

Reverse Engineering the Eview Code in the FRB/US Model

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Chapter 1

Introduction

Chapter 2

FRB/US Package

2.1 example1 program

```
3  <frbus example1 3>≡ (194c)
    ' Program for simple simulation under VAR expectations
    ,
    ' See FRB/US Simulation Basics document for information about
    ' this program

    ' *****
    ' Initial filename and parameter settings
    ' *****

    ' Subroutines
    include ../subs/master_library

    ' Workfile
    %wfstart = "1975q1"
    %wfend = "2030q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

    ' FRB/US model name and location
    %varmod = "stdver"
    %varpath = "../mods/"

    ' Input database
    %dbin = "../data/longbase"

    ' Simulation range
    %simstart = "2020q1"
```

```

%simend    = "2025q4"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' Load equations and coefficients
ld_frbus_eqs(modelname=%varmod,modelpath=%varpath)
ld_frbus_cfs(modelname=%varmod,modelpath=%varpath)

' Load data
dbopen %dbin as longbase
fetch(d=longbase) *

' Set monetary policy rule
smpl @all
call set_mp("dmpintay")

' Turn off zero bound and policy thresholds; hold policymaker's
' perceived equilibrium real interest rate constant
smpl @all
dmptrsh = 0
rffmin = -9999
drstar = 0

' Set fiscal policy
smpl @all
call set_fp("dfpsrp")

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")
call group2zero("endog_aerr")

' Standard solution options
{%varmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
%suftrk = "_0"
smpl %simstart %simend
{%varmod}.addassign @all
{%varmod}.addinit(v=n) @all
{%varmod}.scenario(n,a={%suftrk}) "track"

```

```

{%varmod}.solve
scalar mm = @max(@abs(xgap{%suftrk}-xgap))
if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
endif

' *****
' Simulate a shock to monetary policy rule
' *****

%sufsim = "_1"
{%varmod}.scenario(n,a={%sufsim}) "sim"

smpl %simstart %simstart
rffintay_aerr = rffintay_aerr + 1

smpl %simstart %simend
{%varmod}.solve

' *****
' Make a graph
' *****

smpl %simstart %simend
series zero = 0
series d_rff = rff{%sufsim} - rff
series d_rg10 = rg10{%sufsim} - rg10
series d_lur = lur{%sufsim} - lur
series d_pic4 = pic4{%sufsim} - pic4

graph fig1a.line zero d_rff
fig1a.addtext(t,just(c),font("arial",12)) Federal Funds Rate
fig1a.legend -display

graph fig1b.line zero d_rg10
fig1b.addtext(t,just(c),font("arial",12)) 10-Year Treasury Yield
fig1b.legend -display

graph fig1c.line zero d_lur
fig1c.addtext(t,just(c),font("arial",12)) Unemployment Rate
fig1c.legend -display

graph fig1d.line zero d_pic4
fig1d.addtext(t,just(c),font("arial",12)) Inflation Rate (4-Quarter)

```

```
fig1d.legend -display

graph fig1.merge fig1a fig1b fig1c fig1d
fig1.addtext(t,just(c),font("Arial",16)) Macroeconomic Effects of Funds Rate Pertur
fig1.align(2,1,1.25)
show fig1
```

Uses dbopen 215, dfpsrp 216, dmpintay 216, dmptrsh 216, drstar 216, fetch 215,
group2zero 89a, groupnew 90, ld_frbus.cfs 177a 177b, ld_frbus_eqs 178b 179, lur 216,
master_library 207a, pic4 216, rff 216, rffmin 216, rg10 216, set_fp 92, set_mp 93,
solve 215, wfcreate 215, and xgap 216.

2.2 example2 program

```

7  <frbus example2 7>≡ (194d)
    ' Program for simple simulation with MCE expectations
    ,
    ' The switch variables %mcvars_wp and %mcvars_all control whether
    ' the assumption of MC expectations extends beyond the financial
    ' sector

    ' See the Simulation Basics document for information about
    ' this program

    ' *****
    ' Initial filename and parameter settings
    ' *****

    ' Subroutines
    include ../subs/master_library
    include ../subs/mce_solve_library

    ' Workfile
    %wfstart = "1975q1"
    %wfend = "2100q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

    ' FRB/US model names and locations
    %varmod = "stdver"
    %varpath = "../mods/"
    %mcemod = "pfver"
    %mcepath = "../mods/"

    ' Input database
    %dbin = "../data/longbase"

    ' Simulation range
    %simstart = "2020q1"
    %simend = "2069q4"

    ' *****
    ' Retrieve data, model equations and coefficients, set
    ' policy options, and compute tracking residuals
    ' *****

```

```

' Specify MC expectations variables
%mcvars_wp = "yes"
%mcvars_all = "no"

' MCE asset pricing
%zvars = "zdivgr zgap05 zgap10 zgap30 zrff5 zrff10 zrff30 zpi10 zpi10f zpic30 zpi10b

' MCE elsewhere
if %mcvars_wp = "yes" and %mcvars_all = "no" then
    %zvars = %zvars + "zpicxfe zpieci "
endif
if %mcvars_all = "yes" then
    %zvars = %zvars + "zpicxfe zpieci "
    %zvars = %zvars + "zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvpi zvps zxbd zxbi zxbs z
endif

' Load equations and coefficients
call mce_load_frbus("mce_vars=%zvars,mod_b=%varmod,path_b=%varpath,mod_f=%mcemod,p

' Load data
dbopen %dbin as longdata
fetch(d=longdata) *

' Data for extra variables associated with MC expectations
smpl @all
call make_frbus_mcevars(%zvars)

' Set monetary policy
smpl @all
call set_mp("dmpintay")

' Turn off zero bound and policy thresholds; hold policymaker's
' perceived equilibrium real interest rate constant
smpl @all
dmptrsh = 0
rffmin = -9999
drstar = 0

' Set fiscal policy
smpl @all
call set_fp("dfpsrp")

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")

```

```

    call group2zero("endog_aerr")

' Standard solution options
  {%varmod}.solveopt(o=b,g=12,z=1e-12)
  {%mccmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
  %suftrk = "_0"
  smpl %simstart %simend
  {%varmod}.addassign @all
  {%varmod}.addinit(v=n) @all
  {%varmod}.scenario(n,a={%suftrk}) "track"
  {%varmod}.solve
  scalar mm = @max(@abs(xgap{%suftrk}-xgap))
  if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
  endif
  {%mccmod}.addassign @all
  {%mccmod}.addinit(v=n) @all

' *****
' Simulate a monetary policy shock
' *****

  %sufsim = "_1"
  {%varmod}.scenario(n,a={%sufsim}) "sim"
  {%mccmod}.scenario(n,a={%sufsim}) "sim"

  smpl %simstart %simstart
  rffintay_a = rffintay_a + 1

  %modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
  %algstr = "meth=qnewton"
  %simstr = "type=single"
  smpl %simstart %simend
  call mce_run(%modstr,%algstr,%simstr)

' *****
' Make a graph
' *****

  smpl %simstart %simstart + 39
  series zero = 0
  series d_rff = rff{%sufsim} - rff

```

```

series d_rg10 = rg10{%sufsim} - rg10
series d_lur = lur{%sufsim} - lur
series d_pic4 = pic4{%sufsim} - pic4

graph fig1a.line zero d_rff
fig1a.addtext(t,just(c),font("arial",12)) Federal Funds Rate
fig1a.legend -display

graph fig1b.line zero d_rg10
fig1b.addtext(t,just(c),font("arial",12)) 10-Year Treasury Yield
fig1b.legend -display

graph fig1c.line zero d_lur
fig1c.addtext(t,just(c),font("arial",12)) Unemployment Rate
fig1c.legend -display

graph fig1d.line zero d_pic4
fig1d.addtext(t,just(c),font("arial",12)) Inflation Rate (4-Quarter)
fig1d.legend -display

graph fig1.merge fig1a fig1b fig1c fig1d
%title = " Macroeconomic Effects of Funds Rate Shock\r"
if %mcvars_wp = "no" and %mcvars_all = "no" then
    %title = %title + "(MC Expectations in Asset Pricing)"
endif
if %mcvars_wp = "yes" and %mcvars_all = "no" then
    %title = %title + "(MC Expectations in Asset Pricing and Price-Wage Setting)"
endif
if %mcvars_all = "yes" then
    %title = %title + "(MC Expectations in All Sectors)"
endif
fig1.addtext(t,just(c),font("Arial",16)) {%title}
fig1.align(2,1,1.25)
show fig1

```

Uses dbopen 215, dfpsrp 216, dmpintay 216, dmptrsh 216, drstar 216, fetch 215, group2zero 89a, groupnew 90, lur 216, make_frbus_mcevars 173, master_library 207a, mce_load_frbus 169, mce_run 97, mce_solve_library 208 213b, pic4 216, rff 216, rffmin 216, rg10 216, set_fp 92, set_mp 93, solve 215, wfcreate 215, xgap 216, zdivgr 216, zecd 216, zeco 216, zeh 216, zgap05 216, zgap10 216, zgap30 216, zgapc2 216, zlhp 216, zpi10 216, zpi10f 216, zpi5 216, zpib5 216, zpic30 216, zpic58 216, zpicxfe 216, zpieci 216, zrff10 216, zrff30 216, zrff5 216, zvpd 216, zvpi 216, zvps 216, zxbd 216, zxbi 216, zxbs 216, zyh 216, zyhp 216, zyht 216, and zynid 216.

2.3 example3 program

11 `<frbus example3 11>≡` (195a)

```

' Program for simulation under VAR expectations that illustrates how
' to set the monetary policy options that impose the zero lower bound
' on the funds rate and delay the liftoff of the funds rate from the
' ZLB until either the unemployment rate falls below a threshold or
' inflation rises above a threshold.
'
' See FRB/US Simulation Basics document for general information about
' this program.

' Additional notes:

' 1. The scenario involves a set of negative aggregate demand
' shocks and a positive risk premium shock that start in 2003q3,
' when the baseline (historical) funds rate is about one percent.
' The shocks are equal to the equation errors actually observed
' in the four quarters starting in 2008q4.

' 2. To impose the ZLB set %zb = "yes" (rather than "no")

' 3. To impose the policy liftoff threshold conditions set both
' %zb = "yes" and %threshold = "yes". For illustrative purposes
' and reflecting the baseline conditions in 2003 and the years
' that immediately follow, the inflation threshold is set to 3.0
' and the unemployment threshold is set to 7.0, subject to the
' the adjustments described next.

' 4. Because the threshold conditions only make sense once the ZLB is
' binding, unemployment is above its threshold level (lurtrsh),
' and inflation is below its threshold (pitrsh), which is not the
' case in the initial simulation quarters, the program turns on the
' threshold code (using dmptrsh) in the 5th simulation quarter,
' at which point these conditions hold. In addition, for the threshold
' code to work properly, the endogenous switch variable dmptr must be
' zero in the quarter prior to the quarter in which the threshold code is
' turned on. This is accomplished by setting the baseline data on dmptr
' to zero and by setting the unemployment and inflation thresholds
' (lurtrsh, pitrsh) to values in the first four simulation quarters that
' would not flip the dmptr switch to one.

' 4. Choose one of the five available policy rules by setting
' %policy to one of rffintay, rfftay, rfftlr, rffalt, or rffgen.

' 5. If neither the ZLB or thresholds are imposed, the monetary policy

```

```

' equations have baseline-tracking adds and the simulation is
' a standard deviations-from-baseline exercise.

' 6. If either the ZLB or thresholds are imposed, the add factors on
' monetary policy equations are set to zero after the tracking adds
' are computed so that the ZLB and threshold conditions are based on the
' actual simulated outcomes for the funds rate and inflation and unemployment,
' not their deviations from baseline.

' *****
' Initial filename and parameter settings
' *****

' Subroutines
include ../subs/master_library

' Workfile
%wfstart = "1975q1"
%wfend = "2012q4"
%mainpage = "main"
wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

' FRB/US model name and location
%varmod = "stdver"
%varpath = "../mods/"

' Input database
%dbin = "../data/longbase"

' Simulation range
%simstart = "2003q3"
%simend = "2008q2"

' Policy
%zb = "yes"
%threshold = "yes"
%policy = "rfftay"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' Load equations and coefficients
ld_frbus_eqs(modelname=%varmod,modelpath=%varpath)

```

```

ld_frbus_cfs(modelname=%varmod,modelpath=%varpath)

' Load data
dbopen %dbin as longbase
fetch(d=longbase) *

' Set monetary policy rule
smpl @all
%policydmp = @replace(%policy,"rff","dmp")
call set_mp(%policydmp)

' Set ZLB
if %zb = "yes" then
    rffmin = .125
else
    rffmin = -9999
endif

' Set threshold variables
if %threshold = "yes" then
    if %zb = "no" then
        @uiprompt("When policy thresholds are imposed, the zero bound must also be imposed")
        stop
    endif
    smpl @all
    call dateshift(%simstart,%quarter4,3)
' thresholds (dmptrsh and dmptr) not active in first 4 qtrs
    smpl %simstart - 1 %quarter4
    dmptrsh = 0
    lurtrsh = -9999
    pitrsh = 9999
    dmptr = 0
' thresholds (dmptrsh and dmptr) active starting in qtr 5
    smpl %quarter4 + 1 %simend
    dmptrsh = 1
    lurtrsh = 7.0
    pitrsh = 3.0
    smpl @all
    else
    smpl @all
    dmptrsh = 0
    endif

smpl @all
drstar = 0

```

```

' Set fiscal policy
  smpl @all
  call set_fp("dfpsrp")

' Set _aerr variables to zero
  smpl @all
  {%varmod}.makegroup(a,n) endog @endog
  call groupnew("endog","_aerr")
  call group2zero("endog_aerr")

' Standard solution options
  {%varmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
  %suftrk = "_0"
  smpl %simstart 2012q4
  {%varmod}.addassign @all
  {%varmod}.addinit(v=n) @all
  {%varmod}.scenario(n,a={%suftrk}) "track"
  {%varmod}.solve
  scalar mm = @max(@abs(xgap{%suftrk}-xgap))
  if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
  endif

' Set monetary policy add factors to zero when ZLB or threshold are
' imposed

if %zb = "yes" then
  smpl @all
  {%policy}_a = 0
  rffrule_a = 0
  rffe_a = 0
  if %threshold = "yes" then
    dmptpi_a = 0
    dmptlur_a = 0
    dmptmax_a = 0
    dmptr_a = 0
  endif
endif

' *****
' Simulation
' *****

```

```

%sufsim = "_1"
{%varmod}.scenario(n,a={%sufsim}) "sim"

' shock values are taken from equation residuals for 2008q4-2009q3
eco_a.fill(o=%simstart) -.006, -.006, -.011, -.001
ecd_a.fill(o=%simstart) -.091, -.018, -.021, .029
eh_a.fill(o=%simstart) -.076, -.078, -.040, .073
epd_a.fill(o=%simstart) -.096, -.062, .014, .032
eps_a.fill(o=%simstart) -.018, -.046, -.036, -.017
rbbbp_a.fill(o=%simstart) 2.70, 0.38, -0.89, -1.35

smpl %simstart %simend
{%varmod}.solve

' *****
' Make a graph
' *****

smpl %simstart %simend

graph fig1a.line rff rff{%sufsim}
fig1a.addtext(t,just(c),font("arial",12)) Federal Funds Rate
fig1a.legend -display

graph fig1b.line rg10 rg10{%sufsim}
fig1b.addtext(t,just(c),font("arial",12)) 10-Year Treasury Yield
fig1b.legend -display

graph fig1c.line lur lur{%sufsim}
fig1c.addtext(t,just(c),font("arial",12)) Unemployment Rate
fig1c.legend -display

graph fig1d.line pic4 pic4{%sufsim}
fig1d.addtext(t,just(c),font("arial",12)) Inflation Rate (4-Quarter)
fig1d.legend -display

%title = "Macroeconomic Effects of Negative AD Shock\r(VAR Expectations"
%title = %title + "; Policy = " + %policy + ")"
if %zb = "yes" and %threshold = "no" then
    %title = %title + "\r(ZLB Imposed)"
endif
if %zb = "yes" and %threshold = "yes" then
    %title = %title + "\r(ZLB and Thresholds Imposed)"
endif

```

```
graph fig1.merge fig1a fig1b fig1c fig1d
fig1.addtext(t,just(c),font("Arial",16)) {%title}
fig1.addtext(b,just(c),font("Arial",16)) Blue: Actual; Red: Simulated
fig1.align(2,1,1.25)
show fig1
```

Uses dateshift 87, dbopen 215, dfpsrp 216, dmptr 216, dmptrsh 216, drstar 216, fetch 215, group2zero 89a, groupnew 90, ld_frbus.cfs 177a 177b, ld_frbus_eqs 178b 179, lur 216, lurtrsh 216, master_library 207a, pic4 216, ptrsh 216, rff 216, rffalt 216, rffgen 216, rffintay 216, rffmin 216, rfftay 216, rfftlr 216, rg10 216, set_fp 92, set_mp 93, solve 215, wfcreate 215, and xgap 216.

