

Distributing Incomes Between Representative Households In Dynamic CGE Models: Empirical Test of Alternative Structures

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Introduction

- Dynamic CGE models may have a one or many representative households (RHs).
- If > 1 RH, alternative assumptions may be made regarding changes over time for household shares in population and incomes from factors and other sources.
- Purpose of paper: Review selected approaches and test their impact in a recursive dynamic CGE model.
- The topic is important: Income distribution is a central economic policy issue and the focus of many CGE applications.
- Work in progress.
- Outline
 - Review of approaches
 - CGE application (model, data, simulations)
- Conclusions.

Review of approaches

- Single RH
 - The challenge of allocating population and incomes across RHs is gone.
 - The CGE model is silent on size distribution although this may be handled via micro simulations.
 - Key question: Are results for household incomes and prices influenced by the disaggregation (or lack thereof) of the household sector.
 - Many examples in the literature.
- Multiple RHs. Alternative approaches to RH income shares:
 1. Fixed
 2. Scaled by population growth
 3. Defined by endogenous RH stock (endowment) and population shares
 4. Approach 2 for non-capital and approach 3 for capital
- More on the approaches...

More on alternative multiple-household approaches

1. Fixed base-year RH shares. Factor stocks and RH populations grow at exogenous (and different) rates but RH income shares fixed. This treatment is common (acc. to model documentation).
2. Population-growth scaled RH shares (= population-weighted RH per-capita shares). Here tested for the first time. Using s for income share; pop for population; h , h' , t , 1 , H , and T for household and time set indices and set names; and suppressing the factor subscript:

More on alternative multiple-household approaches – cont.

$$S_{h,t} = \left(\sum_{h' \in H} S_{h',1} \right) \left(\frac{S_{h,1} \cdot \frac{pop_{h,t}}{pop_{h,1}}}{\sum_{h' \in H} S_{h',1} \cdot \frac{pop_{h',t}}{pop_{h',1}}} \right) = \left(\sum_{h' \in H} S_{h',1} \right) \left(\frac{\frac{S_{h,1}}{pop_{h,1}} \cdot pop_{h,t}}{\sum_{h' \in H} S_{h',1} \cdot \frac{pop_{h',t}}{pop_{h',1}}} \right) \quad \begin{array}{l} h \in H \\ t \in T \end{array}$$

More on alternative multiple-household approaches – cont.

3. Endowment-based RH shares. Population and factor stocks are endogenous. Example: Lofgren et al. (2013). Main features:
 - RHs hold fixed shares in each labor stock. Total stocks for each category may be exogenous or endogenous (education, migration, ...)
 - RH populations scaled on the basis of changes in labor endowments → The “identity” of each RH (pattern of savings, consumption, ...) is determined by labor endowment).
 - RH shares and holdings of non-labor stocks influenced by initial shares, population growth, and investment.

Approach 3: Factor income shares by RH

- In each year, factor income share parameters are defined on the basis of stock (or endowment) shares:

$$SHIF_{h,f,t} = \frac{QHF_{h,f,t}}{\sum_{i \in I} QHF_{i,f,t}} \quad h \in H, f \in F, t \in T$$

$$\begin{bmatrix} \text{share of } h \text{ in} \\ \text{income of } f \end{bmatrix} = \begin{bmatrix} \text{share of } h \text{ in} \\ \text{stock of } f \end{bmatrix}$$

Approach 3: Computing stocks by RH (in words)

- Steps (recursive over time):
 - a. Labor factors for all years: Stocks allocated across RHs on the basis of base-year labor income shares.
 - b. Population after base year: Population allocated across RHs on the basis of changes in labor stocks subject to total population constraint.
 - c. Non-labor factors for base year: Stocks allocated across RHs on the basis of base-year income shares.
 - d. Capital after base year (start of year): Start-of-year stock = stock at end of previous year adjusted for population growth subject to total capital stock constraint.
 - e. Other factors (not labor or capital) after base year: Stock defined on the basis of initial stock and population growth, subject to total stock constraint.
 - f. More details (in math)...

