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ANARRES

ANARRES_t: Macroeconomic Closures

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Outline

- Modelling principle
- The Real Exchange Rate
- Equation and Variable counts
- Macroeconomic Closures
  - Numéraire
  - Foreign exchange market closure
  - Investment-Savings closure
  - Government account closure
    - Tax accounts
    - Government expenditures

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Modelling Principle

Different applications, users/uses require different closure settings. Therefore, the model should allow

- Multiple different closure settings
- Sensitivity testing of closure choices
- Acknowledgment of the tensions between (Walrasian) Microeconomic and Macroeconomic 'visions'
- Be simple to change

Differences in the 'visions' about macroeconomic theories are **contentious**.

In the context of CGE models these differences are overwhelmingly captured through decisions about which variables are endogenous, and which are exogenous

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The Real Exchange Rate

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Exchange Rate in CGE Models

- The (nominal and real) exchange rates are not financial variables
  - –No financial assets in the model
  - –No inter-temporal equilibrium concept
- The (nominal and real) exchanges rate are determined by the prices of tradable and non/semi tradable goods and services

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Exchange Rate in CGE Models

- Nominal Exchange rate, ER_r = local currency/foreign currency
- Uses in the model code
  - – Current account balance denominated in foreign currency in the model

trade balance

```
KAPEQUIL(r)..
  KAPWOR(r)  = E= SUM(w, KAPREG(w,r)) ;

KAPREQUIL(w,r)$wgn(w)..
 KAPREG(w,r)
  =E= SUM(c, PWMFOB(w,c,r)*QMR(w,c,r))
      - SUM(c, PWE(c,w,r)*QER(c,w,r)) ;
```


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Exchange Rate in CGE Models

- Uses in the model code
  - Domestic prices of imports and exports report the prices in local currency units, using *ER*

```
PMRDEF2(w,c,r)$cmr(w,c,r)..
 PMR(w,c,r) =E= PWM(w,c,r)*(1+TM(w,c,r))*ER(r) ;

PERDEF2(c,w,r)$cer(c,w,r)..
 PER(c,w,r) =E= PWE(c,w,r)*(1-TE(c,w,r))*ER(r) ;

TOTSAVEQ(r)$rgn(r)..
 TOTSAV(r)
    =E= SUM(h,YH(h,r)*(1-TYH(h,r))*SHH(h,r))
        + SUM(f,deprec(f,r)*YF(f,r))
        + KAPGOV(r) + (KAPWOR(r)*ER(r)) ;
```


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Exchange Rate in CGE Models

- Real Exchange Rate = $PI_{tradable} / PI_{nontradable}$
- Armington assumption ➔ imports and domestic goods are imperfect substitutes, so 'semi-tradable' goods rather than a pure non-traded good
- Price (index) of the 'non-traded'/'semi-traded' goods is a weighted average of the price of domestically produced goods sold on the domestic market, e.g.,

```
resP_IND("rer",r) =
     resP_IND("er",r) *
        [resP_IND("pw_ind ",r)
              /resP_IND("pd_ind ",r)] ;
```


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Numéraire

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Numéraire

ANARRES_t has *r+1* numéraire

1. One global numéraire
   - Default: Exchange rate index
2. One numéraire for each 'real' region
   - Default: CPI_r
3. The GLOBE region
   - Default: global numéraire

ALL global CGE models must have *(r+1)* numéraire

- ALL global models (that we have been able to check) have (implicit) fixed exchange rates, i.e., (*r+1*) numéraire

Exchange rates are critical for the valuation of *inter* region transfers

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Numéraire

```
CPIDEF(r)$rgn(r)..
        CPI(r) =E= SUM(c,comtotsh(c,r)*PQCD(c,r)) ;

CPI.FX("glo")  = 0.0 ;

PPIDEF(r)$rgn(r)..
        PPI(r) =E= SUM(c,vddtotsh(c,r)*PD(c,r)) ;

PPI.FX("glo")   = 0.0 ;

ERPIDEF..     ERPI =E= SUM(ref,tradtotsh(ref)*ER(ref)) ;
```


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Numéraire

```
*## FOREIGN EXCHANGE MARKET CLOSURE
* fix world numeraire in which foreign transactions are valued

 ERPI.FX                  = ERPI0 * numerchk ;

*## MISCELLANEOUS FIXED VARIABLES

* To use CPI as the numeraire fix CPI

 CPI.FX(r)              = CPI0(r) * numerchk ;

* To fix the real exchange rate fix ER and PPI

* PPI.FX(r)             = PPI0(r) * numerchk ;
```