2.4 example4 program

```

17  <frbus example4 17>≡ (195b)
    ' This MCE example program illustrates:
    '
    ' 1. how to use a monetary policy rule that is not one of the policy
    '   alternatives included in FRB/US;
    ' 2. how to add new MCE expectations variables;
    ' 3. how to drop one of the regular FRB/US equations as part of the process
    '   of loading the model
    '
    ' Most of the code needed illustrate these issues is located between
    ' the "start of new code" and "end of new code" comments below
    '
    ' The switch variables %mcvars_wp and %mcvars_all control whether
    ' the assumption of MC expectations extends beyond the financial
    ' sector
    '
    ' See the Simulation Basics document for information about
    ' this program
    '
    ' *****
    ' Initial filename and parameter settings
    ' *****
    '
    ' Subroutines
    include ../subs/master_library
    include ../subs/mce_solve_library
    '
    ' Workfile
    %wfstart = "1975q1"
    %wfend = "2100q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}
    '
    ' FRB/US model names and locations
    %varmod = "stdver"
    %varpath = "../mods/"
    %mcmod = "pfver"
    %mcepath = "../mods/"
    '
    ' Input database
    %dbin = "../data/longbase"
    '
    ' Simulation range

```

```

%simstart = "2010q1"
%simend   = "2069q4"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' Specify MC expectations variables
%mcvars_wp = "no"
%mcvars_all = "yes"

' MCE asset pricing
%zvars = "zdivgr zgap05 zgap10 zgap30 zrff5 zrff10 zrff30 zpi10 zpi10f zpic30 zpi10f"

' MCE elsewhere
if %mcvars_wp = "yes" and %mcvars_all = "no" then
    %zvars = %zvars + "zpicxfe zpieci "
endif
if %mcvars_all = "yes" then
    %zvars = %zvars + "zpicxfe zpieci "
    %zvars = %zvars + "zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvpi zvps zxbd zxbi zxbs "
endif

' Load equations and coefficients

' drop one of the FRB/US monetary policy rule equations (rffgen) so that it can be
' replaced below with an alternative rule
%allbut = "rffgen"
call mce_load_frbus("mce_vars=%zvars,mod_b=%varmod,path_b=%varpath,mod_f=%mcemod,path_f=%varpath")

' Load data
dbopen %dbin as longdata
fetch(d=longdata) *

' *****
' *****
' start of new code (aside from the change above to mce_load_frbus and
' the change below to the call to set_mp)

' Code a first-difference interest rate rule as rffgen. The first-difference rule d
' the expected output gap three quarters ahead (zgap3) and on expected 4-qtr inflation
' quarters ahead (zpic43). The name of each new expectation must start with a "z".
{%varmod}.append rffgen-rffgen_aerr = rffe(-1) + .5*(zpic43-pitarg) + .5*(zgap3-zg

```



```

' Add the MCE definitions of zgap3 and zpic43 to the forward-looking model,
' noting that the MCE names of these variables must start with a "w" rather than a "z".
{%mccmod}.append wgap3-wgap3_aerr = xgap2(3)
{%mccmod}.append wpic43-wpic43_aerr = picx4(3)
' Add expectations error equations to the MCE model
{%mccmod}.append ezgap3 = zgap3-wgap3
{%mccmod}.append ezpic43 = zpic43-wpic43

' Add to the backward-looking model simple equations for the new expectations variables.
' Technically, these equations should be the appropriate VAR expectations formulas, but
' because in this program these expectations will always be MCE, the form of their
' backward-looking identities is not very important.
{%varmod}.append zgap3-zgap3_aerr = .5*xgap2(-1)
{%varmod}.append zpic43-zpic43_aerr = .5*picx4(-1)+.5*ptr(-1)

' Add the new MCE variables to the %zvars string
%zvars = %zvars + " zgap3 zpic43"

' Define baseline values of the new expectations variables
smpl @all
series zgap3 = xgap2(3)
series zpic43 = picx4(3)

' Make sure that the baseline data for rffgen matches the baseline data for rffe
rffgen = rffe

' end of new code
' *****
' *****

' Data for extra variables associated with MC expectations
smpl @all
call make_frbus_mcevars(%zvars)

' Set monetary policy to use the first-difference policy rule (coded as rffgen)
smpl @all
call set_mp("dmpgen")

' Turn off zero bound and policy thresholds; hold policymaker's
' perceived equilibrium real interest rate constant
smpl @all
dmptrsh = 0
rffmin = -9999
drstar = 0

' Set fiscal policy

```

```

smpl @all
call set_fp("dfpsrp")

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")
call group2zero("endog_aerr")

' Standard solution options
{%varmod}.solveopt(o=b,g=12,z=1e-12)
{%mccmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
%suftrk = "_0"
smpl %simstart %simend
{%varmod}.addassign @all
{%varmod}.addinit(v=n) @all
{%varmod}.scenario(n,a={%suftrk}) "track"
{%varmod}.solve
scalar mm = @max(@abs(xgap{%suftrk}-xgap))
if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
endif
{%mccmod}.addassign @all
{%mccmod}.addinit(v=n) @all

' *****
' Simulate the effects of a one-percent consumption shock
' *****

%sufsim = "_1"
{%varmod}.scenario(n,a={%sufsim}) "sim"
{%mccmod}.scenario(n,a={%sufsim}) "sim"

smpl %simstart %simstart
eco_a = eco_a + .01

%modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
%algstr = "meth=qnewton"
%simstr = "type=single"
smpl %simstart %simend
call mce_run(%modstr,%algstr,%simstr)

```

```

'*****
' Make a graph
'*****

smpl %simstart %simstart + 39
series zero = 0
series d_rff = rff{%sufsim} - rff
series d_rg10 = rg10{%sufsim} - rg10
series d_lur = lur{%sufsim} - lur
series d_pic4 = pic4{%sufsim} - pic4

graph fig1a.line zero d_rff
fig1a.addtext(t,just(c),font("arial",12)) Federal Funds Rate
fig1a.legend -display

graph fig1b.line zero d_rg10
fig1b.addtext(t,just(c),font("arial",12)) 10-Year Treasury Yield
fig1b.legend -display

graph fig1c.line zero d_lur
fig1c.addtext(t,just(c),font("arial",12)) Unemployment Rate
fig1c.legend -display

graph fig1d.line zero d_pic4
fig1d.addtext(t,just(c),font("arial",12)) Inflation Rate (4-Quarter)
fig1d.legend -display

graph fig1.merge fig1a fig1b fig1c fig1d
%title = " Macroeconomic Effects of a Shock to Consumption\r"
if %mcvars_wp = "no" and %mcvars_all = "no" then
    %title = %title + "(MC Expectations in Asset Pricing)"
endif
if %mcvars_wp = "yes" and %mcvars_all = "no" then
    %title = %title + "(MC Expectations in Asset Pricing and Price-Wage Setting)"
endif
if %mcvars_all = "yes" then
    %title = %title + "(MC Expectations in All Sectors)"
endif
fig1.addtext(t,just(c),font("Arial",16)) {%title}
fig1.align(2,1,1.25)
show fig1

```

Uses dbopen 215, dfpsrp 216, dmpgen 216, dmptrsh 216, drstar 216, fetch 215,
group2zero 89a, groupnew 90, lur 216, make_frbus_mcevars 173, master_library 207a,
mce_load_frbus 169, mce_run 97, mce_solve_library 208 213b, pic4 216, picx4 216,

pitarg 216, ptr 216, rff 216, rffe 216, rffgen 216, rffmin 216, rg10 216, set_fp 92, set_mp 93, solve 215, wfcreate 215, xgap 216, xgap2 216, zdivgr 216, zecd 216, zeco 216, zeh 216, zgap05 216, zgap10 216, zgap30 216, zgapc2 216, zlhp 216, zpi10 216, zpi10f 216, zpi5 216, zpib5 216, zpic30 216, zpic58 216, zpicxfe 216, zpieci 216, zrff10 216, zrff30 216, zrff5 216, zvpd 216, zvpi 216, zvps 216, zxbd 216, zxbi 216, zxbs 216, zyh 216, zyhp 216, zyht 216, and zynid 216.

2.5 ocpolicy program

23 `<frbus ocpolicy 23>≡` (195c)

```

' Routine to simulate how the SEP baseline forecast would change if
' policymakers commit to a path for the federal funds rate that is
' determined by optimal-control (OC) techniques to minimize a
' quadratic loss function.
'
' Detailed information on the mechanics of the OC algorithm and the
' various required and optional parameters that set up and guide its
' execution is available in the MCE Solve Users Guide in the
' documentation directory. Most relevant is the part of section 5
' that describes the "opt" simulation type as well as table 7.
'
' As specified below, the loss function penalizes equally weighted
' squared deviations of the unemployment rate from the natural rate,
' squared deviations of inflation from a 2 percent, and squared
' quarterly changes in the funds rate.
'
' In the SEP baseline, agents with model-consistent (MC) expectations
' are initially assumed to project that the funds rate will follow the
' baseline path and to set their baseline expectations
' accordingly. At the start of the optimal control simulation, however,
' these agents immediately and fully revise their expectations to be
' consistent with the revision to the funds rate path that occurs under
' optimal control -- that is, agents have rational expectations and
' announced policy actions are completely credible.
'
' The experiment can be run with the zero lower bound (ZLB) imposed
' (%zerobound = "yes") or not imposed (%zerobound = "no"). When
' the ZLB is imposed, a penalty term is added to the loss function.
'
' *****
' Initial filename and parameter settings
' *****
'
' Subroutines
' include ../subs/master_library
' include ../subs/mce_solve_library
'
' Workfile
' %wfstart = "1975q1"
' %wfend = "2100q4"
' %mainpage = "main"
' wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

```

```

' FRB/US model names and locations
%varmod = "stdver"
%varpath = "../mods/"
%mcemod = "pfver"
%mcepath = "../mods/"

' Input database
%dbin = "../data/longbase"

' Simulation range
%simstart = "2014q4"
%simend = "2070q4"

' Primary loss function parameters: The value of the policy instrument
' is chosen optimally from %drvstart to %drvend (60 qtrs) to minimize
' the loss function from %evlstart to %evlend (80 qtrs). The three
' arguments of the period loss function are weighted by the the
' weight parameters and over time losses are discounted at the rate
' %discount
%evlstart = %simstart
%drvstart = %simstart
call dateshift(%evlstart,%evlend,79)
call dateshift(%drvstart,%drvend,59)
%discount = ".99"
%u_weight = "1.0"
%p_weight = "1.0"
%r_weight = "1.0"

' Optionally impose the zero lower bound
%zerobound = "yes"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' Specify MC expectations variables
%mcvars_wp = "yes"
%mcvars_all = "no"

' MCE asset pricing
%zvars = "zdivgr zgap05 zgap10 zgap30 zrff5 zrff10 zrff30 zpi10 zpi10f zpic30 zpi10f"

' MCE elsewhere
if %mcvars_wp = "yes" and %mcvars_all = "no" then

```

```

    %zvars = %zvars + "zpicxfe zpieci "
    endif
    if %mcvars_all = "yes" then
        %zvars = %zvars + "zpicxfe zpieci "
        %zvars = %zvars + "zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvpi zvps zxbd zxnfbz zxnfbz zyh zy"
    endif

' Load equations and coefficients
    call mce_load_frbus("mce_vars=%zvars,mod_b=%varmod,path_b=%varpath,mod_f=%mce_mod,path_f=%mce_path")

' Add a ugap equation
    {%varmod}.append ugap - ugap_aerr = lur - lurnat

' Load data
    dbopen %dbin as longdata
    fetch(d=longdata) *

' Define SEP-consistent ustar and ugap series; this step is needed because
' the baseline value of lurnat may not be fully SEP-consistent in the
' short-to-medium ruun
    smpl @all
    series ustar = lurnat
    smpl %simstart 2025q4
    ustar = 5.35
    smpl @all
    series ugap = lur-ustar
    series ugap_aerr = 0

' Data for extra variables associated with MC expectations
    smpl @all
    call make_frbus_mcevars(%zvars)

' Set monetary policy option (the residual on the equation of
' the chosen option is the OC policy instrument)
    smpl @all
    call set_mp("dmptay")

' Initially turn off zero lower bound; if %zerobound = "yes", it will be
' imposed below by adding a penalty term to the loss function.
    smpl @all
    rffmin = -9999

' Turn off policy thresholds
    dmptrsh = 0

' Let the perceived equilibrium real interest rate vary
    drstar = 1

```

```

' Set fiscal policy so that it is exogenous for first 20 qtrs and then
' turns on debt targeting rule
smpl %simstart %simstart + 19
call set_fp("dfpex")
smpl %simstart + 20 %simend
call set_fp("dfpdbl")

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")
call group2zero("endog_aerr")

' Standard solution options
{%varmod}.solveopt(o=b,g=12,z=1e-12)
{%mccmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
%suftrk = "_0"
smpl %simstart %simend
{%varmod}.addassign @all
{%varmod}.addinit(v=n) @all
{%varmod}.scenario(n,a={%suftrk}) "track"
{%varmod}.solve
scalar mm = @max(@abs(xgap{%suftrk}-xgap))
if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
endif
{%mccmod}.addassign @all
{%mccmod}.addinit(v=n) @all

'*****
' optimal policy setup
'*****

' The policy instrument is a time varying constant in the equation
' for the selected policy rule
group opt_instrus rftay_aerr

' Loss function variables (unemployment gap, 4-qtr PCE inflation,
' and the first difference of the federal funds rate)
group opt_targs ugap pic4 delrff

```



```

' The desired paths of the loss function variables are specified in
' series with "_t" suffix.
smpl @all
series ugap_t = 0
series delrff_t = 0
series pic4_t = 2.0

' The weights on the loss function arguments are specified in
' series with "_w" suffix.
series ugap_w = @val(%u_weight)
series pic4_w = @val(%p_weight)
series delrff_w = @val(%r_weight)

!discount = @val(%discount)
smpl %simstart+1 %simend
ugap_w = !discount * ugap_w(-1)
pic4_w = !discount * pic4_w(-1)
delrff_w = !discount * delrff_w(-1)

' Zero bound penalty function
if %zerobound = "yes" then
    {%varmod}.append penalty - penalty_aerr = _
        @recode(rff<(rff_lo_bnd+rff_lo_shift), _
            3.0*((rff_lo_bnd+rff_lo_shift)-rff), _
            0) _
        + @recode(rff<(rff_lo_bnd+rff_lo_shift), _
            .10*exp(10*(rff-(rff_lo_bnd+rff_lo_shift))), _
            .10*exp(-20*(rff-(rff_lo_bnd+rff_lo_shift))))
smpl @all
series rff_lo_bnd = .125
series rff_lo_shift = .00
series penalty = 0
series penalty_aerr = 0
series rffmin = -9999
%penalty_weight = "10.0"
opt_targs.add penalty
smpl @all
series penalty_a = 0
series penalty_t = 0
series penalty_w = @val(%penalty_weight)
smpl %simstart+1 %simend
penalty_w = !discount * penalty_w(-1)
endif

```

```

'*****
' optimal policy simulation
'*****

% sufcontrol = "_1"

' In %simstr, the "type=opt" string designates a commitment-based
' OC simulation. The required "instrus" and "targs" keywords point to
' the groups containing the policy instrument(s) and target variables.
' FRB/US simulations of this type generally run much more quickly with
' the newton MCE algorithm than they do with qnewton.
%modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
%algstr = "jinit=interp(4), meth=newton"
%simstr = "type=opt,instrus=opt_instrus,targs=opt_targs"
%simstr = %simstr + ",scen,suf=" + %sufcontrol + ",solveopt=%sopt"
%simstr = %simstr + ",lend=" + %evlend + ",iend=" + %drvend + ",lmax=20"
smpl {%simstart} {%simend}
call mce_run(%modstr,%algstr,%simstr)

' When the ZLB is imposed, run the OC algorithm a second time,
' after adjusting the intercept of the penalty function,
' to hit ZLB more closely
if %zerobound = "yes" then
    smpl if rff{%sufcontrol} < .2
        rff_lo_shift = .125 - rff{%sufcontrol}
        %modstr = ""
        %algstr = ""
        %simstr = "type=opt,instrus=opt_instrus,targs=opt_targs"
        %simstr = %simstr + ",solveopt=%sopt"
        %simstr = %simstr + ",lend=" + %evlend + ",iend=" + %drvend + ",lmax=20"
        smpl {%simstart} {%simend}
        call mce_run(%modstr,%algstr,%simstr)
    endif

'*****
' graph results
'*****

call dateshift(%simstart,%graphstart,-8)
call dateshift(%simstart,%graphend,32)

smpl %graphstart %graphend
graph fig1a.line rff{%sufcontrol} rff
fig1a.options size(7,4.2)
fig1a.legend display -inbox position(3.8,2.8) font("arial",15)

```

```

fig1a.datelabel format(yy)
fig1a.addtext(6.4,-.30,font("arial",13),keep) percent
fig1a.axis(left) font("arial",15)
fig1a.axis(bottom) font("arial",15)
fig1a.setelem(1) lcolor(red) legend("optimal control") lwidth(2)
fig1a.setelem(2) lcolor(black) legend("SEP-consistent baseline") lwidth(2)
fig1a.addtext(t,just(c),font("arial",18)) Federal Funds Rate

```

```

smpl %graphstart %graphend
graph fig1b.line rg10{%sufcontrol} rg10
fig1b.options size(7,4.2)
fig1b.legend display -inbox position(3.8,2.8) font("arial",15)
fig1b.datelabel format(yy)
fig1b.addtext(6.4,-.30,font("arial",13),keep) percent
fig1b.axis(left) font("arial",15)
fig1b.axis(bottom) font("arial",15)
fig1b.setelem(1) lcolor(red) legend("optimal control") lwidth(2)
fig1b.setelem(2) lcolor(black) legend("SEP-consistent baseline") lwidth(2)
fig1b.addtext(t,just(c),font("arial",18)) 10-Year Treasury Yield

```

```

smpl %graphstart %graphend
graph fig1c.line lur{%sufcontrol} lur
fig1c.options size(7,4.2)
fig1c.legend display -inbox position(3.9,0.3) font("arial",15)
fig1c.datelabel format(yy)
fig1c.addtext(6.4,-.30,font("arial",13),keep) percent
fig1c.axis(left) font("arial",15)
fig1c.axis(bottom) font("arial",15)
fig1c.setelem(1) lcolor(red) legend("optimal control") lwidth(2)
fig1c.setelem(2) lcolor(black) legend("SEP-consistent baseline") lwidth(2)
fig1c.addtext(t,just(c),font("arial",18)) Unemployment Rate

```

```

smpl %graphstart %graphend
graph fig1d.line pic4{%sufcontrol} pic4
fig1d.options size(7,4.2)
fig1d.legend display -inbox position(0.5,0.2) font("arial",15)
fig1d.datelabel format(yy)
fig1d.addtext(6.4,-.30,font("arial",13),keep) percent
fig1d.axis(left) font("arial",15)
fig1d.axis(bottom) font("arial",15)
fig1d.setelem(1) lcolor(red) legend("optimal control") lwidth(2)
fig1d.setelem(2) lcolor(black) legend("SEP-consistent baseline") lwidth(2)
fig1d.addtext(t,just(c),font("arial",18)) PCE Inflation Rate (4-Quarter)

```

```

graph fig1.merge fig1a fig1b fig1c fig1d
if %mcvars_wp = "no" and %mcvars_all = "no" then
    %title = "Macroeconomic Effects of Optimal-Control Policy with Rational Expectations"
endif
if %mcvars_wp = "yes" and %mcvars_all = "no" then
    %title = "Macroeconomic Effects of Optimal-Control Policy\n With Rational Expectations"
endif
if %mcvars_all = "yes" then
    %title = "Macroeconomic Effects of Optimal-Control Policy With Full Rational Expectations"
endif

if %zerobound = "yes" then
    %title = %title + "\rZLB Imposed"
else
    %title = %title + "\rZLB not Imposed"
endif

fig1.addtext(t,just(c),font("Arial",20)) {%title}
fig1.align(2,1,1.25)
show fig1

```

Uses dateshift 87, dbopen 215, delrff 216, dfpdbl 216, dfpex 216, dmptay 216, dmptrsh 216, drstar 216, fetch 215, group2zero 89a, groupnew 90, left 216, lur 216, lurnat 216, make_frbus_mcevars 173, master_library 207a, mce_load_frbus 169, mce_run 97, mce_solve_library 208 213b, pic4 216, rff 216, rffmin 216, rg10 216, set_fp 92, set_mp 93, solve 215, wfcreate 215, xgap 216, zdivgr 216, zecd 216, zeco 216, zeh 216, zgap05 216, zgap10 216, zgap30 216, zgapc2 216, zlhp 216, zpi10 216, zpi10f 216, zpi5 216, zpib5 216, zpic30 216, zpic58 216, zpidxfe 216, zpieci 216, zrff10 216, zrff30 216, zrff5 216, zvpd 216, zvpi 216, zvps 216, zxbd 216, zyh 216, zyhp 216, zyht 216, and zynid 216.