Labor stocks by RH for all years

- a. Stocks allocated across RHs on the basis of base-year (SAM) labor income shares. (Total stock could be endogenous.)

$$QHF_{h,f,t} = s_{h,f,0} \cdot qhf_{total,f,t} \quad h \in H, f \in FLAB, t \in T$$

$$\begin{bmatrix} \text{stock for} \\ \text{hhd } h \text{ of} \\ \text{labor type} \\ f \text{ in } t \end{bmatrix} = \begin{bmatrix} \text{share of } h \\ \text{in base-} \\ \text{year in-} \\ \text{come of } f \end{bmatrix} \cdot \begin{bmatrix} \text{total} \\ \text{stock} \\ \text{of } f \\ \text{in } t \end{bmatrix}$$

Population by RH for all years

- b. Population allocated across RHs on the basis of changes in labor stocks subject to total population constraint:

$$POP_{h,t} = POP_{h,0} \left(\frac{\sum_{f \in FLAB} qhf_{h,f,t}}{\sum_{f \in FLAB} qhf_{h,f,0}} \right) \cdot \left(\frac{POP_{total,t}}{\sum_{h' \in H} POP_{h',t}} \right) \quad h \in H, t \in T$$

$$\left[\begin{array}{c} \text{pop'on} \\ \text{of } h \\ \text{in } t \end{array} \right] = \left[\begin{array}{c} \text{base-} \\ \text{year} \\ \text{pop'on} \\ \text{of } h \end{array} \right] \cdot \left[\begin{array}{c} \text{ratio bt. labor} \\ \text{stock for } h \\ \text{in } t \text{ and} \\ \text{base-year} \end{array} \right] \cdot \left[\begin{array}{c} \text{scaling to} \\ \text{match} \\ \text{exogenous} \\ \text{pop'on total} \end{array} \right]$$

Non-labor stocks by RH for base year

- c. Stocks allocated across RHs on the basis of base-year income shares (capital, land, ...)

$$QHF_{h,f,0} = s_{h,f,0} \cdot qhf_{total,f,0}$$

$$\left[\begin{array}{l} \text{stock for} \\ \text{hhd } h \text{ of} \\ \text{factor } f \\ \text{in base year} \end{array} \right] = \left[\begin{array}{l} \text{share of } h \\ \text{in base-} \\ \text{year in-} \\ \text{come of } f \end{array} \right] \cdot \left[\begin{array}{l} \text{total stock} \\ \text{of } f \text{ in} \\ \text{base year} \end{array} \right]$$

$$h \in H, f \in F, f \notin FLAB, t = 1$$

Capital stocks by RH after base year

- d. Stock (available for use during a year) = stock at end of previous year adjusted for population growth subject to total capital stock constraint:

$$QFHEND_{h,f,t} = (1 - depr_f) QFH_{h,f,t} + DKH_{h,f,t}$$

$$\left[\begin{array}{l} \text{stock for} \\ h \text{ of } f \text{ at} \\ \text{end of } t \end{array} \right] = \left[\begin{array}{l} \text{stock for } h \text{ of } f \\ \text{at start of } t \text{ net} \\ \text{of depreciation} \end{array} \right] + \left[\begin{array}{l} \text{investment} \\ \text{by } h \text{ in } f \\ \text{during } t \end{array} \right]$$

$$h \in H, f \in FCAP, t \in T$$

Capital stocks by RH after base year – cont.

d. -- cont.

$$QFH_{h,f,t} = QFHEND_{h,f,t-1} \left(\frac{POP_{h,t}}{POP_{h,t-1}} \right) \left(\frac{\sum_{h' \in H} QFHEND_{h',f,t-1}}{\sum_{h' \in H} QFH_{h',f,t}} \right)$$

$$\left[\begin{array}{l} \text{stock for} \\ h \text{ of } f \text{ during} \\ \text{(at } start \text{ of) } t \end{array} \right] = \left[\begin{array}{l} \text{stock for} \\ h \text{ of } f \text{ at} \\ end \text{ of } t-1 \end{array} \right] \cdot \left[\begin{array}{l} \text{ratio bt.} \\ \text{pop'on} \\ \text{of } h \text{ in} \\ t \text{ and } t-1 \end{array} \right] \cdot \left[\begin{array}{l} \text{scaling so that} \\ \text{total stocks at} \\ \text{start of } t \text{ and end} \\ \text{of } t-1 \text{ are equal} \end{array} \right]$$

$$h \in H, f \in FCAP, t > 1$$

Other factor stocks by RH – after base year

- e. Stock (of e.g. land) defined on the basis of initial stock and population growth, subject to total stock constraint:

$$QHF_{h,f,t} = QHF_{h,f,0} \left(\frac{POP_{h,t}}{pop_{h,0}} \right) \left(\frac{qf_{f,t}}{\sum_{h' \in H} QHF_{h',f,t}} \right)$$

