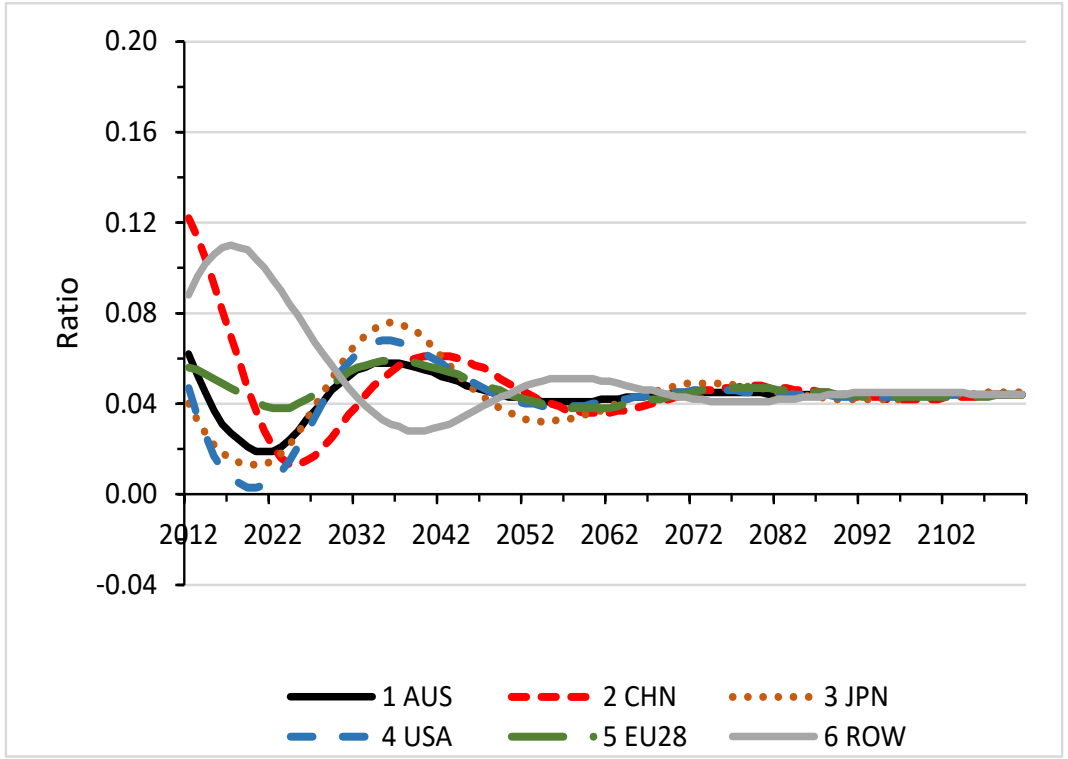


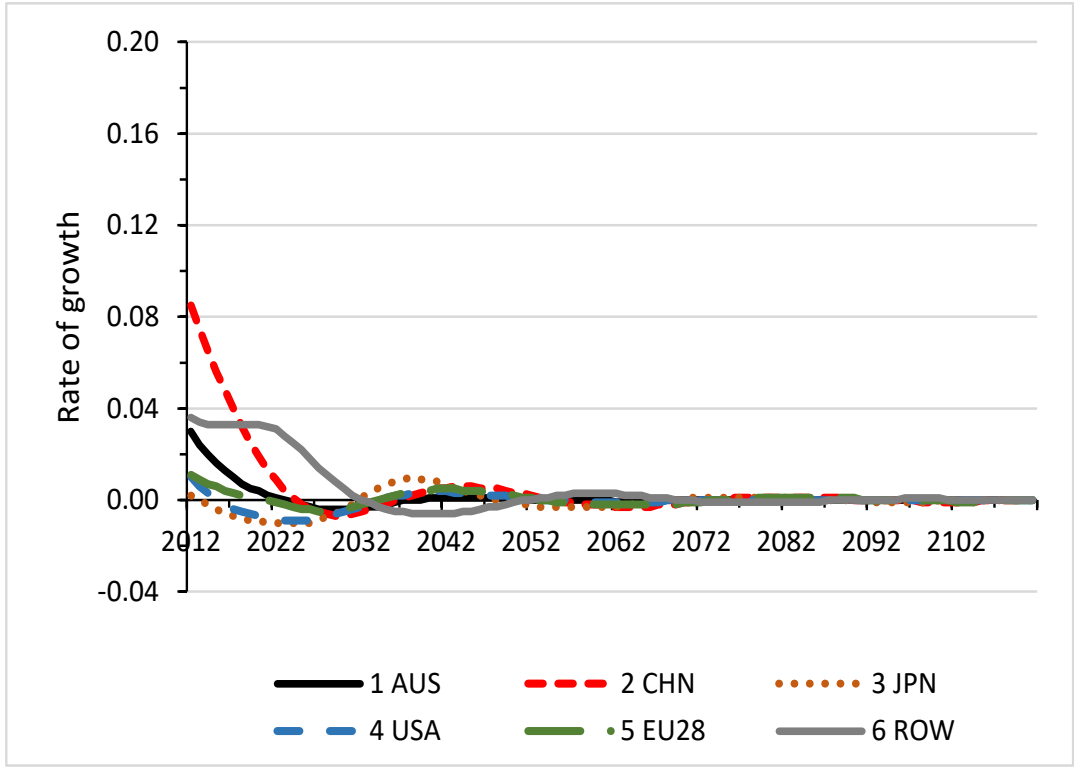
Regional rates converge to neighbourhood of global steady state from different starting points