2.6 pings program

```

31  <simulate six ping simulations, aka simple IRFs 31>≡ (195d)
    ' Simulate six ping simulations (AKA simple IRFs)
    '
    ' Notes:
    '
    ' 1. Choose between VAR expectations and several MCE alternatives
    ' with the %mcevars parameter.
    '
    '   - %mcevars = "none"    => VAR expectations everywhere
    '   - %mcevars = "mcap"   => MCE in asset pricing, VAR expectations elsewhere
    '   - %mcevars = "mcapwp" => MCE in asset pricing and price-wage setting;
    '       VAR expectations elsewhere
    '   - %mcevars = "all"    => MCE everywhere
    '
    ' Note that even when %mcevars = "none", the program does many
    ' of the setup steps for an MCE simulation even though it never
    ' uses what they create.
    '
    ' 2. Seven of the pings are one-time shocks to the residual of an
    ' equation whose structure contains a large autoregressive
    ' element. The remaining ping involves a permanent increase in the
    ' level of trend MFP.
    '
    ' 3. The eight pings are:
    '
    '   - A 100 basis point upward shock to the rffintay monetary
    '     policy rule
    '   - An increase in federal purchases equal to one percent of
    '     baseline GDP
    '   - A one percent permanent increase in the level of trend MPF
    '   - A 100 bp increase in the equity premium
    '   - A $10 per barrel increase in the price of oil
    '   - A 1 percent (ar) increase in the growth rate of
    '     multifactor productivity
    '   - Increases of 100 basis points to the 10-year Treasury term premium,
    '     75 basis points to the 5-year premium, and 30 basis points to the
    '     30-year premium
    '   - A 10 percent increase in the (real) exchange rate
    '
    ' *****
    ' Initial filename and parameter settings
    ' *****
    '
    ' Subroutines

```

```

include ../subs/master_library
include ../subs/mce_solve_library

' Workfile
%wfstart = "1975q1"
%wfend = "2100q4"
%mainpage = "main"
wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

' FRB/US model names and locations
%varmod = "stdver"
%varpath = "../mods/"
%mcemod = "pfver"
%ncepath = "../mods/"

' Input database
%dbin = "../data/longbase"

' Simulation range
%simstart = "2020q1"
%simend = "2069q4"

' Choose an expectations option ("none" => VAR expectations, "mcap", "mcapwp", "all")
%mcevars = "none"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' MCE variable setup
if %mcevars = "none" then
    %zvars = "zpic58 "
else
    %zvars = "zdivgr zgap05 zgap10 zgap30 zrff5 zrff10 zrff30 zpi10 zpi10f zpic30 zp
    if %mcevars = "mcapwp" or %mcevars = "all" then
        %zvars = %zvars + "zpicxfe zpieci "
    endif
    if %mcevars = "all" then
        %zvars = %zvars + "zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvpi zvps zxbd zxbi zxb
    endif
endif

' Load equations and coefficients
call mce_load_frbus("mce_vars=%zvars,mod_b=%varmod,path_b=%varpath,mod_f=%mcemod,p

```

```

' Load data
dbopen %dbin as longdata
fetch(d=longdata) *

' Data for extra variables associated with MC expectations
smpl @all
call make_frbus_mcevars(%zvars)

' Set monetary policy
smpl @all
call set_mp("dmpintay")

' Turn off zero bound and policy thresholds; hold policymaker's
' perceived equilibrium real interest rate constant
smpl @all
dmptrsh = 0
rffmin = -9999
drstar = 0

' Set fiscal policy
smpl @all
call set_fp("dfpsrp")

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")
call group2zero("endog_aerr")

' Standard solution options
{%varmod}.solveopt(o=b,g=12,z=1e-12)
{%mccmod}.solveopt(o=b,g=12,z=1e-12)

' Assign baseline tracking add factors
%suftrk = "_0"
smpl %simstart %simend
{%varmod}.addassign @all
{%varmod}.addinit(v=n) @all
{%varmod}.scenario(n,a={%suftrk}) "track"
{%varmod}.solve
scalar mm = @max(@abs(xgap{%suftrk}-xgap))
if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
    stop
endif
{%mccmod}.addassign @all

```

```

{%mccmod}.addinit(v=n) @all

' *****
' Ping simulations
' *****

%suf = "_1"
{%varmod}.scenario(n,a={%suf}) "ping"
{%mccmod}.scenario(n,a={%suf}) "ping"

' *****
' Federal Funds Rate: RFF ping

%ping = "rff"

smpl %simstart %simstart
rffintay_aerr = rffintay_aerr + 1
smpl %simstart %simend
if %mcevars = "none" then
    {%varmod}.solve
else
    %modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
    %algstr = "meth=qnewton"
    %simstr = "type=single,solveopt=%sopt,suf=" + %suf
    call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
rffintay_aerr = rffintay_aerr - 1
call copyit

' *****
' Treasury Term Premium: RG10P, RG5P, and RG30P ping

%ping = "prem"
smpl @all
series rg30p_aerr = 0
smpl %simstart %simstart
rg10p_aerr = rg10p_aerr + 1
rg5p_aerr = rg5p_aerr + .75
rg30p_aerr = rg30p_aerr + .35
smpl %simstart %simend
if %mcevars = "none" then

```



```

    {%varmod}.solve
  else
    %modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
    %algstr = "meth=qnewton"
    %simstr = "type=single,solveopt=%sopt,suf=" + %suf
    call mce_run(%modstr,%algstr,%simstr)
  endif
  smpl %simstart %simstart
  rg10p_aerr = rg10p_aerr - 1
  rg5p_aerr = rg5p_aerr - 0.75
  rg30p_aerr = rg30p_aerr - .35
  call copyit
  smpl %simstart %simend
  series rg10p_{%ping} = rg10p{%suf} - rg10p

' *****
' Federal Purchases: EGFO ping

%ping = "eg"
smpl %simstart %simstart
egfo_aerr = egfo_aerr + .01*xgdpn/egfon
smpl %simstart %simend
if %mcevars = "none" then
  {%varmod}.solve
else
  %modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
  %algstr = "meth=qnewton"
  %simstr = "type=single,solveopt=%sopt,suf=" + %suf
  call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
egfo_aerr = egfo_aerr - .01*xgdpn/egfon
call copyit
smpl %simstart %simend
series egfn_shr_{%ping} = 100*(egfn{%suf}/xgdpn{%suf} - egfn/xgdpn)

' *****
' Equity Premium: REQP ping

%ping = "reqp"
smpl %simstart %simstart
reqp_aerr = reqp_aerr + 1
smpl %simstart %simend
if %mcevars = "none" then
  {%varmod}.solve
else

```

```

%modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
%algstr = "meth=qnewton"
%simstr = "type=single,solveopt=%sopt,suf=" + %suf
call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
reqp_aerr = reqp_aerr - 1
call copyit
smpl %simstart %simend
series reqp_{%ping} = reqp{%suf} - reqp

' *****
' Oil Prices: POILR ping

%ping = "oil"
smpl %simstart %simstart
poilr_aerr = poilr_aerr + 10/pxb
smpl %simstart %simend
if %mcevars = "none" then
    {%varmod}.solve
else
    %modstr = "mod_b=%varmod,mod_f=%mccmod,mce_vars=%zvars"
    %algstr = "meth=qnewton"
    %simstr = "type=single,solveopt=%sopt,suf=" + %suf
    call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
poilr_aerr = poilr_aerr - 10/pxb
call copyit
smpl %simstart %simend
series poil_{%ping} = poil{%suf} - poil

' *****
' Exchange Rate: FPXRR ping

%ping = "exch"
smpl %simstart %simstart
series shock_fpxr = log(1.1)
fpxrr_aerr = fpxrr_aerr + shock_fpxr

smpl %simstart %simend
if %mcevars = "none" then
    {%varmod}.solve

```

```

else
%modstr = "mod_b=%varmod,mod_f=%mcevar,mod_g=%mcevar"
%algstr = "meth=qnewton"
%simstr = "type=single,solveopt=%sopt,suf=" + %suf
call mce_run(%modstr,%algstr,%simstr)
endif

series fpxr_{%ping} = fpxr{%suf} - fpxr
smpl %simstart %simstart
fpxrr_aerr = fpxrr_aerr - shock_fpxr
call copyit

' *****
' HMFPT ping

%ping = "hmfpt"
smpl %simstart %simstart
hmfpt_aerr = hmfpt_aerr + 1
smpl %simstart %simend
if %mcevars = "none" then
    {%varmod}.solve
else
%modstr = "mod_b=%varmod,mod_f=%mcevar,mod_g=%mcevar"
%algstr = "meth=qnewton"
%simstr = "type=single,solveopt=%sopt,suf=" + %suf
call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
hmfpt_aerr = hmfpt_aerr - 1
call copyit
smpl %simstart %simend
series hmfpt_{%ping} = hmfpt{%suf} - hmfpt

' *****
' MFPT ping

%ping = "mfp"
smpl %simstart %simstart
mfpt_aerr = mfpt_aerr + .01
smpl %simstart %simend
if %mcevars = "none" then
    {%varmod}.solve
else
%modstr = "mod_b=%varmod,mod_f=%mcevar,mod_g=%mcevar"

```

```

%algstr = "meth=qnewton"
%simstr = "type=single,solveopt=%sopt,suf=" + %suf
call mce_run(%modstr,%algstr,%simstr)
endif
smpl %simstart %simstart
mfpt_aerr = mfpt_aerr - .01
call copyit
smpl %simstart %simend
series mfpt_{%ping} = 100*(mfpt{%suf}/mfpt - 1)

' *****
' Individual ping graphs
' *****
call graphit

' *****
' Composite figures
' *****

if %mcevars = "none" then
    %exp = "VAR Expectations"
endif
if %mcevars = "mcap" then
    %exp = "MC (MCAP) Expectations"
endif
if %mcevars = "mcapwp" then
    %exp = "MC (MCAP+WP) Expectations"
endif
if %mcevars = "all" then
    %exp = "MC (ALL) Expectations"
endif

%t1 = "FRB/US Ping Simulations: " + %exp + " -- I"
%t2 = "FRB/US Ping Simulations: " + %exp + " -- II"
%t3 = "FRB/US Ping Simulations: " + %exp + " -- III"

' Figure 1

graph fig_1.merge gr_rff gr_eg gr_reqp
fig_1.align(3,.4,1.0)
fig_1.addtext(t,just(c),font(12)) %t1
show fig_1

```

' Figure 2

```
graph fig_2.merge gr_oil gr_hmfp gr_mfp
fig_2.align(3,.4,1.0)
fig_2.addtext(t,just(c),font(12)) %t2
show fig_2
```

' Figure 3

```
graph fig_3.merge gr_prem gr_exch
fig_3.align(3,.4,1.0)
fig_3.addtext(t,just(c),font(12)) %t3
show fig_3
```

Uses copyit 196a, dbopen 215, dfpsrp 216, dmpintay 216, dmptrsh 216, drstar 216, egfn 216, egfon 216, fetch 215, fpxr 216, graphit 197, group2zero 89a, groupnew 90, hmfpt 216, make_frbus_mcevars 173, master_library 207a, mce_load_frbus 169, mce_run 97, mce_solve_library 208 213b, mfpt 216, pings 195d, poil 216, pxb 216, reqp 216, rff 216, rffintay 216, rffmin 216, rg10p 216, set_fp 92, set_mp 93, solve 215, wfcreate 215, xgap 216, xgdpn 216, zdivgr 216, zecd 216, zeco 216, zeh 216, zgap05 216, zgap10 216, zgap30 216, zgapc2 216, zlhp 216, zpi10 216, zpi10f 216, zpi5 216, zpib5 216, zpic30 216, zpic58 216, zpicxfe 216, zpieci 216, zrff10 216, zrff30 216, zrff5 216, zvpd 216, zvpi 216, zvps 216, zxbd 216, zxbi 216, zxbs 216, zyh 216, zyhp 216, zyht 216, and zynid 216.

2.7 stochsim program

```

40  <stochastic simulations under variable expectations 40>≡ (205a)
    ' Program for stochastic sims under VAR expectations

    ' The stochastic shocks are bootstrapped from the de-meaned
    ' historical errors of stochastic equations. The parameters
    ' %residstart and %residend declare the historical error range.
    ' A list of stochastic equations is extracted from the file
    ' pointed to by %varinfo.

    ' The bootstrap procedure randomly draws one historical quarter
    ' at a time when the parameter %errorblock = 1; alternatively, if
    ' %errorblock = 2, then the procedure would randomly draw two
    ' successive quarters at a time.

    ' The stochastic replications are simulated in a simple loop,
    ' rather than using the built-in EViews stochastic simulation
    ' procedure, so that shocks in the first simulation quarter can
    ' be scaled down by the parameter %q1_shock_damp. This feature
    ' is useful when uncertainty about the first simulation quarter
    ' in real-time analysis by known information. The shocks are
    ' not rescaled when %q1_shock_damp = 1.

    ' Similarly, the parameter %rff_weight_q1 is also designed to be
    ' used in real-time analysis when the first simulation quarter
    ' corresponds to a quarter that is already under way. The
    ' parameter provides the fractional value to be given to the
    ' monetary policy rule; the remaining fractional value is given to
    ' an exogenous value.

    ' The document Simulation Basics discusses the effects of
    ' imposing the zero lower bound (ZLB) on the federal funds rate
    ' (%zerobound parameter) and imposing threshold conditions
    ' on the liftoff of the funds rate from a ZLB episode
    ' (%threshold parameter).

    ' *****
    ' Initial filename and parameter settings
    ' *****

    ' Subroutines
    include ../subs/master_library

    ' Workfile
    %wfstart = "1965q1"

```

```

%wftend = "2020q4"
%mainpage = "main"
wfcreate(wf=aaa,page={%mainpage}) q {%wftstart} {%wftend}

' FRB/US model name and location
%varmod = "stdver"
%varpath = "../mods/"
%varinfo = "../mods/stdver_varinfo"

' Input database
%dbin = "../data/longbase"

' Simulation range
%simstart = "2014q1"
%simend = "2018q4"

' Stochastic parameters
rndseed 12345
%errorblock = "1"
%residstart = "1970q1"
%residend = "2012q4"
%nsims = "1000"
%q1_shock_damp = ".5"
%dbout_series = "rff lur picxfe picnia picx4 xgap2 hggdp anngr"

' Monetary policy
%zerobound = "yes"
%threshold = "yes"
%rff_weight_q1 = ".25"

' *****
' Retrieve data, model equations and coefficients, set
' policy options, and compute tracking residuals
' *****

' Load equations, coefficients, and variable information
ld_frbus_eqs(modelname=%varmod,modelpath=%varpath)
ld_frbus_cfs(modelname=%varmod,modelpath=%varpath)
ld_varinfo(pathname=%varinfo)

' add 4-qtr gdp growth equation
{%varmod}.append anngr - anngr_aerr = 100*((xgdp/xgdp(-4))-1)

' Load data
dbopen %dbin as longbase
fetch(d=longbase) *
```

```

smpl @all
series anngr = 100*((xgdp/xgdp(-4))-1)

' Set monetary policy to inertial Taylor rule (dmpintay, rffintay)
smpl @all
call set_mp("dmpintay")
if %zerobound = "yes" then
    rffmin = .250
else
    rffmin = -9999
endif
if %threshold = "yes" and %zerobound = "no" then
    %err = "Error: policy threshold conditions can only be used when the ZLB is imposed"
    @uiprompt(%err)
    stop
endif
if %threshold = "yes" and %zerobound = "yes" then
    dmptrsh = 1
    dmptr = 0
else
    dmptrsh = 0
endif
drstar = 0

smpl {%simstart} {%simstart}
dmpintay = @val(%rff_weight_q1)
dmpex = 1 - dmpintay

' Set fiscal policy
smpl @all
call set_fp("dfpex")

dmpstb = 1

' Set _aerr variables to zero
smpl @all
{%varmod}.makegroup(a,n) endog @endog
call groupnew("endog","_aerr")
call group2zero("endog_aerr")

' Standard solution options
{%varmod}.solveopt(o=b,g=14,z=1e-14)

' Assign baseline tracking add factors
%suftrk = "_0"
smpl %residstart %simend

```



```

{%varmod}.addassign @all
{%varmod}.addinit(v=n) @all
{%varmod}.scenario(n,a={%suftrk}) "track"
{%varmod}.solve
scalar mm = @max(@abs(xgap{%suftrk}-xgap))
if mm > .0001 then
    statusline dynamic tracking simulation failed for {%varmod}
stop
endif

' *****
' More monetary policy settings
' *****

' if policy thresholds are turned on, set add factors on endogenous
' threshold switch variables to zero
if %threshold = "yes" then
    smpl @all
    dmptpi_a = 0
    dmptlur_a = 0
    dmptmax_a = 0
    dmptr_a = 0
endif

' if the zero bound is binding in part or all of the baseline, the
' adds (_a) on the policy rule and the funds rate equations are
' determined so as to satisfy the following conditions.
'
' a. the stochastic funds rate equals the maximum of the zero bound and
' the prediction of the chosen policy rule (this simply requires that
' rffe_a and rffe_aerr be zero)
' b. the prediction of the chosen policy rule is subject to _a add factors
' that are determined as follows:
' (1) in quarters when the zero bound is not binding in the baseline,
' the associated add factors equal the values that make
' the policy rule equation match the baseline funds rate under
' baseline conditions (this is satisfied by the tracking adds on
' the policy rule as long as the baseline value of the policy rule
' variable equals the baseline funds rate);
' (2) in quarters when the zero bound is binding in the baseline,
' the associated add factors are determined by linear interpolation
' of the add factors generated according to b(1) for the
' unbound quarters;
' (3) when the zero bound is binding in all baseline quarters, the
' policy rule add factors are zero;

```

```

'      (4) the zero bound is assumed to be binding in the baseline whenever
'          the baseline funds rate (rffe) is within 25 basis points of the
'          zero bound variable (rffmin).

smpl %simstart %simend
series not_constrnd = ((rffe - rffmin) >= .25)
!tmp_max = @max(not_constrnd)
!tmp_min = @min(not_constrnd)

' zero bound binding in some quarters
if (!tmp_max = 1) and (!tmp_min = 0) then
    smpl %simstart %simend
    rffe_a = 0
    rffe_aerr = 0
    rffintay_aerr = 0
    smpl %simstart %simend if (not_constrnd = 0)
    rffintay_a = NA
    %series_in = "rffintay_a"
    %series_out = %series_in + "_int"
    call interp_lin(%series_in,%series_out,%simstart,%simend)
    rffintay_a = {%series_out}
endif

' zero bound binding in all quarters
if (!tmp_max = 0) and (!tmp_min = 0) then
    smpl %simstart %simend
    rffe_a = 0
    rffe_aerr = 0
    rffintay_aerr = 0
    rffintay_a = 0
endif

' *****
' Stochastic shocks
' *****

' copy historical residuals into series whose names have _err suffixes
smpl %residstart %residend
copy *_a *_err

' use vinfo table to create list/group of equations to receive shocks
%tmp = " "
for !i = 1 to vinfo_size
    %vname = @word(vinfo_vname,!i)
    %stoch = @word(vinfo_stoch,!i)
    if %stoch <> "NO" then