$$\begin{bmatrix} \text{stock} \\ \text{for } h \\ \text{of } f \\ \text{in } t \end{bmatrix} = \begin{bmatrix} \text{base-year} \\ \text{stock} \\ \text{for } h \text{ of } f \end{bmatrix} \cdot \begin{bmatrix} \text{ratio bt. pop'on} \\ \text{for } h \text{ in } t \text{ and} \\ \text{base year} \end{bmatrix} \cdot \begin{bmatrix} \text{scaling to} \\ \text{match} \\ \text{exogenous} \\ \text{stock total} \end{bmatrix}$$

$$h \in H, f \in FOTH, t > 1$$

CGE application: model, data, and simulations

- Recursive-dynamic CGE model applied to data for Guatemala.
- Analysis tests alternative model structures; not analysis of Guatemala.
- Simulations are done for the period 2011-2030.
- Model and data disaggregation:
 - 8 factors: 2 labor (skilled and unskilled); 2 capital (private and government); 4 natural resources
 - 24 activities and 24 commodities (but not 1-1 mapping)
 - **4 households: rural skilled and unskilled; urban skilled and unskilled**
 - Other institutions: government, enterprise, rest of world

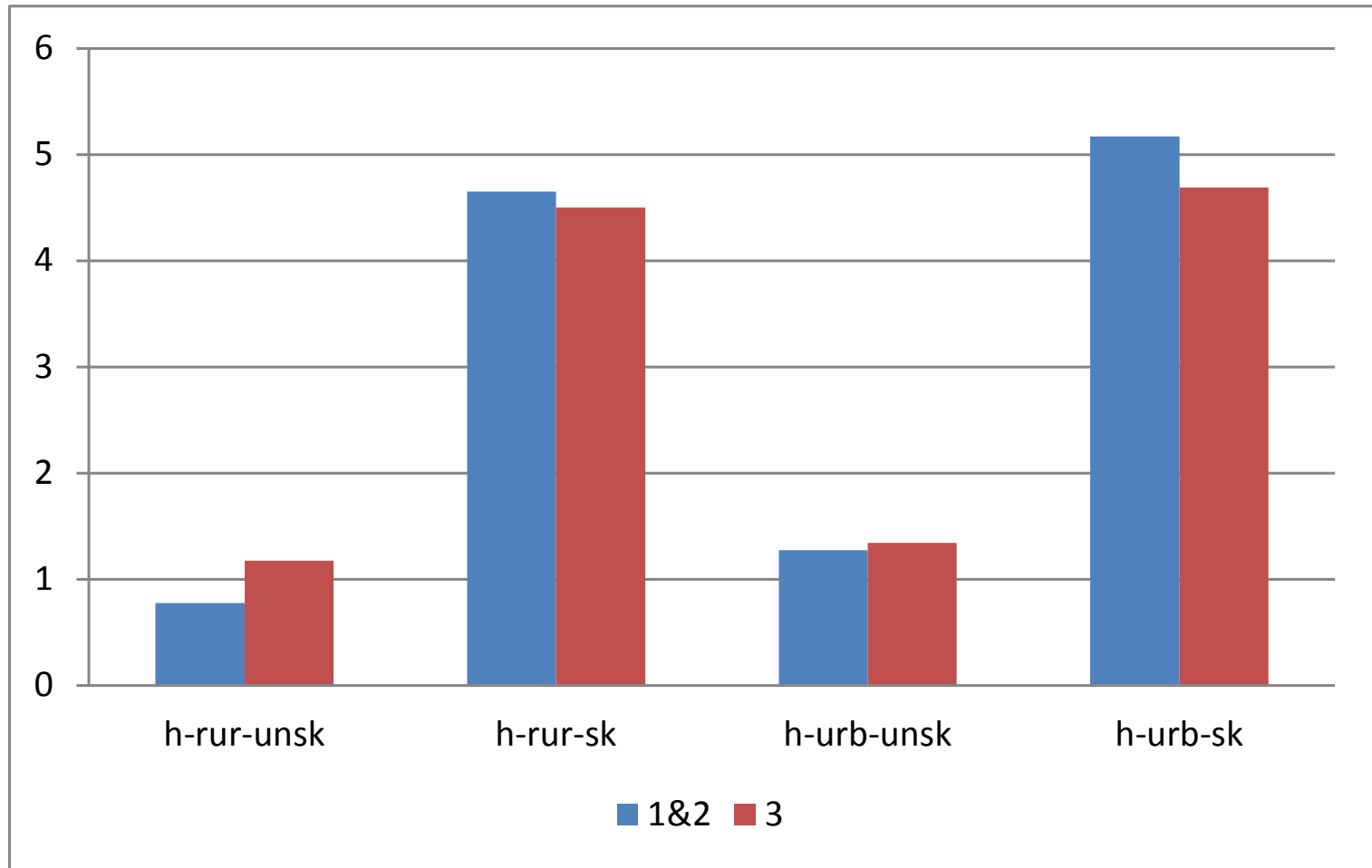
CGE application: model, data, and simulations