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Absorption

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Absorption Shares

- Value of final demand
  - Household demand
    - + Government demand
    - + Investment demand
- Value shares for
  - Investment
  - Government
- Household share
  - By default (Walras Law)

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Absorption Shares

```
* #### Absorption Closure

VFDOMD(r)  =E= SUM(c, PQCD(c,r) *  SUM[h,QCD(c,h,r)])
               + SUM(c,PQD(c,r) *
                 [QGD(c,r) + QINVD(c,r)]) ;


INVESTSHEQ(r)$rgn(r)..
       INVESTSH(r) * VFDOMD(r) =E= INVEST(r) ;


VGDSHEQ(r)$rgn(r)..
  VGDSH(r) * VFDOMD(r) =E= SUM(c,PQD(c,r) * QGD(c,r)) ;
```

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Macroeconomic Closures

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SAMs & Macroeconomy - Counting

$$t_{jk} = t_{jk}(y; p, f, \lambda) \longrightarrow \mathbf{VARS} = [y] + [p] + [f] + [\lambda]$$

$$p = p(y; p, f, \lambda)$$

$$y = n + x$$

$$\Rightarrow \mathbf{EQNS} = [y] + [p] - 1$$

$$\text{Degrees of Freedom} = [f] + \lambda + 1$$

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Foreign Exchange Market Closure

```
*## FOREIGN EXCHANGE MARKET CLOSURE

* fix world numeraire in which foreign transactions are
valued

 ERPI.FX                 = ERPI0 * numerchk ;

* globe transactions are in the numeraire currency

 ER.FX("glo")            = ERPI0 * numerchk;

* globe's trade balance is zero by definition of tship
* and the fact that there is only one imported
* commodity
```


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Foreign Exchange Market Closure

```
$ontext
 The 'standard' presumption in this MODEL is that ONE of the
exchange rate or the trade balance is FIXED for each region

 IF the exchange rate is FIXED the trade balance is the
equilibrating variable.

 IF the trade balance is FIXED the exchange rate is the
equilibrating variable.
$offtext

* EITHER the exchange rate is FIXED

* ER.FX(rgn)                  = ER0(rgn) ;

* OR the trade balance is FIXED

 KAPWOR.FX(rgn)             = KAPWOR0(rgn) ;
```

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Investment-Savings Closure

```
*######## INVESTMENT-SAVINGS CLOSURE
$ontext
 The 'standard' presumption in this MODEL is that ONE of the savings
rate or the 'level' of investment is FIXED for each region
 Savings rates can be fixed multiplicatively or additively. IF the
saving rate is FIXED, investment is the equilibrating variable
 The 'level' of investment can be fixed in terms of VOLUME, VALUE
or Share of Absorption. IF the investment is FIXED, savings rate is the
equilibrating variable
$offtext
*#### Savings
* SADJ controls multiplicative changes in savings rates

* SADJ.FX(r)          = SADJ0(r) ;

* DSHH controls additive changes in savings rates
* NB DSHH needs to be used in conjunction with shh01

 DSHH.FX(r)          = DSHH0(r) ;
```

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Investment-Savings Closure

```
SHHDEF(h,r)..
 SHH(h,r) =E= ((shhb(h,r) + dabshh(h,r)) * SADJ(r))
                        + (DSHH(r) * shh01(h,r)) ;
```

- If *SADJ* for a region is a variable, then the solution value for *SADJ* yields optimum equiproportionate change in the savings rate necessary to satisfy model constraints.
- If *SADJ* for one region is a variable, and any elements of *dabshh* are non zero, then the solution value for *SADJ* yields the optimum equiproportionate change in the *applied* savings rates, i.e., *shhb* + *dabshh*.
- If any element of *dabshh* is not zero, then an absolute change in the initial savings rates for the relevant household are imposed.
- If *DSHH* for one region is made a variable, and ALL elements of *shh*01 are ONE then ALL the elements of *shhb* increase (additively) by an equal absolute amount determined by the solution value for *DSHH*.
- If *DSHH* for one region is made a variable, AND at least one element of *shh*01 is ONE then the subset of elements of *shhb* identified by *shh*01 are allowed to (additively) increase by an equal absolute amount determined by the solution value for *DSHH* so as to satisfy the model.
- If the change in the applied savings rates is to be other than equal then values of *shh*01 other than one can be applied.