```

```

        %tmp = %tmp + " " + %vname
    endif
next
group shock {%tmp}

' demean historical residuals and store them in a matrix

smpl %residstart %residend
%error_names = " "
for !i = 1 to shock.@count
    %temp = shock.@seriesname(!i) + "_err"
    scalar mm = @mean({%temp})
    series {%temp} = {%temp} - mm
    %error_names = %error_names + " " + %temp
next

group errors {%error_names}
smpl %residstart %residend
stom(errors,errorformat)

' create table of error statistics
!nrows = 3 + errors.@count
!ncols = 3
table(!nrows,!ncols) error_tab
error_tab.setjust(r1c1:r{!nrows}c1) left
error_tab.setwidth(1) 20
error_tab(1,1) = "error"
error_tab(1,2) = "mean"
error_tab(1,3) = "std-dev"
smpl %residstart %residend
for !i = 1 to errors.@count
    series tseries = errors(!i)
    error_tab(!i+3,1) = errors.@seriesname(!i)
    error_tab(!i+3,2) = @mean(tseries)
    error_tab(!i+3,3) = @stdev(tseries)
next

' miscellaneous

smpl %simstart %simend
scalar nqtrs = @obssmpl
scalar nrepl = {%nsims}
scalar nsims = {%nsims}
scalar nerrors = @rows(errorformat)
scalar bbbb = nqtrs-nerrors

```

```

call groupnew("shock","_aerr")

group track {%dbout_series}
call groupnames2string("track",%tracknames)

' for tracked variables, set up matrices to hold stochastic results
for !i = 1 to track.@count
    %temp = track.@seriesname(!i)
    matrix(nqtrs,nrepl) {%temp}_mat
next

' *****
' Stochastic sims
' *****

%sufstoch = "_1"
{%varmod}.scenario(n,a={%sufstoch}) "stoch sims"

' *****
' stochastic simulation loop (sims are run one at a time)

smpl %simstart %simend
for !i = 1 to nrepl
    statusline running stochastic sim number !i
    ' draw nqtrs random rows from the matrix of historical errors,
    ' damp the shocks in the first drawn row, and load the shocks
    ' into the respective _aerr error series
    matrix stocherrors = @resample(errormat,bbbb,{%errorblock})
    for !j = 1 to @columns(stocherrors)
        stocherrors(1,!j) = @val(%q1_shock_damp) * stocherrors(1,!j)
    next
    mtos(stocherrors,shock_aerr)
    {%varmod}.solve
' store solution values
for !j = 1 to track.@count
    %temp = track.@seriesname(!j)
    %temp1 = %temp + "_mat"
    stom({%temp}{%sufstoch},tmp)
    colplace({%temp1},tmp,!i)
next
next

' *****
' Statistics

```

```

' *****

statusline computing statistics

smpl %simstart %simend
!index = 2
series year = @year
series quarter = @quarter
alpha yyyyqq = @str(year) + "Q" + @str(quarter)
!lqtr = @dtoo(%simstart) - 1
!nstats = 8

'create a summary table in which to store key results

call tableform("summary_tab","100")

' loop over each tracked variable,
for !ii1 = 1 to track.@count
    %trkname = track.@seriesname(!ii1)
' compute statistics
    call makestats(%trkname)

' load statistics into variable-specific table
    %tabname = %trkname + "_tab"
    call tableform(%tabname,@str(nqtrs+2))
    for !ii2 = 1 to nqtrs
        {%trkname}_tab(!ii2+2,1) = yyyyqq(!lqtr + !ii2)
        for !ii3 = 1 to !nstats
            {%trkname}_tab(!ii2+2,!ii3+1) = {%trkname}_stats(!ii2,!ii3)
        next
    next

' load statistics for each q4 observation into summary table
    !index = !index + 1
    summary_tab(!index,1)= %trkname
    !index = !index + 1
    for !ii2 = 1 to nqtrs
        if quarter(!lqtr+!ii2) = 4 then
            for !ii3 = 1 to !nstats + 1
                summary_tab(!index,!ii3) = {%trkname}_tab(!ii2+2,!ii3)
            next
            !index = !index + 1
        endif
    next

' make graph showing 70 and 90 percent bands

```

```

graph {%trkname}_graph.band {%trkname}_lo90 {%trkname}_hi90 {%trkname}_lo70 _
      {%trkname}_hi70 {%trkname}_base
{%trkname}_graph.addtext(t) %trkname
{%trkname}_graph.options size(6,4.5)

next

' *****
' summary graph

lur_graph.addtext(t,just(c),font("arial",12)) Unemployment Rate
rff_graph.addtext(t,just(c),font("arial",12)) Federal Funds Rate
picx4_graph.addtext(t,just(c),font("arial",12)) 4-qtr Core Inflation Rate
anngr_graph.addtext(t,just(c),font("arial",12)) 4-qtr Real GDP Growth Rate
lur_graph.legend -display
rff_graph.legend -display
picx4_graph.legend -display
anngr_graph.legend -display

graph summary_graph.merge lur_graph rff_graph picx4_graph anngr_graph
summary_graph.legend -display
summary_graph.addtext(t,just(c),font("Arial",16)) Stochastic Simulations\r(70 and 9
show summary_graph

' *****
' summary spool
spool results
summary_tab.deleterow(!index) 100
results.append summary_tab
results.append summary_graph
results.append error_tab
results.display

```

Uses dbopen 215, dfpex 216, dmpex 216, dmpintay 216, dmpstb 216, dmptr 216, dmptrsh 216, drstar 216, fetch 215, group2zero 89a, groupnames2string 89b, groupnew 90, hggdp 216, interp.lin 91, ld_frbus_cfs 177a 177b, ld_frbus_eqs 178b 179, ld_varinfo 192 193, left 216, lur 216, makestats 206, master.library 207a, picnia 216, picx4 216, picxfe 216, rff 216, rffe 216, rffintay 216, rffmin 216, set_fp 92, set_mp 93, solve 215, tableform 205b, wfcreate 215, xgap 216, xgap2 216, and xgdp 216.

Chapter 3

Model Consistent Expectation Solve Package

3.1 example1 program

```
49  <mce example1 49>≡ (212a)
    ' This example illustrates:
    '
    ' - The automated approach to constructing the two operational
    '   models
    ' - How to define the multiplier shock in a text
    '   file whose lines are executed from within the call to
    '   mce_run
    ' - How to declare the model scenario and the scenario
    '   scenario alias within the call to mce_run
    ' - The use of the "linear" option of the "newton" algorithm
    '   for a linear model in which the maximum endogenous lead and
    '   lag is one period

    '*****
    '*****
    '*****
    ' Section 1: Workfile, model name, simulation range

    include mce_solve_library

    ' Workfile
    %wfstart = "2000q1"
    %wfend = "2100q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}
```

```

' Model name
  %mod = "simple"

' Simulation range
  %simstart = "2001q1"
  %simend = "2025q4"

' *****
' *****
' *****
' Section 2: Model, coefficients, and data

' equations

model {%mod}
{%mod}.append pinf = cp(1) * pinf(-1) + (.98-cp(1))*pinf(1)+ cp(2) * ygap
{%mod}.append rate = cr(1)*rate(-1)+(1-cr(1))*(cr(2)*pinf + cr(3)*ygap)
{%mod}.append ygap = cy(1) * ygap(-1) + (.98-cy(1))*ygap(1) + cy(2) * (rate - pinf

' coefficients

coef(2) cy
cy.fill .50, -.02
coef(2) cp
cp.fill .50, .02
coef(3) cr
cr.fill .75, 1.5, 0.5

' set all data to zero
smpl @all
%vars = {%mod}.@varlist
for !i = 1 to @wcount(%vars)
  %tmp = @word(%vars,!i)
  series {%tmp} = 0
next

' *****
' *****
' *****
' Section 3: Simulation

text shock1

```



```
shock1.append smpl {%simstart} {%simstart}
shock1.append series rate_a = rate_a + 1

%mopts = "create,mod=%mod,adds,track"
%aopts = "jinit=linear"
%sopts = "type=single,txt=shock1,scen,suf=_1"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)
copy mce_sim_spool mce_sim_spool_1
show mce_sim_spool_1

series zero = 0
smpl %simstart %simstart + 39
graph gr1.line zero rate_1 pinf_1 ygap_1
gr1.addtext(t,c,font(14)) "Positive interest rate shock"
show gr1
```

Uses `mce_run` 97, `mce_solve_library` 208 213b, and `wfcreate` 215.

3.2 example2 program

```

52  <mce example2 52>≡ (212b)
    ' This example illustrates:
    '
    '   - A manual approach to constructing the two operational
    '     models that mimics what the automated approach does
    '   - How to define the multiplier shock in a text
    '     file whose lines are executed from within the call to
    '     mce_run
    '   - How to declare the model scenario and the scenario
    '     scenario alias within the call to mce_run
    '   - The use of the "linear" option of the "newton" algorithm
    '     for a linear model in which the maximum endogenous lead and
    '     lag is one period

    ' *****
    ' *****
    ' *****
    ' Section 1:  Workfile, model name, simulation range

    include  mce_solve_library

    ' Workfile
    %wfstart = "2000q1"
    %wfend = "2100q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

    ' Model names
    %modb = "simpleb"
    %modf = "simplef"

    ' Simulation range
    %simstart = "2001q1"
    %simend = "2025q4"

    ' *****
    ' *****
    ' *****
    ' Section 2:  Model, coefficients, and data

    ' equations in backward-looking model

    model {%modb}

```

```

{%modb}.append pinf = cp(1) * pinf(-1) + (.98-cp(1))*zpinf+ cp(2) * ygap
{%modb}.append rate = cr(1)*rate(-1)+(1-cr(1))*(cr(2)*pinf + cr(3)*ygap)
{%modb}.append ygap = cy(1) * ygap(-1) + (.98-cy(1))*zygap + cy(2) * (rate - zpinf)

' equations in expectations errors model

model {%modf}
{%modf}.append ezpinf = zpinf - pinf(1)
{%modf}.append ezygap = zygap - ygap(1)

' coefficients

coef(2) cy
cy.fill .50, -.02
coef(2) cp
cp.fill .50, .02
coef(3) cr
cr.fill .75, 1.5, 0.5

' set all data to zero
smpl @all
%vars = {%modb}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next
%vars = {%modf}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next

' declare mce variables and instruments
%instrus = "zpinf zygap"
%errs = "ezpinf ezygap"

' *****
' *****
' *****
' Section 3: Simulation

text shock1
shock1.append smpl {%simstart} {%simstart}
shock1.append series rate_a = rate_a + 1

```

```
%mopts = "mod_b=%modb,mod_f=%modf,mce_instrus=%instrus,mce_errs=%errs,adds,track"
%aopts = "jinit=linear"
%sopts = "type=single,txt=shock1,scen,suf=_1"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)
copy mce_sim_spool mce_sim_spool_1
show mce_sim_spool_1

series zero = 0
smpl %simstart %simstart + 39
graph gr1.line zero rate_1 pinf_1 ygap_1
gr1.addtext(t,c,font(14)) "Positive interest rate shock"
show gr1
```

Uses `mce_run` 97, `mce_solve_library` 208 213b, and `wfcreate` 215.

3.3 example3 program

```

55  <mce example3 55>≡ (212c)
    ' This example illustrates:
    '
    ' - Another manual approach to constructing the two operational
    '   models that introduces new endogenous variables for the
    '   expectations leads along with simple equations for the new
    '   endogenous variables.
    ' - The MCE instruments are the add factors on the equations for
    '   the new endogenous variables; this circumstance requires that
    '   add factors be assigned to the operational models prior to
    '   the call to mce_run.
    ' - The option of defining the multiplier shock in commands that
    '   are executed prior to the call to mce_run, when the manual
    '   approach is used.
    ' - The option of declaring model scenarios and the scenario
    '   scenario alias prior to the call to mce_run, when the manual
    '   approach is used.
    ' - The model no longer satisfies the conditions for which the
    '   "jinit=linear" option of the "newton" algorithm is designed.
    '   This example uses "jinit=interp(4)" to specify a
    '   particular approximate Jacobian.
    '
    ' - This example runs three simulations. In the second and third
    '   simulations, the assignment of null strings to the first two
    '   arguments of the mce_run subroutine causes the simulations to be
    '   run with the same internal models and algorithm (including
    '   the Newton MCE Jacobian) that were created or declared in the
    '   first simulation.

    ' *****
    ' *****
    ' *****
    ' Section 1: Workfile, model name, simulation range

    include mce_solve_library

    ' Workfile
    %wfstart = "2000q1"
    %wfend = "2100q4"
    %mainpage = "main"
    wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

    ' Model names
    %modb = "simpleb"

```

```

%modf = "simplef"

' Simulation range
%simstart = "2001q1"
%simend = "2025q4"

'*****
'*****
'*****
' Section 2: Model, coefficients, and data

' equations in backward-looking model

model {%modb}
{%modb}.append pinf = cp(1) * pinf(-1) + (.98-cp(1))*zpinf+ cp(2) * ygap
{%modb}.append rate = cr(1)*rate(-1)+(1-cr(1))*(cr(2)*pinf + cr(3)*ygap)
{%modb}.append ygap = cy(1) * ygap(-1) + (.98-cy(1))*zygap + cy(2) * (rate - zpinf)
{%modb}.append zpinf = @movav(pinf(-1),4)
{%modb}.append zygap = @movav(ygap(-1),4)

' equations in expectations errors model

model {%modf}
{%modf}.append ezpinf = zpinf - pinf(1)
{%modf}.append ezygap = zygap - ygap(1)

' coefficients

coef(2) cy
cy.fill .50, -.02
coef(2) cp
cp.fill .50, .02
coef(3) cr
cr.fill .75, 1.5, 0.5

' set all data to zero
smpl @all
%vars = {%modb}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next
%vars = {%modf}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)

```

```

        series {%tmp} = 0
    next

' declare mce variables and instruments
%instrus = "zpinf_a zygap_a"
%errs = "ezpinf ezygap"

' assign tracking add factors
smpl %simstart %simend
{%modb}.addassign @all
{%modb}.addinit(v=n) @all
{%modf}.addassign @all
{%modf}.addinit(v=n) @all

' *****
' *****
' *****
' Section 3: Simulations

%sufm = "_1"
{%modb}.scenario(n,a=%sufm) "multiplier"
{%modf}.scenario(n,a=%sufm) "multiplier"

' Sim 1: interest rate shock

smpl {%simstart} {%simstart}
rate_a = rate_a + 1

%mopts = "mod_b=%modb,mod_f=%modf,mce_instrus=%instrus,mce_errs=%errs"
%aopts = "jinit=interp(4)"
%sopts = "type=single"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)
smpl {%simstart} {%simstart}
rate_a = rate_a - 1

series zero = 0
smpl %simstart %simstart + 39
graph gr1.line zero rate{%sufm} pinf{%sufm} ygap{%sufm}
gr1.addtext(t,c,font(14)) "Positive interest rate shock"
show gr1

' Sim 2: output gap shock

```

```

smpl {%simstart} {%simstart}
ygap_a = ygap_a + 1

%mopts = ""
%aopts = ""
%sopts = "type=single"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)
smpl {%simstart} {%simstart}
ygap_a = ygap_a - 1

series zero = 0
smpl %simstart %simstart + 39
graph gr2.line zero rate{%sufm} pinf{%sufm} ygap{%sufm}
gr2.addtext(t,c,font(14)) "Positive output gap shock"
show gr2

' Sim 3:  inflation shock

smpl {%simstart} {%simstart}
pinf_a = pinf_a + 1

%mopts = ""
%aopts = ""
%sopts = "type=single"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)
smpl {%simstart} {%simstart}
pinf_a = pinf_a - 1

series zero = 0
smpl %simstart %simstart + 39
graph gr3.line zero rate{%sufm} pinf{%sufm} ygap{%sufm}
gr3.addtext(t,c,font(14)) "Positive inflation shock"
show gr3

```

Uses mce_run 97, mce.solve.library 208 213b, and wfcreate 215.

3.4 example4 program

```

59  <mce example4 59>≡ (212d)
    ' This example illustrates:
    '
    '   - The simulation of a nonlinear model (zero bound imposed)
    '     (because the baseline data is set to zero; the zero-bound
    '       is set illustratively to -1)
    '   - The use of the qnewton algorithm
    '
    ' *****
    ' *****
    ' *****
    ' Section 1:  Workfile, model name, simulation range
    '
    ' include  mce_solve_library
    '
    ' Workfile
    ' %wfstart = "2000q1"
    ' %wfend = "2100q4"
    ' %mainpage = "main"
    ' wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}
    '
    ' Model names
    ' %modb = "simpleb"
    ' %modf = "simplef"
    '
    ' Simulation range
    ' %simstart = "2001q1"
    ' %simend = "2025q4"
    '
    ' *****
    ' *****
    ' *****
    ' Section 2:  Model, coefficients, and data
    '
    ' equations in backward-looking model
    '
    ' model {%modb}
    ' {%modb}.append pinf = cp(1) * pinf(-1) + (.98-cp(1))*zpinf+ cp(2) * ygap
    ' {%modb}.append rate_u = cr(1)*rate(-1)+(1-cr(1))*(cr(2)*pinf + cr(3)*ygap)
    ' {%modb}.append rate = @recode( rate_u>rate_min,rate_u,rate_min)
    ' {%modb}.append ygap = cy(1) * ygap(-1) + (.98-cy(1))*zygap + cy(2) * (rate - zpinf)
    ' {%modb}.append zpinf = @movav(pinf(-1),4)
    ' {%modb}.append zygap = @movav(ygap(-1),4)

```

```

' equations in expectations errors model

model {%modf}
{%modf}.append ezpinf = zpinf - pinf(1)
{%modf}.append ezygap = zygap - ygap(1)

' coefficients

coef(2) cy
cy.fill .50, -.02
coef(2) cp
cp.fill .50, .02
coef(3) cr
cr.fill .75, 1.5, 0.5

' set all data to zero
smpl @all
%vars = {%modb}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next
%vars = {%modf}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next

' declare mce variables and instruments
%instrus = "zpinf_a zygap_a"
%errs = "ezpinf ezygap"

' assign tracking add factors
smpl %simstart %simend
{%modb}.addassign @all
{%modb}.addinit(v=n) @all
{%modf}.addassign @all
{%modf}.addinit(v=n) @all

' *****
' *****
' *****
' Section 3: Simulation

%zb = "yes"

```

```

%sufm = "_1"
{%modb}.scenario(n,a=%sufm) "multiplier"
{%modf}.scenario(n,a=%sufm) "multiplier"

if %zb = "yes" then
    smpl @all
    rate_min = -1
else
    rate_min = -9999
endif

smpl {%simstart} {%simstart}
ygap_a = ygap_a - 5

%mopts = "mod_b=%modb,mod_f=%modf,mce_instrus=%instrus,mce_errs=%errs"
%aopts = "meth=qnewton"
%sopts = "type=single"
smpl {%simstart} {%simend}
tic
call mce_run(%mopts,%aopts,%sopts)
scalar elapsed = @toc
show elapsed

series zero = 0
smpl %simstart %simstart + 39
graph gr1.line zero rate{%sufm} pinf{%sufm} ygap{%sufm}
%title = "Negative Output Shock"
if %zb = "yes" then
    %title = %title + "\r(zero bound imposed)"
else
    %title = %title + "\r(zero bound not imposed)"
endif
gr1.addtext(t,c,font(14)) %title
show gr1

```

Uses mce_run 97, mce.solve.library 208 213b, and wfcreate 215.