- Key model assumptions and features:
 - **Endogenous capital stock growth (a function of initial stock, investment and depreciation)**
 - For other factors, total factor stock growth is exogenous.
 - Factor markets: rent clearing; wage curve and unemployment for labor
- Simulations:
 1. Base
 2. World export price increase for agricultural sectors

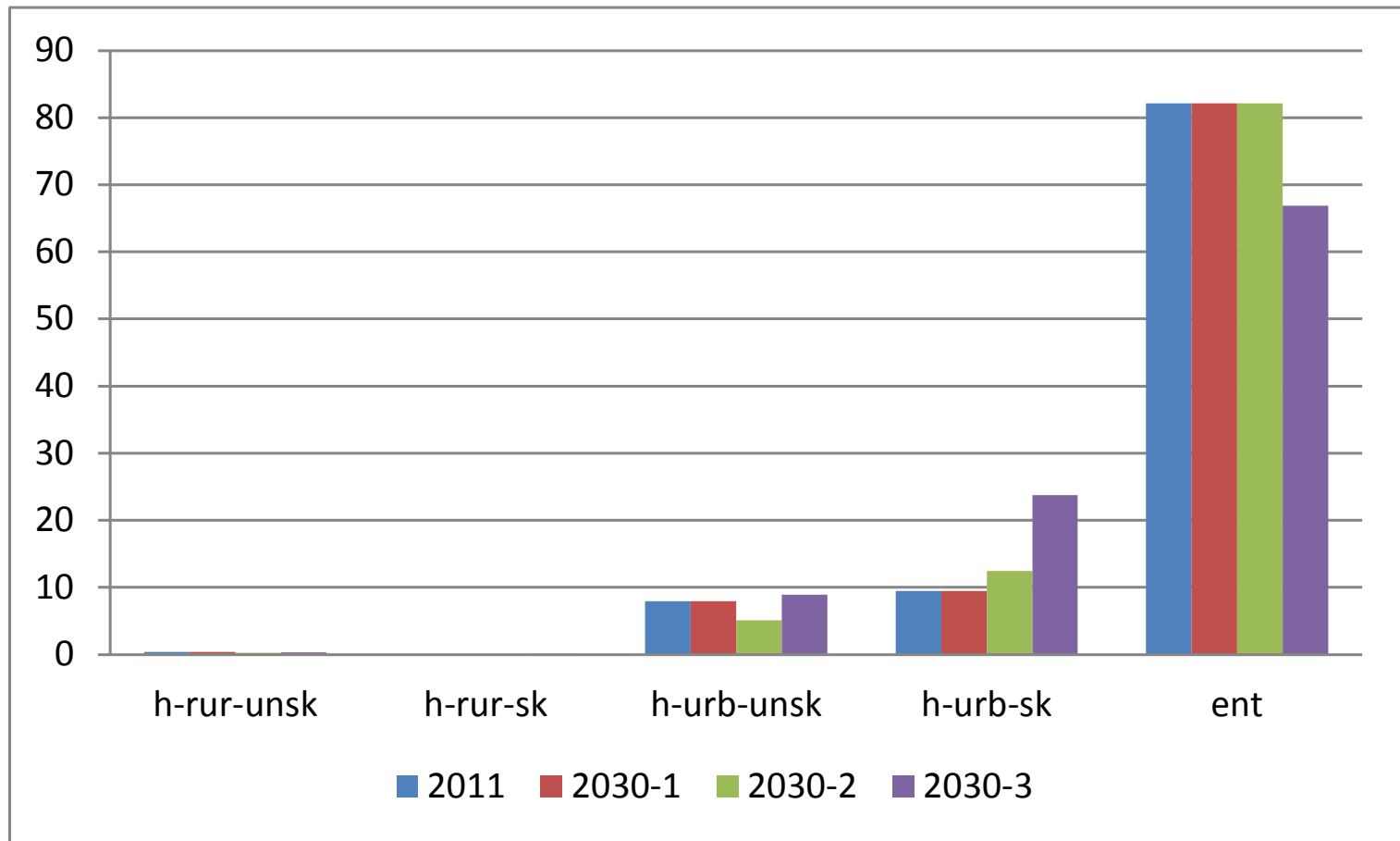
CGE application: model, data, and simulations – cont.