Capital ratios converge to expected values and remain stable (reported to 100 years, tested to 200 years)

I/K ratio converges to neighbourhood of dep'n rate	Real capital growth converges to zero





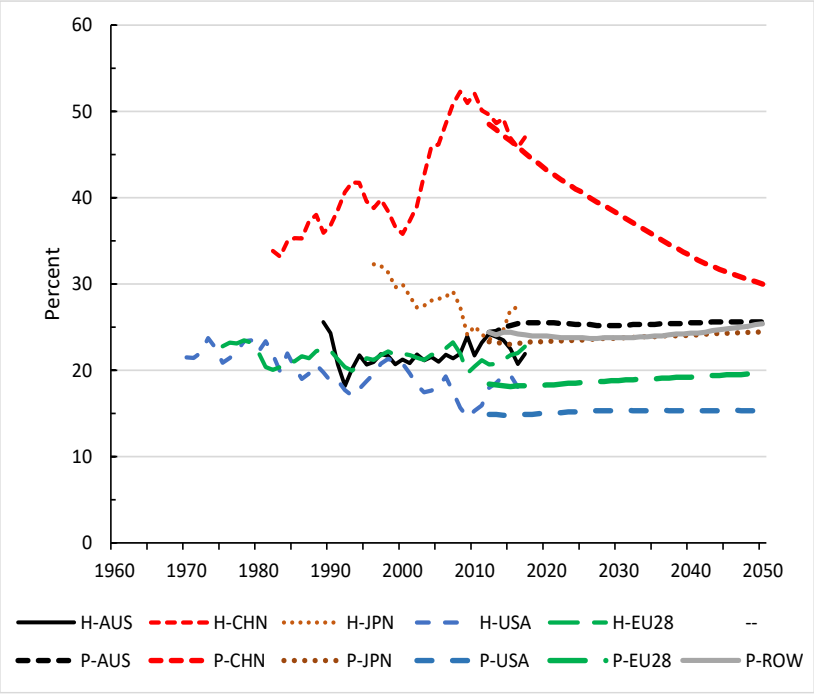
(2) Apply twist method to project saving/GDP rates in baseline – an illustration

- Base projections of GDP, Popn, Labour to 2050
- For CHN capture transition from historically high saving rates and export led growth to more domestically focused growth
  - Derive saving rate by projecting baseline with BoT/Income ratio fixed and twistcs variable
  - … via **Swap** twistcs(*"CHN"*) = DTBALR(*"CHN"*) ; !EN=EX
- Extract the projected values for twistcs(*"CHN"*) from solution file
- Rerun the base line with twistcs(*"CHN"*) fixed

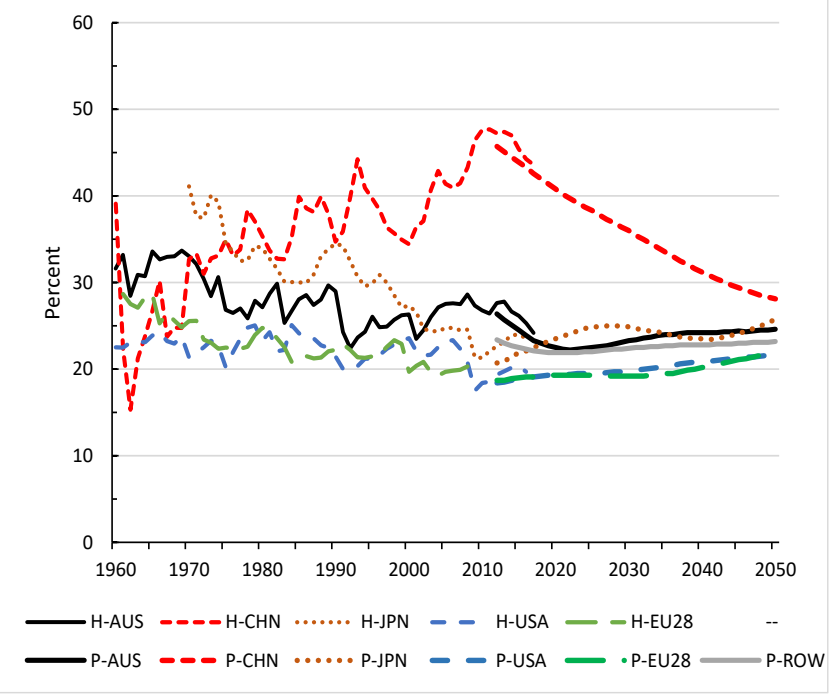
Historically high saving and accumulation rates for CHN projected to revert to mean