3.5 example5 program

```

62  <mce example5 62>≡ (213a)
    ' This example illustrates the two optimal policy simulation types
    '
    '   - Simulate the effects of a positive shock to the output gap
    '       using sequentially
    '
    '       (a) the model's interest rate rule
    '
    '       (b) the opt simulation type to find the optimal interest rate
    '           path under commitment
    '
    '       (c) the opttc simulation type to find the optimal time-consistent
    '           or discretionary interest rate path; note that the solution in
    '           this case is only approximate
    '
    '       In both (b) and (c) the policy instrument is the residual of
    '           the interest rule
    '
    '   - The illustrative loss function penalizes equally weighted,
    '       discounted, squared deviations of the output gap,
    '       inflation, and the first difference of the interest rate.
    '
    ' *****
    ' *****
    ' *****
    ' Section 1: Workfile, model name, simulation range
    '
    ' include mce_solve_library
    '
    ' Workfile
    ' %wfstart = "2000q1"
    ' %wfend = "2100q4"
    ' %mainpage = "main"
    ' wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}
    '
    ' Model name
    ' %mod = "simple"
    '
    ' Simulation range
    ' %simstart = "2001q1"
    ' %simend = "2025q4"
    ' *****

```

```

'*****
'*****
' Section 2: Model, coefficients, and data

' equations

model {%mod}
{%mod}.append pinf = cp(1) * pinf(-1) + (.98-cp(1))*pinf(1)+ cp(2) * ygap
{%mod}.append rate - rate_aerr = cr(1)*rate(-1)+(1-cr(1))*(cr(2)*pinf + cr(3)*ygap)
{%mod}.append ygap = cy(1) * ygap(-1) + (.98-cy(1))*ygap(1) + cy(2) * (rate - pinf(1))
{%mod}.append drate = rate - rate(-1)

' coefficients

coef(2) cy
cy.fill .50, -.02
coef(2) cp
cp.fill .50, .02
coef(3) cr
cr.fill .75, 1.5, 0.5

' set all data to zero
smpl @all
%vars = {%mod}.@varlist
for !i = 1 to @wcount(%vars)
    %tmp = @word(%vars,!i)
    series {%tmp} = 0
next

'*****
'*****
'*****
' Section 3: Optimal policy setup

' targets, instruments
group opt_instrus rate_aerr
group opt_targs pinf ygap drate

' desired target trajectories
smpl @all
series pinf_t = 0
series ygap_t = 0
series drate_t = 0

' loss function weights

```

```

%discount = ".99"
%y_weight = "1.0"
%p_weight = "1.0"
%r_weight = "1.0"
smpl @all
series ygap_w = @val(%y_weight)
series pinf_w = @val(%p_weight)
series drate_w = @val(%r_weight)
!discount = @val(%discount)
smpl %simstart+1 %simend
ygap_w = !discount * ygap_w(-1)
pinf_w = !discount * pinf_w(-1)
drate_w = !discount * drate_w(-1)

'*****
'*****
'*****
' Section 3: Simulations

text shock1
shock1.append smpl {%simstart} {%simstart}
shock1.append series ygap_a = ygap_a + 3

' run the simulation using the monetary policy rule

%mopts = "create,mod=%mod,adds,track"
%aopts = "jinit=linear"
%sopts = "type= single,txt=shock1,scen,suf=_1"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)

smpl @all
series rate_rule = rate_1
series pinf_rule = pinf_1
series ygap_rule = ygap_1

' run the simulation using opt

%mopts = ""
%aopts = ""
%sopts = "type=opt,instrus=opt_instrus,targs=opt_targs"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)

```

```

smpl @all
series rate_opt = rate_1
series pinf_opt = pinf_1
series ygap_opt = ygap_1

' run the simulation using opttc

%mopts = ""
%aopts = ""
%sopts = "type=opttc,instrus=opt_instrus,targs=opt_targs"
smpl {%simstart} {%simend}
call mce_run(%mopts,%aopts,%sopts)

smpl @all
series rate_opttc = rate_1
series pinf_opttc = pinf_1
series ygap_opttc = ygap_1

'graph

smpl %simstart %simstart + 39
series zero = 0
graph gr1.line zero rate_rule rate_opt rate_opttc
graph gr2.line zero pinf_rule pinf_opt pinf_opttc
graph gr3.line zero ygap_rule ygap_opt ygap_opttc
graph gr4.merge gr1 gr2 gr3
%title = "Effects of Positive Output Shock Under Three Policy Responses"
%title = %title + "\r1.  An inertial interest rate rule (_rule)"
%title = %title + "\r2.  Optimal policy under commitment (_opt)"
%title = %title + "\r3.  Optimal time-consistent policy (_opttc)"
gr4.addtext(t,c,font(14)) %title
show gr4

```

Uses mce_run 97, mce.solve_library 208 213b, and wfcreate 215.

Chapter 4

State Space Package

4.1 Estimate Model

```
67  <estimation model 67>≡ (213e)
    ' Program to estimate the FRB/US state-space model and
    ' generate estimates of model states.

    ' Subroutines:
    ' To transform data
    include "./data_transformations"

    ' To estimate the model
    include "./estimation_code"
    include "./initial_values"

    close @all
    wfcreate kf_data q 1949:1 2020:4

    %estend      = "2013q4"
    %eststart    = "1963q2"
    %datastart   = "1949q1"

    sample estsample %eststart %estend
    sample datasample %datastart %estend
    %datasmpl = %datastart + " " + %estend
    %modname = "ss_model"
```

```

'*****
' Retrieve variables from the database

' Definitions of series in database
'   See FRB/US model documentation for more complete descriptions

' XGDP   - GDP, cw 2009$
' XGDPN  - GDP
' XB     - BLS Business output, 2009$
' XBN    - BLS Business output
' XGDIN  - GDI

' PGDP   - Price index for GDP, cw
' PXB    - BLS Business price

' LEP    - Employment in business sector (employee and self-employed)
' LHP    - Aggregate labor hours, business sector (employee and self-employed)
' LUR    - Civilian unemployment rate (break adjusted)
' LF     - Civilian labor force (break adjusted)
' N16    - Noninstitutional population, aged 16 and over (break adjusted)

' KS     - Capital services, 2009 $
' LQUALT - Labor quality, trend level
' VEOA   - Average energy-output ratio of existing capital stock

' PCXFE  - Price index for personal consumption expendits ex. food and energy, cw (N1
' PCER   - Price index for personal consumption expenditures on energy (relative to 1

' PMO    - Price index for imports ex. petroleum, cw
' UCES   - Energy share of nominal consumption expenditures
' EMON   - Imports of goods and services ex. petroleum
' XGDEN  - Nominal Absorption
' PTR    - 10-year expected inflation (Hoey/Philadelphia survey)

%dbin = "state_space_data"
dbopen %dbin as dbin

string varlist = " xgdpn xbn pgdp pxb pcxfe pcer xgdp xb lep uces emon xgden ptr "
varlist = varlist + " ks lqualt veoa lhp lur lf n16 pmo xgdin "

fetch(d=dbin) {varlist}

'*****

```

```

' Make model observable series, set priors

smpl datasample

call data_transformations

'*****
' Specify and estimate model, save for re-use

smpl estsample

statusline Estimating model
call ss_estimation

{%modname}.makefilter saved_results

'*****
' Create states

{%modname}.makestates(t=pred) *_prs      ' one-step ahead state predictions
{%modname}.makestates(t=filt) *_1        ' filter states
{%modname}.makestates(t=smooth) *_2      ' smoothed states
{%modname}.makestates(t=disturb) *err    ' estimate of the disturbances
{%modname}.makestates(t=filtse) *se      ' RMSE of the filtered states
{%modname}.makestates(t=smoothse) *se2   ' RMSE of the smoothed states

{%modname}.makesignals(t=pred) *_pr      ' one-step ahead signal predictions
{%modname}.makesignals(t=resid) *_res    ' error in one-step ahead signal predictions
{%modname}.makesignals(t=stdresid) *_sres ' standardized one-step ahead prediction residual

'*****
' Transformation into FRB/US mnemonics

series xbt = exp((tmfp_2/.965 + 0.725*(terate_2 + tlfpr_2 + thtfactor_2 + tww_2) + _
                0.275*lkls + 0.725*llqualt + (.035/.965)*lveoa + lpop)/100)
series hmfpt = gtmfp_2
series qlfpr = exp(tlfpr_2/100)
series hqlfpr = (gtlfpr_2/400)*qlfpr(-1)
series hqlww = gtw_2
series huxb = gtotfactor_2
series leppot = exp((tlfpr_2+terate_2+thtfactor_2)/100) * n16
series lurnat = 100*(1-exp(terate_2/100))
series qlww = exp(tww_2/100)

```

```
series uxbt    = exp(totfactor_2/100)
series xgdpt   = xbt * uxbt
series xgdo    = exp(cycle_2/100)*xgdpt
```

```
wfsave saved_results_new
```

Defines:

`saved_results_new`, never used.

Uses `close` 215, `data_transformations` 213c, `dbopen` 215, `emon` 216, `estimation_code` 213d, `ex` 216, `fetch` 215, `hmfpt` 216, `hqlfpr` 216, `hqlww` 216, `huxb` 216, `initial_values` 81 214b, `ks` 216, `lep` 216, `leppot` 216, `lf` 216, `lhp` 216, `lqualt` 216, `lur` 216, `lurnat` 216, `n16` 216, `pcer` 216, `pcxfe` 216, `pgdp` 216, `pmo` 216, `ptr` 216, `pxb` 216, `qlfpr` 216, `qlww` 216, `ss_estimation` 74, `uces` 216, `uxbt` 216, `veoa` 216, `wfcreate` 215, `wfsave` 215, `xb` 216, `xbn` 216, `xbt` 216, `xgden` 216, `xgdin` 216, `xgdo` 216, `xgdp` 216, `xgdpn` 216, and `xgdpt` 216.

4.2 Data Transformations

```

71  <data transformations 71>≡ (213c)
    subroutine data_transformations()

      ' Subroutine for FRB/US state-space model package to
      ' transform raw data from EViews database to observables
      ' used in the estimation of the state-space model.

      ' 1. Data transformations

      series lpop = 100*log(n16)

      'Business - product side
      series nbp = xbn
      series bp = log(xb)*100 -lpop

      'GDP
      series gdp = log(xgdp)*100 -lpop

      'Buseness - income side
      series dsnst_q = xgdpn - xgdin
      series nbi = nbp - dsnst_q
      series rbi = nbi/(pxb/100)
      series bi = log(rbi)*100 -lpop

      ' Employment Business sector
      series eb = log(lep)*100 - lpop

      ' Workweek
      series hb = log(lhp)*100 - lpop
      series bw = hb - eb

      ' Employment Rate
      series erate = 100*log((100-lur)/100)

      ' Participation Rate
      series lfpr = 100*log(lf/n16)

      ' Variables for TMFP:
      series lks = 100*log(ks) - lpop
      series llqualt = 100*log(lqualt)
      series lveoa = 100*log(veoa)

      ' Series for the price equation
      series clpcex = @pca(pcxfe)

```

```

series engylag_pcex = 0.5*(uces(-1)+uces(-2))*@pca(pcer(-1))
series sw_coreimp_pcex = 0.5*((emon/xgden)+(emon(-1)/xgden(-1)))*@pca(pmo/pcxfe)
series dum84 = @year>=1985
series frzbulg = 0      ''' Nixon wage-price control programs
smpl 1971q3 1974q1
frzbulg = 1
smpl 1974q2 1974q4
frzbulg = -3.666

' For the output-sector ratio, we use the median unbiased approach of Stock
' and Watson (1998). Thus, tau_oti is the ratio of the variances of the level
' and drift shocks.

scalar tau_oti = .033260  ' modifier for the drift totfactor (OSR*) error term

'*****

' 2. Prior starting values for states.

'   For mean zero level states, set prior to zero.
'   For other level states, set prior to a data-based
'       value near the start of the sample.
'   For most drift terms, set prior to zero.
'       Exception is trend MFP, set equal to sample average.

' Cycle
scalar  icycle =      0
scalar  icycle1 =     0
scalar  icycle2 =     0

' Measurement error
scalar  ie3p =      0
scalar  ie3i =      0

' Levels of trends
scalar  itotfactor =  @elem(gdp,%eststart) - @elem(bp,%eststart)
scalar  itmfp =       .965*(@elem(bp,%eststart) - 0.725*(@elem(eb,%eststart)
                        + @elem(bww,%eststart)) - 0.275*@elem(lks,%eststart)
                        - 0.725*@elem(llqualt,%eststart) -
                        - (.035/.965)*@elem(lveoa,%eststart))

scalar  itww =        @elem(bww,%eststart)
scalar  ithtfactor =  @elem(eb,%eststart) - @elem(erate,%eststart) -
                        - @elem(lfpr,%eststart)

```

```

scalar      itlfpr =                @elem(lfpr,%eststart)
scalar      iterate =                @elem(erate,%eststart)

' Initial drift terms
scalar      igtotfactor =            0.0
scalar      igtmfp =                  1.7
scalar      igtww =                   0.0
scalar      igthtfactor =            0.0
scalar      igtlfpr =                 0.0

scalar nstate = 25

' The mpriors *must* be in the same order as the states are in the model object
vector(nstate) mpriors
mpriors.fill  0, ie3p, ie3i, 0, 0, _
              0, 0, icycle, icycle1, icycle2, _
              itotfactor, igtotfactor, itmfp, igtmfp, itww, _
              itww, igtww, ithtfactor, ithtfactor, igthtfactor, _
              itlfpr, itlfpr, igtlfpr, iterate, iterate

' Set starting values for variance priors
'   Variance priors set at a high value. In estimation, variance
'   drops sharply in early periods of estimation sample.

sym(nstate) vpriors
for !d = 1 to nstate
    vpriors(!d, !d) = 3
next

' A tighter prior for drift variances,
vpriors(12,12) = 1    ' igtotfactor
vpriors(14,14) = 1    ' igtmfp
vpriors(17,17) = 1    ' igtww
vpriors(20,20) = 1    ' igthtfactor

endsub

Uses data_transformations 213c, emon 216, ks 216, lep 216, lf 216, lfpr 216, lhp 216,
lqualt 216, lur 216, n16 216, pcer 216, pcxfe 216, pmo 216, pxb 216, uces 216, veoa 216,
xb 216, xbn 216, xgden 216, xgdin 216, xgdp 216, and xgdpn 216.

```

4.3 Estimation Code

```

74  <estimation code 74>≡ (213d)
      subroutine ss_estimation()

      ' Subroutine for FRB/US state-space model package to
      ' estimate the model parameters.

      '*****

      ' 1. Starting values for parameters.

      ' All of the coefficients in equations appear as beta or phi.
      ' Note that some values that are set here are hard coded in the estimation code below

      call initial_values

      '*****
      ' Model

      sspace {%modname} ' Declare a new state-space model object

      ' 2. Output equations.

      ' In the output equations, trend output is related to the capital stock, energy inter
      ' and trends for labor input using a production function. The parameters of the pro
      ' function are hard-coded to the values in the FRB/US model.

      ' GDP observable
      {%modname}.append @signal gdp = totfactor + tmfp/.965 + 0.725*(terate + tlfpr + thtf
          + 0.275*lks + 0.725*llqualt + (.035/.965)*lveoa _
          + cycle + beta(11)*beta(6) + beta(11)*e3p + rexo
      {%modname}.append @state rexo = [var=0.0000001^2]

      ' Buisines sector product-side observable
      {%modname}.append @signal bp = tmfp/.965 + 0.725*(terate + tlfpr + thtfactor + tww)
          + 0.275*lks + 0.725*llqualt + (.035/.965)*lveoa _
          + beta(10)*cycle + beta(6) + e3p
      {%modname}.append @state e3p = beta(602)*e3p(-1) + re3p
      {%modname}.append @ename re3p 'business prod error
      {%modname}.append @evar var(re3p) = (beta(125)^2)

      ' Business sector income-side observable
      {%modname}.append @signal bi = tmfp/.965 + 0.725*(terate + tlfpr + thtfactor + tw
          + 0.275*lks + 0.725*llqualt + (.035/.965)*lveoa _
          + beta(10)*cycle - beta(6) + e3i

```



```

{%modname}.append @state e3i =    beta(602)*e3i(-1) + re3i
{%modname}.append @ename re3i 'business income error
{%modname}.append @evar var(re3i) =    (beta(126)^2)

' 3. Labor equations.

' Workweek observable
' To make this equation more consistent with the FRB/US workweek specification,
' a contemporaneous change in the cycle is included as well as the level of the
' cycle. In addition, the coefficient on the lagged gap term in this equation is
' hard-coded at a value similar to that implicit in the FRB/US model.

{%modname}.append @signal bww =    tww _
      + phi(20)*(cycle-cycle1) _
      + phi(22)*cycle1 _
      + 0.82*(bww(-1)-tww1) _
      + eww
{%modname}.append @state eww =    [var=beta(104)^2]

' Employment observable
{%modname}.append @signal eb =    terate + tlfpr + thtfactor + _
      + phi(30)*cycle _
      + phi(31)*(eb(-1)-(terate1 + tlfpr1 +thtfactor1)) _
      + eeb
{%modname}.append @state eeb =    [var=beta(105)^2]

' Employment rate observable
{%modname}.append @signal erate =    terate + phi(50)*cycle _
      + phi(51)*(erate(-1)-terate1) _
      + eerate
{%modname}.append @state eerate =    [var=beta(106)^2]

' Labor force participation observable
{%modname}.append @signal lfpr =    tlfpr + phi(40)*cycle _
      + phi(41)*(lfpr(-1)-tlfpr1) _
      + elfpr
{%modname}.append @state elfpr =    [var=beta(107)^2]

' 4. Price observable
      {%modname}.append @ename ec
      {%modname}.append @evar var(ec) =    (beta(109)^2)
      {%modname}.append @signal c1pcex = _
      beta(401)*c1pcex(-1) + (1-beta(401))*(ptr(-1)+.1) _
+ beta(404)*(((.50*cycle + .33*cycle1 + .17*cycle2 )) ) _
      + beta(405)*@movav(engylag_pcex(-1),6) _
      + beta(406)*@movav(dum84*engylag_pcex(-1),6) _

```

```

+ beta(407)*frzbulg _
+ beta(408)*sw_coreimp_pcex + beta(409)*sw_coreimp_pcex(-1) _
+ ec

' 5. State equations

' Cycle state
{%modname}.append @state cycle = beta(1)*cycle(-1) + beta(2)*cycle1(-1) + ecycle
{%modname}.append @state cycle1 = cycle(-1)
{%modname}.append @state cycle2 = cycle1(-1)
{%modname}.append @ename ecycle
{%modname}.append @evar var(ecycle) = (beta(111)^2)

' Trends

' Totfactor = OSR* in F.R.(2011)
' tau_oti is taken from FR(2011)
{%modname}.append @state totfactor = totfactor(-1) + 0.25*.95*(gtotfactor(-1) ) + 0.25*
                                     etotfactor + 0.25*egtotfactor
{%modname}.append @state gtotfactor = .95*gtotfactor(-1) + .05*beta(213) + egtotfactor
{%modname}.append @ename etotfactor
{%modname}.append @evar var(etotfactor) = (beta(112)^2)
{%modname}.append @ename egtotfactor
{%modname}.append @evar var(egtotfactor) = (4*((tau_oti))*beta(112))^2

' Multi-Factor Productivity (OPH*)
{%modname}.append @state tmfp = tmfp(-1) + etmfp + 0.25*.95*(gtmfp(-1)) + 0.25*0.05*egtmfp
{%modname}.append @state gtmfp = 0.95*gtmfp(-1) + 0.05*beta(214) + egtmfp
{%modname}.append @ename etmfp
{%modname}.append @evar var(etmfp) = beta(114)^2
{%modname}.append @ename egtmfp
{%modname}.append @evar var(egtmfp) = 0.14^2 ' beta(115)^2

' For the workweek, employment-sector ratio, and LFPR, the level variances are hard-coded.
' This hard-coding is done for convenience in production work. In particular, the
' values are close to the values these parameters take on when they are freely estimated.
' However, the t-ratios for these parameters are not very high, and that impedes
' to sluggish convergence; imposing these values shortens the time needed for estimation.

' Workweek (WW*)
{%modname}.append @state tww = tww(-1) + 0.25*.95*(gtww(-1) ) + etww + 0.25*.05*egtww
{%modname}.append @state tww1 = tww(-1)
{%modname}.append @state gtww = .95*gtww(-1) + .05*beta(216) + egtww
{%modname}.append @ename etww
{%modname}.append @ename egtww
{%modname}.append @evar var(etww) = 0.1^2

```

```

{%modname}.append @evar var(egttww) = beta(117)^2

' Employment Sector Ratio (ESR*)
{%modname}.append @state thtfactor = thtfactor(-1) + 0.25*.95*gtthtfactor(-1) + _
                                0.25*egthtfactor + ethtfactor
{%modname}.append @state thtfactor1 = thtfactor(-1)
{%modname}.append @state gtthtfactor = 0.95*gtthtfactor(-1) + egthtfactor
{%modname}.append @ename ethtfactor
{%modname}.append @evar var(ethtfactor) = .01^2 ' beta(118)^2
{%modname}.append @ename egthtfactor
{%modname}.append @evar var(egthtfactor) = (beta(119)^2)

' Labor Force Participation (LFPR*)
{%modname}.append @state tlfpr = tlfpr(-1) + 0.25*(.95*gtlfr(-1) + egtlfr) + etlfr
{%modname}.append @state tlfpr1 = tlfpr(-1)
{%modname}.append @state gtlfr = 0.95*gtlfr(-1) + egtlfr
{%modname}.append @ename etlfr
{%modname}.append @evar var(etlfr) = .05^2 ' beta(122)^2
{%modname}.append @ename egtlfr
{%modname}.append @evar var(egtlfpr) = beta(123)^2

' Employment Rate (ER*), no drift
{%modname}.append @state terate = terate(-1) + eterate
{%modname}.append @state terate1 = terate(-1)
{%modname}.append @ename eterate
{%modname}.append @evar var(eterate) = beta(124)^2

{%modname}.append @vprior vpriors

{%modname}.append @mprior mpriors

freeze({%modname}_results) {%modname}.ml(m=100,showopts)

endsub

```

Defines:

ss_estimation, used in chunk 67.