- Main outcome indicators: per-capita consumption (aggregate and for each RH), poverty, inequality, and growth rates for disaggregated factor incomes.
- Poverty and inequality indicators generated on the assumption that the distribution within each RH group is unchanged (based on household survey).

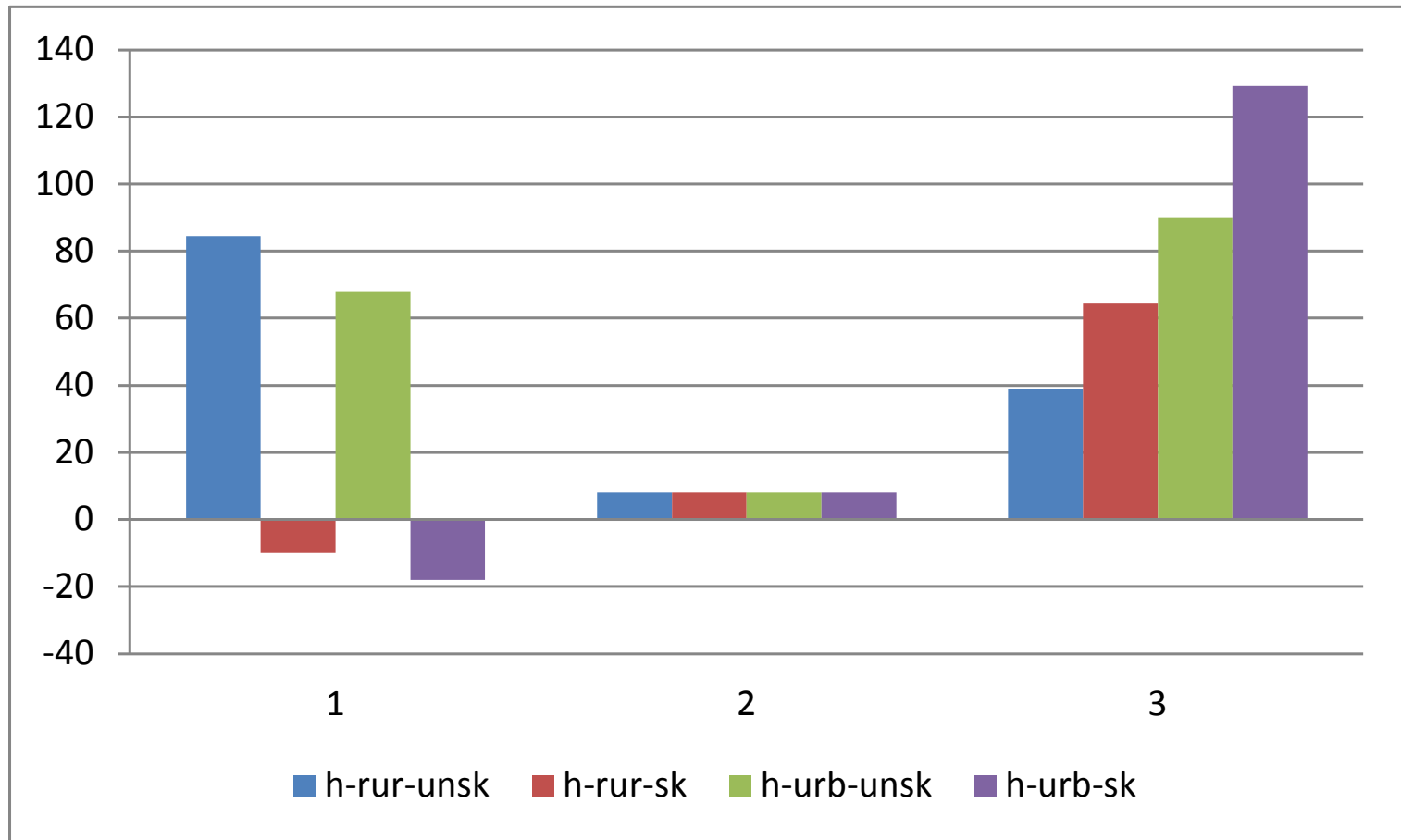
Population growth by RH and approach (%)