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Investment-Savings Closure

```
*#### Investment

* If investment volume fixed then scaling factor is fixed

* IADJ.FX(r)          = IADJ0(r) ;

* OR if the value of investment is fixed the

* INVEST.FX(r)        = INVEST0(r) ;

* OR shares of domestic final demand of investment fixed

 INVESTSH.FX(r)      = INVESTSH0(r) ;
```

*** Closure rule for Government savings is part of the Govt Closure Rules**

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Government Closure Rules

```
$ontext
 The 'default' setting for this MODEL is that Tax rates and govt
'demand' are FIXED
     Govt saving is then the equilibrating variable (FLEXIBLE)

 The 'standard' presumption is this MODEL is that when Govt savings
and 'demand' are FIXED
     ONE (or more) tax instrument is the equilibrating variable (FLEX)

 Thus, tax rates can be policy instruments and/or equilibrating
       variables, which complicates matters.

  Govt 'demand' FIXED in terms of VOLUME, VALUE or Share of Absorption
       Govt 'demand' can also be an equilibrating variable (QGDADJ)
$offtext
```

- 'Default' setting
  - All tax rates and shares of absorption FIXED
  - Government savings the equilibrating variables

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Which Tax Rate?

- Tax rates
  - Policy instruments
    - Shocks – must be parameters in the model
  - Equilibrating variables
    - Tax replacement closures – 'standard'

OPTIONS

- Absolute values
- Absolute changes
- Equiproportionate changes
- Equal additive changes
- Differential additive changes

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Government Closure: Tax Rates 1

```
*#### Tax rates - ALL tax rates are FIXED in 'default'

*## Tax rate scaling factors

* T*ADJ control multiplicative changes in tax rates

 TEADJ.FX(r)          = TEADJ0(r) ;
 TMADJ.FX(r)          = TMADJ0(r) ;
 TSADJ.FX(r)          = TSADJ0(r) ;
 TVADJ.FX(r)          = TVADJ0(r) ;
 TXADJ.FX(r)          = TXADJ0(r) ;
 TYFADJ.FX(r)         = TYFADJ0(r) ;
 TYHADJ.FX(r)         = TYHADJ0(r) ;
 TFADJ.FX(r)          = TFADJ0(r) ;
```

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Government Closure: Tax Rates 2

```
*#### Tax rates - ALL tax rates are FIXED in 'default'

* DT* control additive changes in tax rates
* NB DT* needs to be used in conjunction with t*01

 DTE.FX(r)            = DTE0(r) ;
 DTM.FX(r)            = DTM0(r) ;
 DTS.FX(r)            = DTS0(r) ;
 DTV.FX(r)            = DTV0(r) ;
 DTX.FX(r)            = DTX0(r) ;
 DTYF.FX(r)           = DTYF0(r) ;
 DTYH.FX(r)           = DTYH0(r) ;
 DTF.FX(r)            = DTF0(r) ;
```

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Government Closure: Expenditure

```
*#### GOVERNMENT EXPENDITURE
* FIX volume

* QGDADJ.FX(r)         = QGDADJ0(r) ;

* OR FIX nominal

* EG.FX(r)            = EG0(r) ;

* OR FIX shares of final demand

 VGDSH.FX(r)          = VGDSH0(r) ;
```

- If adjustment via Government savings
  - Uninteresting – 'manna from heaven'
- If Government savings 'fixed'
  - One of more tax rates or expenditure must change to clear

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Government Closure: Savings

```
*#### GOVERNMENT SAVINGS
* Internal balance (Govt savings) can be FIXED or
FLEXIBLE

* KAPGOV.FX(r)        = KAPGOV0(r) ;
```

- 'Default' setting
  - Adjustment via Government savings
- If adjustment via Government savings
  - Uninteresting – 'manna from heaven'
- If Government savings 'fixed'
  - One of more tax rates must change to clear
  - OR expenditure must change to clear

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Government Closure Rules 3

- If Government savings 'fixed' AND investment fixed
  - The savings must adjust to clear the investment-savings account
  - BUT only household savings free to adjust

Interactions between closure rule decisions

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Summary

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Macroeconomic Closures

It is important to understand how different macroeconomic models are closed

- Macro closures are important ECONOMIC determinants of the results from CGE models
  - the mathematics are trivial
- Understanding the roles of macro closures is critical to the interpretation of CGE results
- Acknowledging the assumptions made with macro closures is important

The 'standard' closure options in ANARRES_t are NOT exhaustive. It may be necessary to be creative and/or to modify the code to extend the range of options

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Macroeconomic Closures

The default closure in ANARRES_t is NOT a recommendation.
It is a pragmatic set of assumptions designed to ease deriving a solution that ensures the model is correctly calibrated.

Users need to design, justify and defend the macroeconomic closure settings they choose for policy analysis

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The End

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