Uses close 215, ec 216, initial_values 81 214b, lfpr 216, ptr 216, and sspace 215.

4.4 Supply Filter

```

78  <supply filter 78>≡ (214a)
    ' Program is part of the FRB/US state-space model package.
    ' frbus_supply_filter takes a previously estimated state-space model and
    ' generates estimates of model states.

    ' Subroutines:
    '   To transform data
    include "./data_transformations"

    close @all
    wfcreate kf_data q 1949:1 2020:4

    %estend      = "2014q3"
    %eststart    = "1963q2"
    %datastart   = "1949q1"

    sample estsample %eststart %estend
    sample datasample %datastart %estend

    %modname = "ss_model"

    ' *****
    ' Retrieve variables from the database

    ' Definitions of series in database
    '   See FRB/US model documentation for more complete descriptions

    ' XGDP    - GDP, cw 2009$
    ' XGDPN   - GDP
    ' XB      - BLS NFB output, 2009$
    ' XBN     - BLS NFB output
    ' XGDIN   - GDI

    ' PGDP    - Price index for GDP, cw
    ' PXB     - BLS NFB price

    ' LEP     - Employment in nonfarm business sector (employee and self-employed)
    ' LHP     - Aggregate labor hours, nonfarm business sector (employee and self-employed)
    ' LUR     - Civilian unemployment rate (break adjusted)
    ' LF      - Civilian labor force (break adjusted)
    ' N16     - Noninstitutional population, aged 16 and over (break adjusted)

```

```

' KS      - Capital services, 2009 $
' LQUALT  - Labor quality, trend level
' VEOA    - Average energy-output ratio of existing capital stock

' PCXFE   - Price index for personal consumption expendits ex. food and energy, cw (NIA def.)
' PCER    - Price index for personal consumption expenditures on energy (relative to PCXFE)

' PMO     - Price index for imports ex. petroleum, cw
' UCES    - Energy share of nominal consumption expenditures
' EMON    - Imports of goods and services ex. petroleum
' XGDEN   - Nominal Absorption
' PTR     - 10-year expected inflation (Hoey/Philadelphia survey)

```

```

smpl datasample
%dbin = "./state_space_data"
dbopen %dbin as histdata
fetch(d=histdata) *

```

```

'*****
' Make model observable series, set priors

```

```

smpl datasample

```

```

call data_transformations

```

```

'*****
' Load saved model; run estimation step with previously estimated
' parameters as starting values (converges quickly).

```

```

smpl estsample

```

```

wfoopen saved_results
copy saved_results::untitled\saved_results kf_data::untitled\{%modname}
wfclose saved_results
freeze({%modname}_results) {%modname}.ml(m=100,showopts)

```

```

'*****
' Create states

```

```

{%modname}.makestates(t=pred) *_prs      ' one-step ahead state predictions
{%modname}.makestates(t=filt) *_1        ' filter states
{%modname}.makestates(t=smooth) *_2      ' smoothed states
{%modname}.makestates(t=disturb) *err    ' estimate of the disturbances

```

```

{%modname}.makestates(t=filtse) *se      ' RMSE of the filtered states
{%modname}.makestates(t=smoothse) *se2   ' RMSE of the smoothed states

{%modname}.makesignals(t=pred) *_pr      ' one-step ahead signal predictions
{%modname}.makesignals(t=resid) *_res    ' error in one-step ahead signal prediction
{%modname}.makesignals(t=stdresid) *_sres ' standardized one-step ahead prediction

'*****
' Transformation into FRB/US mnemonics

series xbt = exp((tmfp_2/.965 + 0.725*(terate_2 + tlfpr_2 + thtfactor_2 + tww_2) +
                 0.275*lks + 0.725*llqualt + (.035/.965)*lveoa + lpop)/100)
series hmfpt = gtmfp_2
series qlfpr = exp(tlfpr_2/100)
series hqlfpr = (gtlfpr_2/400)*qlfpr(-1)
series hqlww = gtw_2
series huxb = gtotfactor_2
series leppot = exp((tlfpr_2+terate_2+thtfactor_2)/100) * n16
series lurnat = 100*(1-exp(terate_2/100))
series qlww = exp(tww_2/100)
series uxbt = exp(totfactor_2/100)
series xgdpt = xbt * uxbt
series xgdo = exp(cycle_2/100)*xgdpt

```

Uses close 215, data.transformations 213c, dbopen 215, ex 216, fetch 215,
 frbus_supply_filter 214a, hmfpt 216, hqlfpr 216, hqlww 216, huxb 216, leppot 216,
 lurnat 216, n16 216, qlfpr 216, qlww 216, uxbt 216, wfclose 215, wfcreate 215,
 wfopen 215, xbt 216, xgdo 216, and xgdpt 216.

4.5 Initial Values

81 $\langle initial\ values\ 81 \rangle \equiv$ (214b)

```

subroutine initial_values

coef(703) beta
coef(60) phi
beta(1)      = 1.497516
beta(2)      = -0.540927
beta(213)    = -0.328852
beta(214)    = 1.061453
beta(216)    = -0.266658
beta(10)     = 1.325310
beta(401)    = 0.625693
beta(404)    = 0.090059
beta(405)    = 0.440360
beta(406)    = -0.324208
beta(407)    = -0.435237
beta(408)    = 0.293555
beta(409)    = 0.253904
beta(6)      = 0.331366
beta(602)    = 0.927692

phi(20)      = 0.301616
phi(22)      = 0.020651
phi(30)      = 0.452297
phi(31)      = 0.649965
phi(40)      = 0.042475
phi(41)      = 0.727876
phi(50)      = 0.299981
phi(51)      = 0.528947

beta(105)    = 0.176896
beta(106)    = 0.086226
beta(107)    = 0.210419
beta(104)    = 0.229143
beta(100)    = 0.000001
beta(109)    = 0.803236
beta(111)    = 0.566205
beta(119)    = 0.099423
beta(123)    = 0.129325
beta(115)    = 0.140001
beta(117)    = 0.081062
beta(124)    = 0.136532
beta(118)    = 0.010000

```

```
beta(122)      = 0.050000
beta(114)      = 0.107852
beta(112)      = 0.044151
beta(126)      = 0.476765
beta(125)      = 0.534807
beta(11) = 1/beta(10)
```

```
endsub
```

Defines:

`initial_values`, used in chunks 67, 74, and 176.

Chapter 5

Data Only Package

Chapter 6

Appendices

Routine Libraries

6.1 Master Library

6.1.1 quarterly date string shift

```
87  <quarterly date string shift 87>≡ (207b)
    subroutine dateshift(string %indate, string %outdate, scalar qtrshift)

    ' this subroutine takes the quarterly date string in %indate (ie, "2001q1") and shifts
    ' it qtrshift quarters, returning the result in %outdate

    !dddd1 = @dateval(%indate,"yyyfq")
    !dddd2 = @dateadd(!dddd1,qtrshift,"q")
    %outdate = @datestr(!dddd2,"yyyfq")

    endsub
```

Defines:

dateshift, used in chunks 11, 23, 91, and 152.

6.1.2 copy series into group

```

88  <copy series into group 88>≡ (207b)
    subroutine group2group(string %fromgroup, string %togroup, string %to_type)

    ' copies a group of series into another group.
    ,
    ' If %to_type = "suffix", then %togroup is interpreted as a suffix to be applied to
    ' %fromgroup and its series.
    ,
    ' If %to_type = "prefix", then %togroup is interpreted as a prefix to be applied to
    ' %fromgroup and its series.
    ,
    ' If %to_type = "group", the %togroup is interpreted as the name of a group that
    ' already exists.

    if %to_type = "group" then
        if {%fromgroup}.@count <> {%togroup}.@count then
            statusline ERROR in GROUP2GROUP:  the two groups do not contain the same number
        endif
        for !ik1 = 1 to {%fromgroup}.@count
            %tmp = {%fromgroup}.@seriesname(!ik1)
            %tmp1 = {%togroup}.@seriesname(!ik1)
            {%tmp1} = {%tmp}
        next
    endif

    if %to_type = "suffix" then
        %tmpa = " "
        %tmpb = %fromgroup + %togroup
        for !ik1 = 1 to {%fromgroup}.@count
            %tmp = {%fromgroup}.@seriesname(!ik1) + %togroup
            %tmpa = %tmpa + " " + %tmp
            if @isobject(%tmp) then
                {%tmp} = {%fromgroup}(!ik1)
            else
                series {%tmp} = {%fromgroup}(!ik1)
            endif
        next
        group {%tmpb} {%tmpa}
    endif

    if %to_type = "prefix" then
        %tmpa = " "
        %tmpb = %togroup + %fromgroup
        for !ik1 = 1 to {%fromgroup}.@count

```

```

    %tmp = %togroup + {%fromgroup}.@seriesname(!ik1)
    %tmpa = %tmpa + " " + %tmp
    if @isobject(%tmp) then
        {%tmp} = {%fromgroup}(!ik1)
    else
        series {%tmp} = {%fromgroup}(!ik1)
    endif
    next
    group {%tmpb} {%tmpa}
endif

```

endsub

Defines:

group2group, never used.

6.1.3 set group to zero

89a *<set group to zero 89a>*≡ (207b)

```

    subroutine group2zero(string %group)

    ' set all series in an existin %group to zero

    for !ik1 = 1 to {%group}.@count
        %tmp = {%group}.@seriesname(!ik1)
        {%tmp} = 0
    next

```

endsub

Defines:

group2zero, used in chunks 3, 7, 11, 17, 23, 31, 40, and 202.

6.1.4 names of all series in group

89b *<names of all series in group 89b>*≡ (207b)

```

    subroutine groupnames2string(string %group, string %groupnames)

    ' creates a string of the names of all the series in a group

    %groupnames = " "
    for !ik1 = 1 to {%group}.@count
        %groupnames = %groupnames + " " + {%group}.@seriesname(!ik1)
    next

```

endsub

Defines:

groupnames2string, used in chunk 40.

6.1.5 create new group

```

90  <create new group 90>≡ (207b)
    subroutine groupnew(string %fromgroup, string %to)

    ' Creates a new group. The names of the new group and associated series are built up
    ' from %fromgroup with %to as a suffix. Series that do not yet exist are set to zero

    %tmpa = " "
    %tmpb = %fromgroup + %to
    for !ik1 = 1 to {%fromgroup}.@count
        %tmp = {%fromgroup}.@seriesname(!ik1) + %to
        %tmpa = %tmpa + " " + %tmp
        if @isobject(%tmp) <> 1 then
            series {%tmp} = 0
        endif
    next
    group {%tmpb} {%tmpa}

    endsub

```

Defines:

groupnew, used in chunks 3, 7, 11, 17, 23, 31, 40, and 202.

6.1.6 interpolate unavailable observations

```

91  <interpolate unavailable observations 91>≡ (207b)
    subroutine interp_lin(string %series_in, string %series_out, string %substart, string %subend)

    ' Subroutine that replaces NA values in a series with
    ' interpolated observations.  NA values at the beginning or end of the series are
    ' replaced with the first or last non-NA value.

    smpl %substart %subend

    ' *****
    ' check that series is not all NAs
    series tmp_check = ({%series_in} = NA)
    if @sum(tmp_check) = @obssmpl then
        statusline Error in interp_lin subroutine:  interpolation cannot be performed because series
        stop
    endif

    series tmp_ser = ({%series_in}<>NA)
    series tmp_id = @cumsum(tmp_ser)
    series tmp_next = @sumsby({%series_in},tmp_id(-1))
    series tmp_prev = @sumsby({%series_in},tmp_id)

    ' *****
    ' check for NAs at either beginning or end of sample

    ' test for NAs at beginning of sample
    series tmp_naprev = (tmp_prev = NA)
    !flag_prev = @max(tmp_naprev)
    if !flag_prev = 1 then
        'at this point, tmp_next will have an undesired NA in its first observation;
        'change it to equal its second observation
        smpl %substart %substart
        call dateshift(%substart,%nextqtr,1)
        tmp_next = @elem(tmp_next,%nextqtr)
        smpl %substart %subend if (tmp_prev = NA)
        tmp_prev = tmp_next
        smpl %substart %subend
    endif

    ' test for NAs at end of sample
    series tmp_nanext = (tmp_next = NA)
    !flag_next = @max(tmp_nanext)
    if !flag_next = 1 then
        smpl %substart %subend if (tmp_next = NA)
    endif

```

```

tmp_next = tmp_prev
smpl %substart %subend
endif

' *****
series tmp_lambda = (@obsid-@minsby(@obsid,tmp_id))/@sumsby(1,tmp_id)
series {%series_out} = tmp_lambda*tmp_next + (1-tmp_lambda)*tmp_prev

delete tmp_ser tmp_prev tmp_next tmp_lambda tmp_id tmp_nanext tmp_naprev tmp_check

endsub
Defines:
  interp_lin, used in chunk 40.
Uses dateshift 87.

```

6.1.7 set fiscal policy option

```

92  <set fiscal policy option 92>≡ (207b)
    subroutine set_fp(string dfpxxx)

        %policy_options = "dfpex dfpsrp dfpdbl"
        %dfpxxx = @lower(dfpxxx)
        %dfpxxx = @replace(%dfpxxx," ","")

        !kz = @wfind(%policy_options,%dfpxxx)
        if !kz > 0 then
            for !izzz = 1 to @wcount(%policy_options)
                %ppp = @word(%policy_options,!izzz)
                if !izzz = !kz then
                    series {%ppp} = 1
                else
                    series {%ppp} = 0
                endif
            next
        else
            %err = %dfpxxx + " is not a valid fiscal policy option; execution terminated"
            @uiprompt(%err)
            stop
        endif

    endsub
Defines:
  set_fp, used in chunks 3, 7, 11, 17, 23, 31, and 40.
Uses dfpdbl 216, dfpex 216, and dfpsrp 216.

```

6.1.8 set monetary policy option

```

93  <set monetary policy option 93>≡ (207b)
    subroutine set_mp(string dmpxxx)

        %policy_options = "dmpex dmprr dmptay dmptlr dmpintay dmpalt dmpgen"
        %dmpxxx = @lower(dmpxxx)
        %dmpxxx = @replace(%dmpxxx," ","")

        !kz = @wfind(%policy_options,%dmpxxx)
        if !kz > 0 then
            for !izzz = 1 to @wcount(%policy_options)
                %ppp = @word(%policy_options,!izzz)
                if !izzz = !kz then
                    series {%ppp} = 1
                else
                    series {%ppp} = 0
                endif
            next
        else
            %err = %dmpxxx + " is not a valid monetary policy option; execution terminated"
            @uiprompt(%err)
            stop
        endif

    endsub

Defines:
    set_mp, used in chunks 3, 7, 11, 17, 23, 31, and 40.
Uses dmpalt 216, dmpex 216, dmpgen 216, dmpintay 216, dmprr 216, dmptay 216,
and dmptlr 216.

```

6.1.9 set monetary policy fed funds rate

94 $\langle \text{set monetary policy fed funds rate 94} \rangle \equiv$ (207b)
 subroutine set_mpvars2rff
 rfffix = rff
 rfftay = rffe
 rfftlr = rffe
 rffalt = rff
 rffintay = rffe
 rffgen = rffe
 rrfix = rffe - @movav(picxfe,4)

endsub

Defines:

set_mpvars2rff, never used.

Uses picxfe 216, rff 216, rffalt 216, rffe 216, rfffix 216, rffgen 216, rffintay 216, rfftay 216, rfftlr 216, and rrfix 216.