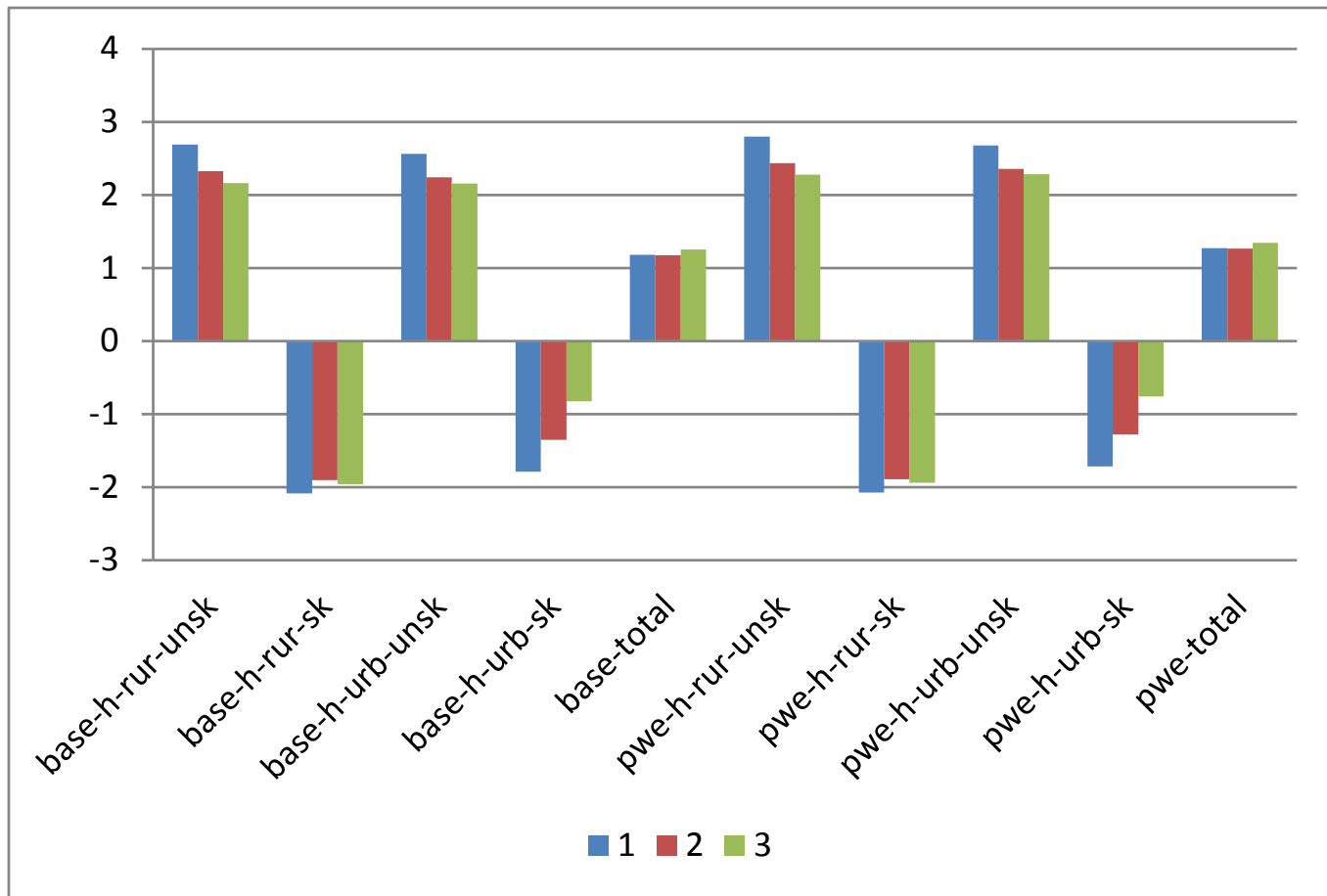
Share of capital income in base by inst and approach