(Base year for projections 2011 USD; projections reflect scale and relative price effects)

Gross saving to GDP



Gross investment to GDP

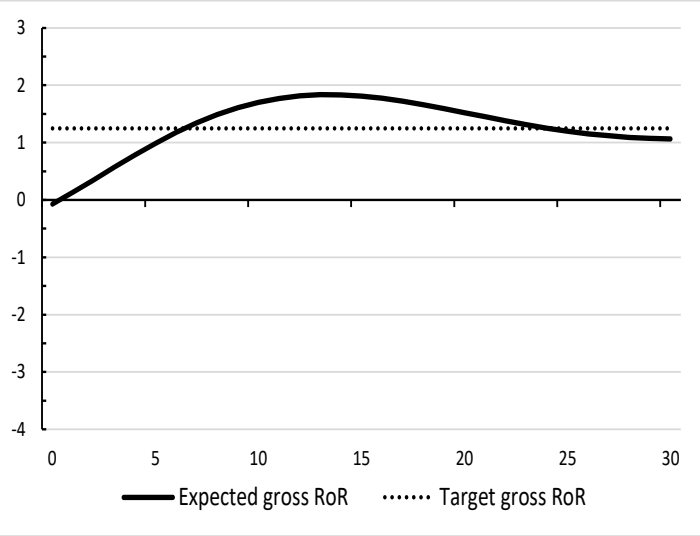


- Broad alignment of I/GDP with S/GDP consistent with of 'home-country' bias hypothesis (Feldstein and Horiok 1980)
- Historical series: WDI data.

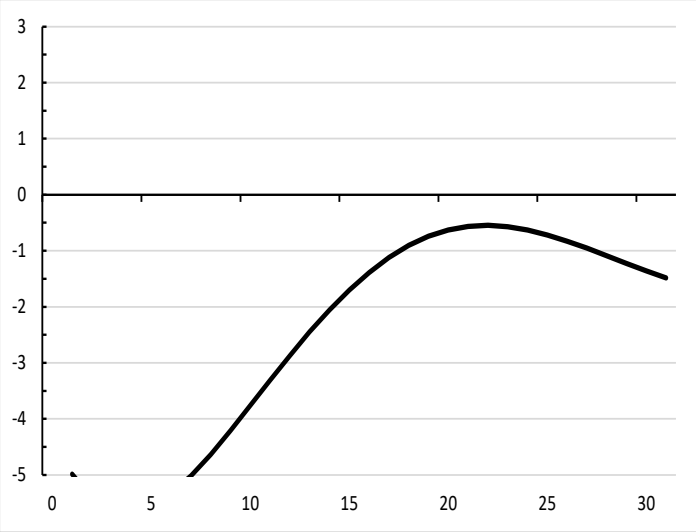
(3) Policy sensitive scenario – increase in the required longer-run rate of return in AUS of 10 basis points

Agents expected returns adapt to exogenous reference rate

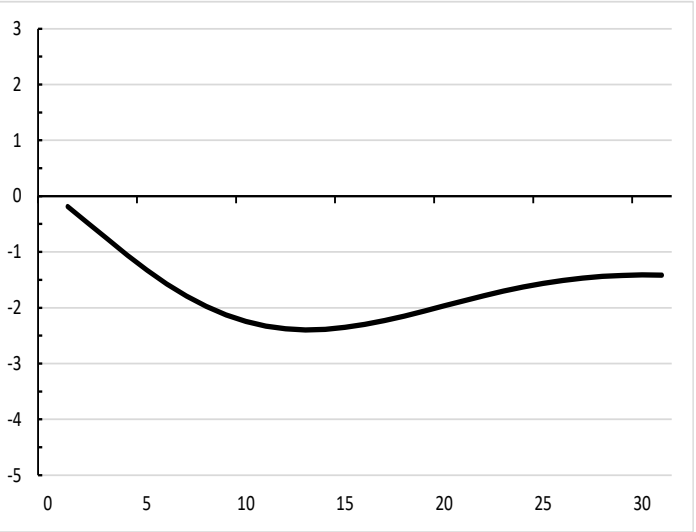
Deviations from base line …



… by adjustments to investment via investment rule



… which flow through to lower capital stocks (& output and income levels)



- Shock equivalent to a 10 percent increase in the difference between the US and Australian real commercial bond rate averaged over the period 2000 to 2017
- … calibrated to the GDyn database rate of 8.1 percent for AUS.

What achieved

- Deepened explanation of developments to achieve longer-run equilibrium in GDyn
- Relaxed the C-D assumption in consumption-saving choice
- Introduced twist theory to consumption-saving/foreign-domestic finance relationships
- Applied the revised model to:
  - (1) Test model stability - Simulate a hypothetical reversion of global saving to steady-state BOTE value, not previously achieved in GDyn
  - (2) Simulate a baseline with reversion to mean in saving and investment for CHN
  - (3) Simulate a policy sensitive scenario - a decline in the willingness to invest in a medium-sized open economy (AUS)

Thank you