6.2 mce solve library

6.2.1 mce solve library change history

```

95  <mce solve library change history 95>= (209)
    ' Changes (1/25/14)
    ,
    ' 1. Removed defaults from mce_load_frbus subroutine
    ,
    ' 2. Added make_frbus_mcevars subroutine
    ,
    ' Changes (1/22/14)
    ,
    ' 1. Added code so that the _$sufsim string variable is assigned the
    '     alias of the currently active scenario when the %mopts argument
    '     is a null string.
    ,
    ' 2. In subroutine mcz_sim, put the contents of string variable
    '     mcz_sim_options into another string, a change which for unknown
    '     reasons eliminates an unexplained Eviews shutdown when running
    '     a pair of simulations of which the first is type=single and the
    '     second is type=opt.

    ' Changes (1/8/14)
    ,
    ' 1. Added the "dontstop" option to the %sopt argument. When invoked,
    '     this option causes the evIEWS program that calls mce_run
    '     to continue executing when running a type=single simulation if
    '     (a) the solution iterations do not
    '     converge within the maximum number of permitted iterations or
    '     (b) the evIEWS solver generates an error when solving either
    '     the backward-looking or forward-looking models in subroutine
    '     mcz_solvit. In the case of nonconvergence the call to mce_run
    '     terminates with the string value %mce_finish = "no". In the
    '     case of a solver error, the call to mce_run terminates with the
    '     string value %mce_finish = "failed_solve". Otherwise,
    '     %mce_finish = "yes".
    ,
    ,
    ,
    ' Changes (2/21/12)
    ,
    ' 1. Fixed problem with code for unconstrained TC policy
    '     calculated via EViews matrices -- the solution at period t
    '     (t = 1, ... !ndrv) must go out through period
    '     the farthest period ever solved -- (!nevl + !ndrv - 1) --
    '     which requires that the opt derivative

```

```

'    matrix must span this many quarters.  The constrained TC
',
' 2. Wrote code for constrained TC policy in EViews when there is
'    a single instrument
',
' 3. Fixed code for constrained TC policy in R -- still need to do matlab

' Changes (2/16/12)
',
' 1. Fixed problem with constrained optimization when
'    number of evaluation periods is not the same as
'    the number of instrument periods
'    (subroutine mcz_opt_qp).  This undoes part of the
'    1/17/12 change #3
',
' Changes (2/13/12)
',
' 1. Added "d=" option for TC damping factor (!tcdamp)

' Changes (1/30/12)
',
' 1. Modified subroutine mca_opt_qp to set options in matlab
'    quadprog function call
',
' Changes (1/17/12)
',
' 1. Added new subroutine (mcz_opt_tc) and new simtype (opttc)
' 2. Added new keywords:  ideriv, for sopt string
'    /xopen, /xclose for R and matlab
' 3. Modified subroutine mcz_opt_qp so that the dimensions of the
'    initial and transformed constraint matrices are based on !ndrv not !nevl
' 4. Dropped the explicit optqp simtype
',

```

Uses make_frbus_mcevars 173, mce_load_frbus 169, mce_run 97, mcz_opt_qp 147,
 mcz_opt_tc 152, mcz_sim 114, and mcz_solvit 123.

6.2.2 run model consistent expectations

```

97  (run model consistent expectations 97)≡ (209)
    subroutine mce_run(string m_opts, string a_opts, string s_opts)

    ' Driver program

    %mcestart = @word(@pagesmpl,1)
    %mceend = @word(@pagesmpl,2)

    ' *****
    ' 1. Examine m_opts string (defines or creates models, mce errors and instruments)
    ' *****
    '
    ' Case 1: null string (ie, "")
    '      => use existing models whose names are contained in %$_mod_b and
    '           %$_mod_f; use existing objects $_mce_instrus
    '           and $_mce_errs.
    ' Case 2: string contains the keywords "create" and "mod=<modname>"
    '      => a model named <modname> is in the workfile and contains explicit
    '           leads; parse it to create the objects $_mod_b, $_mod_f,
    '           $_mce_instrus, and $_mce_errs
    ' Case 3: string contains the keywords "mod_b=", "mod_f=", "mce_errs=", "mce_instrus=";
    '           or the keywords "mod_b=", "mod_f=", "mce_vars="
    '      => each keyword must be assigned to a string variable, whose contents are
    '           used to define $_mod_b, $_mod_f, $_mce_errs, and
    '           $_mce_instrus

    if @isempty(m_opts) = 1 then
    ' *****
    ' case 1 code
    !m_case = 1
    !z1 = @isobject(%$_mod_b)
    !z2 = @isobject(%$_mod_f)
    !z3 = @isobject("$_mce_instrus")
    !z4 = @isobject("$_mce_errs")
    !zsum = !z1+!z2+!z3+!z4
    if !zsum <> 4 then
        %err = "When the first argument to mce_run is a null string, a previous call to "
        %err = %err + "mce_run must have placed the names of the backward and "
        %err = %err + "forward looking models, list of mce instruments names "
        %err = %err + "and list of mce error names in various strings; at least one "
        %err = %err + "these strings either does not exist or contains the name of "
        %err = %err + "an object that does not exist. Execution terminates."

```

```

    @uiprompt(%err)
    stop
  endif
  'find alias of active scenario
  %endog_active = {%_$_mod_b}.@endoglist("@active")
  %endog_actual = {%_$_mod_b}.@endoglist
  %word1_active = @word(%endog_active,1)
  %word1_actual = @word(%endog_actual,1)
  !a1 = @strlen(%word1_active)- @strlen(%word1_actual)
  string $_sufsim = @right(%word1_active,!a1)

  else
  m_opts = @lower(m_opts)
  m_opts = @replace(m_opts," ","")
  m_opts = @replace(m_opts,",",", ")
  m_opts = " " + m_opts + " "

  if @instr(m_opts,"create") and @instr(m_opts,"mod=") then
    ' *****
    ' case 2 code
    !m_case = 2
    call mcz_equalopt("mod",m_opts)
    if @len(%temp)>0 then
      %temp1 = @left(%temp,1)
      if %temp1 = "%" then
        %mod = @lower({%temp})
      else
        %mod = @lower(%temp)
      endif
      call mcz_parsemod({%mod})
    endif
    else
    !z1 = @instr(m_opts,"mod_b=")
    !z2 = @instr(m_opts,"mod_f=")
    !z3 = @instr(m_opts,"mce_errs=")
    !z4 = @instr(m_opts,"mce_instrus=")
    !z5 = @instr(m_opts,"mce_vars=")
    !zsum1 = (!z1>0)+(!z2>0)+(!z3>0)+(!z4>0)
    !zsum2 = (!z1>0)+(!z2>0)+(!z5>0)
    if !zsum1 = 4 or !zsum2 = 3 then
      ' *****
      ' case 3 code
      !m_case = 3
      call mcz_equalopt("mod_b",m_opts)
      if @len(%temp)>0 then
        %temp = @lower({%temp})

```



```

        %_$mod_b = %temp
    endif
    call mcz_equalopt("mod_f",m_opts)
    if @len(%temp)>0 then
        %temp = @lower({%temp})
        %_$mod_f = %temp
    endif
    call mcz_equalopt("mce_errs",m_opts)
    if @len(%temp)>0 then
        %temp = @lower({%temp})
        group _$mce_errs {%temp}
    endif
    call mcz_equalopt("mce_instrus",m_opts)
    if @len(%temp)>0 then
        %temp = @lower({%temp})
        group _$mce_instrus {%temp}
    endif

    else
' *****
' m_opt string does not conform to a valid case
    @uiprompt("first argument to subroutine mce_run is incorrectly specified")
    stop
    endif
endif
endif

if !m_case = 2 or !m_case = 3 then
    call mcz_hasopt("adds",m_opts)
    if !hasflag = 1 then
        {%_$mod_b}.addassign @all
        {%_$mod_f}.addassign @all
    endif
    call mcz_hasopt("track",m_opts)
    if !hasflag = 1 then
        %track = "yes"
        %track_start = @word(@pagesmpl,1)
        %track_end = @word(@pagesmpl,2)
        call mcz_equalopt("tstart",m_opts)
        if @len(%temp)>0 then
            %track_start = @lower(%temp)
        endif
        call mcz_equalopt("tend",m_opts)
        if @len(%temp)>0 then
            %track_end = @lower(%temp)
        endif
    endif
endif

```

```

    smpl %track_start %track_end
    {%_$_mod_b}.addinit(v=n) @all
    {%_$_mod_f}.addinit(v=n) @all
  endif
endif

if !m_case = 2 then
  group $_mce_errs {%mod}_targs}
  group $_mce_instrus {%mod}_instrus}
endif

if !m_case = 3 then
  call mcz_equalopt("mce_vars",m_opts)
  if @len(%temp)>0 then
    %temp = @lower({%temp})
    %errs = @wcross("e",%temp)
    group $_mce_errs {%errs}
    %instrus = @wcross(%temp,"_a")
    group $_mce_instrus {%instrus}
  endif
endif

' *****
' 2.  Examine a_opts string (specifies mce algorithm)
' *****
'
' Case 1:  blank string and %existing_algos = "yes"
'         => do not call mcz_algo (use existing settings)
' Case 2:  blank string and %existing_algos <> "yes"
'         => call mcz_algo to set default options
' Case 3:  nonblank string
'         => call mcz_algo using string to set options overrides

if @isempty(a_opts) = 1 then
  if %existing_algos = "yes" then
    !a_case = 1
  else
    !a_case = 2
    call mcz_algo(%_$_mod_b,%_$_mod_f," ",$_mce_instrus,$_mce_errs)
  endif
else
  !a_case = 3
  call mcz_algo(%_$_mod_b,%_$_mod_f,a_opts,$_mce_instrus,$_mce_errs)
endif

```

```

' *****
' 3. Examine s_opts string (specifies type of simulation)
' *****

if @isempty(s_opts) = 1 then
    @uiprompt("error:  no simulation action requested")
    stop
endif

' make a copy of s_opts for parsing within this subroutine
' (the original is passed to other subroutines for additional
' parsing)
string _$_opts = s_opts
$_opts = @lower($_opts)
$_opts = @replace($_opts," ","")
$_opts = @replace($_opts,","," ")
$_opts = " " + $_opts + " "

' check for keywords that pertain to all simulation types
call mcz_hasopt("scen",$_opts)
if !hasflag = 1 then
    call mcz_equalopt("suf",$_opts)
    if @len(%temp)>0 then
        string $_sufsim = @lower(%temp)
    else
        string $_sufsim = "_1"
    endif
    %sufsim = $_sufsim
    %scenname = "mce_sim" + $_sufsim
    {%$_mod_b}.scenario(n,a=%sufsim) %scenname
    {%$_mod_f}.scenario(n,a=%sufsim) %scenname
endif
call mcz_equalopt("solveopt",$_opts)
{%$_mod_b}.solveopt(o=n,g=12,z=1e-12)
{%$_mod_f}.solveopt(o=n,g=12,z=1e-12)
if @len(%temp)>0 then
    {%$_mod_b}.solveopt({{%temp}})
    {%$_mod_f}.solveopt({{%temp}})
endif
call mcz_equalopt("txt",$_opts)
if @len(%temp)>0 then
    for !j = 1 to {%temp}.@linecount
        %tmp = @lower({%temp}.@line(!j))
        {%tmp}
    next
endif

```

```

!mceshow = 1
call mcz_equalopt("o",_$_opts)
if @len(%temp)>0 then
  !mceshow = @val(%temp)
endif
call mcz_equalopt("sstart",_$_opts)
if @len(%temp)>0 then
  %mcestart = @lower(%temp)
endif
call mcz_equalopt("send",_$_opts)
if @len(%temp)>0 then
  %mceend = @lower(%temp)
endif
smpl %mcestart %mceend
!nqtrs = @obssmpl
call mcz_hasopt("cleanup",_$_opts)
if !hasflag = 1 then
  %cleanup = "yes"
else
  %cleanup = "no"
endif
call mcz_hasopt("dontstop",_$_opts)
if !hasflag = 1 then
  %dontstop = "yes"
  if @maxerrs - @errorcount < 2 then
    !tt = @errorcount + 2
    setmaxerrs !tt
  endif
else
  %dontstop = "no"
endif

' create various program variables and objects that are needed by
' all simulation types; compute initial Jacobian in some cases
call mcz_sim_setup
if %mcz_sim_setup = "err" then
  %mce_finish = "failed_solve"
  return
endif

' determine simulation type
call mcz_equalopt("type",_$_opts)
if @len(%temp) > 0 then
  %simtype = @lower(%temp)
  if %simtype = "single" then
    call mcz_sim(_$_opts)

```

```

    if %mcz_sim = "err" then
        %mce_finish = "failed_solve"
        return
    endif
else
    if %simtype = "opt" or %simtype = "opttc" then
        call mcz_equalopt("targs",_$_opts)
        if @len(%temp)>0 then
            %targs = @lower(%temp)
        else
            @uiprompt("error:  targs keyword is missing")
            stop
        endif
        call mcz_equalopt("instrus",_$_opts)
        if @len(%temp)>0 then
            %instrus = @lower(%temp)
        else
            @uiprompt("error:  instrus keyword is missing")
            stop
        endif
        call mcz_equalopt("cnstr",_$_opts)
        if @len(%temp)>0 then
            %cnstr = @lower(%temp)
            %cnstrflag = "yes"
        else
            text _$_blanktext
            %cnstr = "_$_blanktext"
            %cnstrflag = "no"
        endif
        call mcz_opt_setup(s_opts,{%instrus},{%targs},{%cnstr})
    else
        @uiprompt("error:  invalid simtype")
        stop
    endif
endif
else
    @uiprompt("error:  required simtype keyword not found")
    stop
endif

```

endsub

Defines:

mce_run, used in chunks 7, 17, 23, 31, 49, 52, 55, 59, 62, 95, 112, and 114.

Uses mcz_algo 107, mcz_equalopt 111a, mcz_hasopt 111b, mcz_opt_setup 136,
mcz_parsemod 104, mcz_sim 114, and mcz_sim_setup 112.

6.2.3 determine endogenous and exogenous variables

```

104  <determine endogenous and exogenous variables 104>≡ (209)
      subroutine mcz_parsemod(model modo)
      ,
      ' This subroutine takes modo, a model with explicit leads, and creates
      ' four objects. The name of each created object starts with the name of the
      ' input model, which is denoted by <modname>.
      ,
      ' 1. Model _$_<modname>_b is the same as modo but with all leads replaced
      ' with exogenous variables
      ' 2. Model _$_<modname>_f contains the MCE error equations
      ' 3. String <modname>_instrus of the names of the added exogenous variables,
      ' which are the instruments to be used to drive the MCE errors to zero
      ' 4. String <modname>_targs of the names of the endogenous variables in
      ' <modname>_f, which are the names of MCE error variables

      ' preliminaries
      %ok_chars = "--+*(^ "
      freeze(_$_modtext) modo.text
      string _$_endog = @lower(modo.@endoglist)
      !nvars = @wcount(_$_endog)
      %leadnames = " "
      %errnames = " "

      %mm = @lower(modo.@name)
      %$_mod_b = "_$_" + %mm + "_b"
      %$_mod_f = "_$_" + %mm + "_f"
      model {%$_mod_b}
      model {%$_mod_f}

      ' create model _$_<modname>_b
      smpl @all
      for !i2 = 1 to _$_modtext.@linecount
        %tmp2 = @ltrim(@lower(_$_modtext.@line(!i2)))
        %aa = @left(%tmp2,1)
        if %aa <> "@" then
          for !i1 = 1 to !nvars
            !occurrence = 1
            %tmp1 = @word(_$_endog,!i1) + "("
            !kk = @instr(%tmp2,%tmp1)
            if !kk > 0 then
              while !kk > 0
                'three possibilities
                ' 1. it is part of another variable name

```

```

' 2. it is a lag
' 3. it is a lead
,
'look at character in %tmp2 just before %tmp1 to make sure that %tmp1
'is not part of a longer variable or coefficient name
%before = @mid(%tmp2, !kk-1,1)
if @instr(%ok_chars,%before) > 0 then
    %tmp3 = @mid(%tmp2,!kk)
    !kkll = @instr(%tmp3,"(")
    !kkrr = @instr(%tmp3,")")
    %laglead = @mid(%tmp3,!kkll, !kkrr-!kkll+1)
    !ll = 0 + {%laglead}
    if !ll <= 0 then 'it is a lag -- skip it
        !occurrence = !occurrence + 1
    endif
    if !ll > 0 then 'it is a lead -- define a new variable
        %aaa = @word(_$_endog,!i1) + %laglead
        %bbb = @word(_$_endog,!i1) + "_ld_" + @str(!ll)
        series {%bbb} = {%aaa}
        %tmp4 = @replace(%tmp2,%aaa,%bbb,1)
        %tmp2 = %tmp4
        %leadnames = %leadnames + " " + %bbb
    endif
    else 'it is part of another variable name -- skip it
        !occurrence = !occurrence + 1
    endif
    !kk = @instr(%tmp2,%tmp1,!occurrence)
wend
endif
next
endif
{$_$_mod_b}.append {%tmp2}
next

' create _$_<modname>_f
%leadnames = @wunique(%leadnames)
'smpl @all
for !i1 = 1 to @wcount(%leadnames)
    %tmp1 = @word(%leadnames,!i1)
    !k1 = @instr(%tmp1,"_ld_")
    %tmp2 = @left(%tmp1,!k1-1)
    %tmp3 = @mid(%tmp1,!k1+4)
    %tmp4 = "err_" + %tmp2 + "_" + @str(%tmp3)
    series {%tmp4} = 0
    %errnames = %errnames + " " + %tmp4
    %eqstring = %tmp4 + "=" + %tmp1 + "-" + %tmp2 + "(" + @str(%tmp3) + ")"

```

```
        {%$_mod_f}.append {%eqstring}  
    next  
  
    ' create mce instrument and target strings  
  
    string {%mm}_instrus = %leadnames  
    string {%mm}_targs = %errnames  
  
endsub
```

Defines:

mcz_parsemod, used in chunk 97.