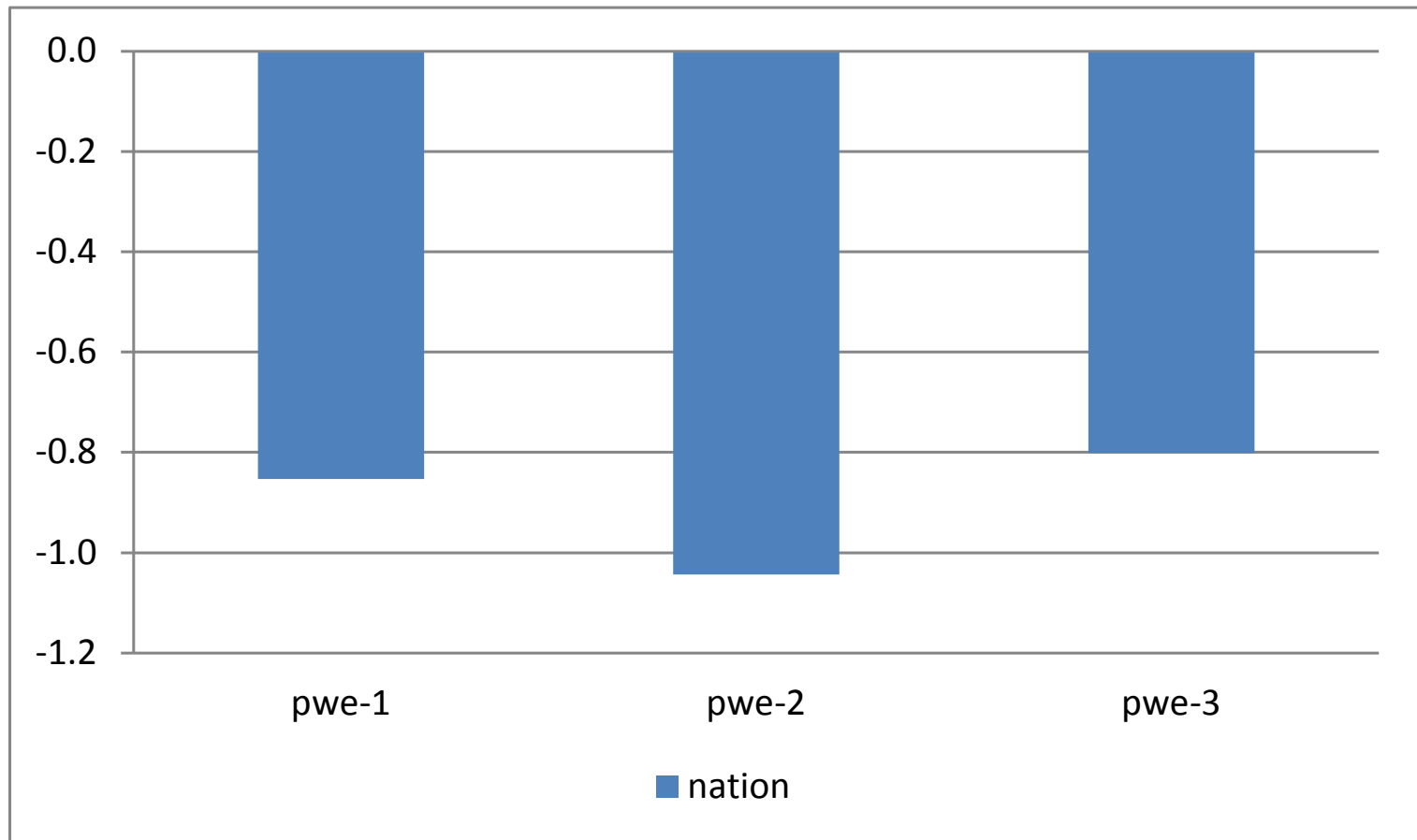
Change in per capita capital income in base 2030 by RH and approach (%)



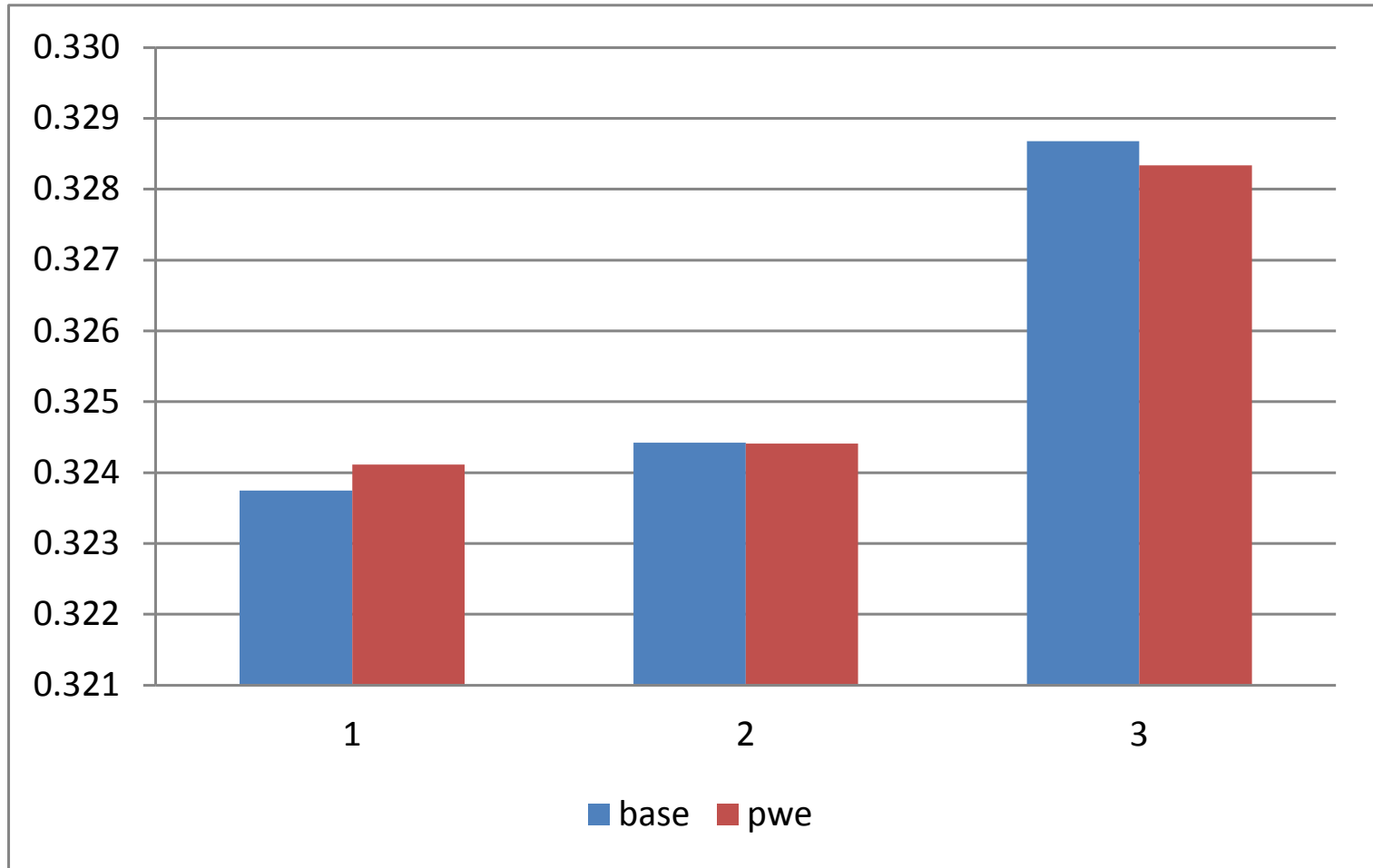
Real household per capita consumption growth 2012-2030 by simulation, RH, and approach (%)



Headcount poverty by approach and simulation in 2030 (pp change wrt base)



Gini by approach and simulation



Conclusions

- In multi-RH applications of dynamic CGE models, important to pay attention and be explicit about links between growth in population, factor supplies, and RH – it may matter for welfare, poverty...
- The case for endogenizing RH income shares is compelling if the total population and labor supplies (total and/or disaggregated) are endogenous.
- Planned additional simulations:
 - Government transfers to RHs eliminating a uniform share of the poverty gap for each RH with headcount poverty rate > 0
 - Sensitivity analysis of the results to a more aggregated treatment of factors and households (single household)

Income structure by RH in base-year

(%)

Income source	Rural unsk hhd	Rural sk hhd	Urban unsk hhd	Urban sk hhd
Transfers from government	4.64	0.91	2.33	0.85
Transfers from RoW	25.37	8.46	10.17	2.92
Transfers from insdng	2.45	1.76	37.41	31.85
Labor, unskilled	62.25	4.45	32.71	1.52
Labor, skilled	4.55	83.89	6.08	53.24
Capital, private	0.70	0.50	10.64	9.06
Land	0.03	0.02	0.43	0.37
Forestry res	0.00	0.00	0.01	0.01
Fishing res	0.00	0.00	0.01	0.01
Extractive res	0.01	0.01	0.21	0.18
Total	100.00	100.00	100.00	100.00