6.2.4 determine default method, linesearch, and other options

```

107  <determine default method, linesearch, and other options 107>≡ (209)
      subroutine mcz_algo(string mcz_mod_b, string mcz_mod_f, string mcz_algo_opts, group mcz_instr

      %existing_algos = "yes"

      mcz_algo_opts = @lower(mcz_algo_opts)
      mcz_algo_opts = @replace(mcz_algo_opts," ","")
      mcz_algo_opts = @replace(mcz_algo_opts,",",", ")
      mcz_algo_opts = " " + mcz_algo_opts + " "

      ' default values for method options
      %meth = "newton"
      %jinit = "interp"
      !nskip = 12
      !jtrigger = .5

      ' default values for linesearch options
      %linemeth = "armijo"
      !linetrigger = .9
      !mcelinemax = 10
      !lambda = 1.0
      !lrat = .5
      !mcz_step_max = 1.0

      ' default values for other options
      !mceconv = .00001
      !mcemaxiter = 20
      !mceptrib = .001
      !broymax = 600

      ' just in case
      %terminal = "no"

      ' are there overrides to defaults?
      if @len(mcz_algo_opts) > 0 then

      ' *****
      ' look for method option
      call mcz_equalopt("meth",mcz_algo_opts)
      if @len(%temp)>0 then
          %meth = @lower(%temp)
          if %meth = "broy" then
              %jinit = "bd"

```

```

        %jupdate = "na"
        %linemeth = "lmr"
        !mccmaxiter = 200
    endif
    if %meth = "qnewton" then
        %jinit = "bd"
        %jupdate = "na"
        %linemeth = "lmr"
        !mccmaxiter = 200
        call mcz_equalopt("broymax",mcz_algo_opts)
        if @len(%temp)>0 then
            !broymax = @val(%temp)
        endif
    endif
    if %meth = "ft" then
        %jinit = "identity"
        %jupdate = "na"
        %linemeth = "na"
        !mccmaxiter = 500
    endif
endif

' *****
' look for jinit and jt options
call mcz_equalopt("jinit",mcz_algo_opts)
if @len(%temp)>0 then
    %temp = @lower(%temp)
    if @instr(%temp,"interp(") then
        !k1 = @instr(%temp,"(")
        !nskip = -@val(@mid(%temp,!k1))
        %tmp1 = @mid(%temp,!k1)
        %jinit = "interp"
    else
        %jinit = @lower(%temp)
    endif
endif
call mcz_equalopt("jt",mcz_algo_opts)
if @len(%temp)>0 then
    !jtrigger = @val(%temp)
endif

' *****
' look for jupdate option
%jupdate = %jinit
call mcz_equalopt("jupdate",mcz_algo_opts)
if @len(%temp)>0 then

```

```

%temp = @lower(%temp)
if @instr(%temp,"interp") then
    !k1 = @instr(%temp,"(")
    !nskip = -@val(@mid(%temp,!k1))
    %tmp1 = @mid(%temp,!k1)
    %jupdate = "interp"
else
    %jupdate = @lower(%temp)
endif
endif

' *****
' look for options related to linesearch
call mcz_equalopt("lmeth",mcz_algo_opts)
if @len(%temp)>0 then
    %linemeth = @lower(%temp)
endif
call mcz_equalopt("lt",mcz_algo_opts)
if @len(%temp)>0 then
    !linetrigger = @val(%temp)
endif
call mcz_equalopt("lmax",mcz_algo_opts)
if @len(%temp)>0 then
    !mcelinemax = @val(%temp)
endif
call mcz_equalopt("lambda",mcz_algo_opts)
if @len(%temp)>0 then
    !lambda = @val(%temp)
endif
call mcz_equalopt("stepmax",mcz_algo_opts)
if @len(%temp)>0 then
    !mcz_step_max = @val(%temp)
endif

' *****
' look for other options
call mcz_equalopt("c",mcz_algo_opts)
if @len(%temp)>0 then
    !mceconv = @val(%temp)
endif
call mcz_equalopt("m",mcz_algo_opts)
if @len(%temp)>0 then
    !mcemaxiter = @val(%temp)
endif
call mcz_equalopt("p",mcz_algo_opts)

```

```

    if @len(%temp)>0 then
        !mceptrb = @val(%temp)
    endif

endif

' *****
' verify the MCE instrument and error arguments

!nmceinstrus = $_mce_instrus.@count
!nmcetargs = $_mce_errs.@count

if !nmcetargs <> !nmceinstrus then
    @uiprompt("Error: There must be as many mce errors as there are mce instruments")
    stop
endif

' *****
' check that mce instruments are exogenous variables or add factors
' in the lag model
%exog_vnames = {%$_mod_b}.@exoglist
%adds_vnames = {%$_mod_b}.@addfactors
%exog_vnames = %exog_vnames + " " + %adds_vnames
%endog_vnames = {%$_mod_b}.@endoglist
for !i = 1 to $_mce_instrus.@count
    %vvv = $_mce_instrus.@seriesname(!i)
    !cc = @wfindnc(%exog_vnames,%vvv)
    if !cc = 0 then
        %errstring = "mce control variable " + %vvv + " is not an exogenous variable or add factor"
        @uiprompt(%errstring)
        stop
    endif
next

' *****
' check that mce errors are endogenous variables in the lead model
%endog_lnames = {%$_mod_f}.@endoglist
for !i = 1 to $_mce_errs.@count
    %vvv = $_mce_errs.@seriesname(!i)
    !cc = @wfindnc(%endog_lnames,%vvv)
    if !cc = 0 then
        %errstring = "mce error variable " + %vvv + " is not an endogenous variable in the lead model"
        @uiprompt(%errstring)
        stop
    endif
endfor

```

```
next
```

```
endsub
```

Defines:

`mcz_algo`, used in chunk 97.

Uses `mcz_equalopt` 111a.

6.2.5 parse options containing equal signs

111a \langle *parse options containing equal signs* 111a $\rangle \equiv$ (209)

```
subroutine mcz_equalopt(string optionstext,string opts)
```

```

' parse an option that contains an "=" sign
optionstext = " " + optionstext + "="
!k10 = @instr(opts,optionstext)
if !k10 > 0 then
    !k11 = @len(optionstext)
    %tmp10 = @mid(opts,!k10+!k11)
    !k12 = @instr(%tmp10," ")
    %temp = @left(%tmp10,!k12-1)
else
    %temp = ""
endif
```

```
endsub
```

Defines:

`mcz_equalopt`, used in chunks 97, 107, 114, 136, and 169.

6.2.6 parse options not containing equal signs

111b \langle *parse options not containing equal signs* 111b $\rangle \equiv$ (209)

```
subroutine mcz_hasopt(string optionstext,string opts)
```

```

' parse an option that does not contain an "=" sign
!k10 = @wfind(opts,optionstext)
if !k10 > 0 then
    !hasflag = 1
else
    !hasflag = 0
endif
```

```
endsub
```

Defines:

`mcz_hasopt`, used in chunks 97, 114, and 136.

6.2.7 create common variables, strings, matrices, vectors, and tables

```

112  <create common variables, strings, matrices, vectors, and tables 112>≡      (209)
      subroutine mcz_sim_setup

' create various program variables, strings, matrices, vectors, and tables
' that are common to all simulation types

      !tmcetargs = !nmcetargs * !nqtrs
      !tmceinstrus = !nmceinstrus * !nqtrs
      %mce_targ_names = _$_mce_errs.@members
      %mce_instru_names = _$_mce_instrus.@members

      string _$_mod_f_exog = @lower({%$_mod_f}.@exoglist)
      string _$_mod_b_endog = @lower({%$_mod_b}.@endoglist)
      %fvars = @wintersect(_$_mod_f_exog,_$_mod_b_endog)
      {%$_mod_f}.override {%fvars}

      !re_counter = 0

' *****
' create additional matrix/vector objects

      vector(!mce_maxiter+1) _$_mce_loss_vec
      vector(!mce_maxiter+1) _$_mce_conv_vec
      vector( !nmceinstrus*!nqtrs) _$_mce_direction = 0
      vector( !nmceinstrus*!nqtrs) _$_mce_instru_vec = 0
      vector(!nmcetargs*!nqtrs) _$_mce_gap_vec
      matrix _$_mce_ptrb_mat = @filledmatrix(!nqtrs,!nmceinstrus,!mceptrb)
      matrix(!nmcetargs*!nqtrs,1) _$_mce_targ_vec
      matrix(!tmcetargs,1) _$_mce_targ_dvec

' *****
' misc

      table(!mce_maxiter+2,6) mce_sim_stats

' *****
' compute initial jacobian except when it is an identity matrix
' or when its been created by a previous call to mce_run
      if %jinit <> "identity" and !a_case <> 1 then
          !mce_try = 1

```

```
    smpl %mcestart %mceend
    call mcz_solvit
    if %mcz_solvit = "err" then
        %mcz_sim_setup = "err"
        return
    endif

    call mcz_derivs
    endif
```

```
endsub
```

Defines:

 mcz_sim_setup, used in chunk 97.

Uses mce_run 97, mcz_derivs 125, and mcz_solvit 123.

6.2.8 model consistent coefficient simulation

```

114  <model consistent coefficient simulation 114>≡ (209)
      subroutine mcz_sim(string mcz_sim_options)

          %mcz_sim = "ok"

          ' *****
          ' 1. set options based on defaults and overrides in string mcz_sim_options
          ' *****

          ' for some unknown reason, sometimes evIEWS bombs unless mcz_sim_options
          ' is assigned to another string before processing it
          %mso = mcz_sim_options

          %mso = @lower(%mso)
          %mso = @replace(%mso," ","")
          %mso = @replace(%mso,","," ")
          %mso = " " + %mso + " "

          %terminal = "no"
          %mcevars_b = " "
          %mcevars_f = " "

          if @len(%mso) > 0 then
              call mcz_hasopt("terminal",%mso)
              if !hasflag = 1 then
                  %terminal = "yes"
                  call mcz_equalopt("mcevars_b",%mso)
                  if @len(%temp)>0 then
                      %mcevars_b = @lower(%temp)
                      call mcz_equalopt("mcevars_f",%mso)
                      if @len(%temp)>0 then
                          %mcevars_f = @lower(%temp)
                          if @wcount(%mcevars_b) <> @wcount(%mcevars_f) then
                              %estring = "Error: mcevars_b and mcevars_f have different numbers of variables"
                              @uiprompt(%estring)
                              stop
                          endif
                      endif
                  endif
              endif
          endif

          if %linemeth = "lmr" then
              !mhistory = 4
          endif
      endsubroutine

```



```

!tmin = .1
!tmax = .5
!gammak = 10(-4)
endif

' *****
' 2. set up table of iteration-by-iteration statistics
' *****

if @isobject("mce_sim_stats") then
    delete mce_sim_stats
endif
table(!mce_maxiter+2,6) mce_sim_stats
mce_sim_stats.setwidth(1:1) 6
mce_sim_stats.setwidth(2:6) 11
mce_sim_stats.setlines(a2:f2) +b
setcell(mce_sim_stats,1,1,"iter")
setcell(mce_sim_stats,1,2,"converge")
setcell(mce_sim_stats,2,2,"stat")
setcell(mce_sim_stats,1,3,"SSR")
setcell(mce_sim_stats,2,3,"stat")
setcell(mce_sim_stats,1,4,"step")
setcell(mce_sim_stats,2,4,"length")
setcell(mce_sim_stats,1,5,"step")
setcell(mce_sim_stats,2,5,"iters")
setcell(mce_sim_stats,1,6,"Newton MCE")
setcell(mce_sim_stats,2,6,"deriv's?")

' *****
' 3. information text file
' *****

if @isobject("mce_sim_text") then
    delete mce_sim_text
endif
text mce_sim_text
mce_sim_text.append Simulation start = {%mcestart}
mce_sim_text.append Simulation end   = {%mceend}
mce_sim_text.append MCE method = %meth
if %meth = "newton" then
    mce_sim_text.append -- Initial jacobian = %jinit
    if %jinit = "interp" then
        mce_sim_text.append ---- Jacobian interpolation parameter = {!nskip}
    endif
endif

```

```

mce_sim_text.append -- Recompute Jacobian based on jtrigger = {!jtrigger}
mce_sim_text.append -- Recompute jacobian using method = {%jupdate}
endif
if %meth = "broy" or %meth = "qnewton" then
mce_sim_text.append -- Initial Jacobian approximation = %jinit
if %jinit = "interp" then
mce_sim_text.append ---- Interpolation parameter = {!nskip}
endif
if %meth = "qnewton" then
mce_sim_text.append ---- QNewton iteration switch = {!broymax}
endif
endif
if %meth = "ft" then
mce_sim_text.append -- Fixed step size =  {!lambda}
endif
mce_sim_text.append Linesearch method = {%linemeth}
if %linemeth <> "na" then
mce_sim_text.append -- Linesearch trigger = {!linetrigger}
mce_sim_text.append -- Maximum linesearch iterations =  {!mcelinemax}
endif
mce_sim_text.append Convergence criteria = {!mceconv}
mce_sim_text.append Maximum number of MCE iterations = {!mce_maxiter}
mce_sim_text.append MCE instrument perturbation factor = {!mceptrib}
mce_sim_text.append Intermediate output level factor = {!mceshow}

mce_sim_text.append MCE instrument variables = {%mce_instru_names}
mce_sim_text.append MCE error variables = {%mce_targ_names}
mce_sim_text.append There are {!tmceinstrus} instrument and {!tmcetargs} error obs

!re_counter = !re_counter + 1

' *****
' 4. solution iterations
' *****

' *****
' initialize counters, switches, etc.

!mcetry = 0
%mce_converge = "no"
smpl %mcestart %mceend
_$_mce_instru_vec = @vec(@convert(_$_mce_instrus))

' *****
' start of iteration loop

```

```

while !mcetry <= !mce_maxiter and %mce_converge = "no"

    !mcetry = !mcetry + 1
    setcell(mce_sim_stats,!mcetry+2,1,!mcetry-1,0)

    vector _$_instru_prev = _$_mce_instru_vec
    vector _$_gap_prev = _$_mce_gap_vec

    !mcz_step = !mcz_step_max
    call mcz_solvit
    if %mcz_solvit = "err" then
        %mcz_sim = "err"
        return
    endif

    if !mcetry > 1 then
        !gamma = _$_mce_loss_vec(!mcetry)/_$_mce_loss_vec(!mcetry-1)
        !loss_prev = _$_mce_loss_vec(!mcetry-1)
        setcell(mce_sim_stats,!mcetry+2,5,1,0)
        if %linemeth <> "none" and !gamma > !linetrigger then
            if %linemeth = "lmr" then
                call mcz_lmr
                if %mcz_lmr = "err" then
                    %mcz_sim = "err"
                    return
                endif
            endif
            if %linemeth = "armijo" then
                call mcz_armijo
                if %mcz_armijo = "err" then
                    %mcz_sim = "err"
                    return
                endif
            endif
        endif
    endif
endif

if !mceshow < 3 then
    statusline mce solution, iteration !mcetry, f(x) = !nconv
endif

' test for convergence or iteration limit
mce_sim_stats(!mcetry+2,2) = _$_mce_conv_vec(!mcetry)
if _$_mce_conv_vec(!mcetry) < !mceconv then
    %mce_converge = "yes"
    mce_sim_text.append At iteration {!mcetry}, convergence

```

```

    %mce_finish = "yes"
  endif
  if !mcetry = !mce_maxiter and _$mce_conv_vec(!mcetry) >= !mceconv then
    mce_sim_text.append No convergence in {!mce_maxiter} iterations
    if %dontstop = "yes" then
      %mce_finish = "no"
      %mce_converge = "yes"
      mce_sim_text.append Terminating call to mce_run, but execution continues
    else
      @uiprompt("No convergence in maximum number of iterations. Execution termin
      stop
    endif
  endif
endif

' continue if not converged
if %mce_converge = "no" then

' *****
' Newton algorithm (optionally update MCE jacobian)
if %meth = "newton" then
  if !mcetry = 1 then
    if %jinit = "identity" then
      matrix _$mce_der_mat = !dfactor*@identity(!nmceinstrus*!nqtrs)
    endif
    if %jinit = "bd" then
      for !ijj = 1 to !nmcetargs
        !r = (!ijj-1)*!nqtrs
        matrix _$mce_der_mat_{!ijj} = @subextract(_$mce_der_mat,!r+1,!r+1,!r-
      next
      delete(noerr) _$mce_der_mat
    endif
    if %jinit <> "identity" then
      mce_sim_stats(!mcetry+3,6) = "yes"
    endif
  else
    if (!gamma >= !jtrigger and %jupdate <> "none") then
      %jinit_bac = %jinit
      %jinit = %jupdate
      call mcz_derivs
      %jinit = %jinit_bac
    endif
  endif

  if %jinit = "bd" then
    for !ijj = 1 to !nmcetargs

```

```

        vector _$_vec_adds = -$_mce_der_mat_{!ijj}*@subextract($_mce_gap_vec,(!ijj-1)*!nqtrs+1,1)
        matplace($_mce_direction, $_vec_adds, (!ijj-1)*!nqtrs+1,1)
    next
else
    $_mce_direction = -($_mce_der_mat*$_mce_gap_vec)
endif

endif

' *****
' Broyden algorithms
if %meth = "broy" or %meth = "qnewton" then
    if !mcetry = 1 then
        if %jinit <> "identity" then
            $_mce_direction = -($_mce_der_mat*$_mce_gap_vec)
        else
            matrix $_mce_der_mat = @identity(!nmceinstrus*!nqtrs)
            $_mce_direction = -$_mce_gap_vec
        endif
        if %jinit = "bd" then
            for !ijj = 1 to !nmcetargs
                !r = (!ijj-1)*!nqtrs
                matrix $_mce_der_mat_{!ijj} = @subextract($_mce_der_mat,!r+1,!r+1,!r+!nqtrs,!r+!nqtrs)
            next
            if %bmeth = "qnewton" then
                delete(noerr) $_mce_der_mat
            endif
        endif
    endif
    if !mcetry > 1 then
        vector $_instru_delta = $_mce_instru_vec - $_instru_prev
        vector $_gap_delta = $_mce_gap_vec - $_gap_prev

        ' *****
        if %meth = "broy" then
            matrix $_jy = $_mce_der_mat*$_gap_delta
            matrix $_sj = @transpose($_instru_delta)*$_mce_der_mat
            scalar $_sjf = @sum(@transpose($_instru_delta)*$_jy)
            $_mce_der_mat = $_mce_der_mat + (($_instru_delta - $_jy)*$_sj)/$_sjf
            $_mce_direction = -($_mce_der_mat*$_mce_gap_vec)
        endif

        ' *****
        if %meth = "qnewton" then
            if !mcetry = 2 then
                ' create some matrices on first pass

```

```

vector(!broymax) _$_stp_nrm
matrix(!tmceinstrus,!broymax) _$_stp
vector(!broymax) _$_lam_rec
matrix(!tmceinstrus,1) _$_z
vector(!broymax) _$_counter
for !iq = 1 to !broymax
  _$_counter(!iq) = !iq
next
endif

if !mcetry <= !broymax + 1 then
  !q = !mcetry-1
  !f = !q
else
  !q = @mod(!mcetry-1,!broymax) + 1
  !f = !broymax
call shiftright(_$_counter,1)
endif

colplace(_$_stp,_$_instru_delta,!q)
_$_stp_nrm(!q) = @norm(_$_instru_delta,2)
_$_lam_rec(!q) = !mcz_step

if %jinit = "bd" and !mcetry <= !broymax + 1 then
  for !ijj = 1 to !nmcetargs
    vector _$_vec_adds = -_$_mce_der_mat_{!ijj}* @subextract(_$_mce_gap_vec,
    matplace(_$_z,_$_vec_adds,(!ijj-1)*!nqtrs+1,1)
    next
  else
    _$_z = -_$_mce_gap_vec
  endif

if !mcetry > 2 then
  for !kbroy = 2 to !f
    !k0 = _$_counter(!kbroy)
    !k1 = _$_counter(!kbroy - 1)
    !a = _$_lam_rec(!k1)/_$_lam_rec(!k0)
    !b = _$_lam_rec(!k1) - 1
    _$_z = _$_z + (!a*@columnextract(_$_stp,!k0)+!b*@columnextract(_$_stp,
  next
endif

!nrm2 = _$_stp_nrm(!q)^2
!lam = _$_lam_rec(!q)
!stz = @sum(@transpose(_$_instru_delta)*_$_z)
_$_mce_direction = (!nrm2*_$_z-(1-!lam)*!stz*_$_instru_delta)/(!nrm2-!lam)
endif

```

```

        endif
    endif

    ' *****
    ' Fair-Taylor algorithm
    if %meth = "ft" then
        _$_mce_direction = -!lambda*$_mce_gap_vec
    endif
    ' *****

endif

wend

' *****
' 5. final steps
' *****

scalar _$_iterations = !mcetry

if !mceshow = 2 then
    close mce_sim_stats
endif

if !mceshow = 1 or !mceshow = 2 then
    if @isobject("mce_sim_spool") then
        delete mce_sim_spool
    endif
    spool mce_sim_spool
    mce_sim_spool.append mce_sim_stats
    mce_sim_spool.append mce_sim_text
    mce_sim_spool.name untitled01 mce_sim_stats
    mce_sim_spool.name untitled02 mce_sim_text
    show mce_sim_spool
endif

if !mceshow < 3 then
    statusline mcz_sim finished
endif

if %simtype = "single" and %cleanup = "yes" then
    delete(noerr) _$_*
endif

```

endsub

Defines:

`mcz_sim`, used in chunks 95, 97, 147, 152, 160, and 162.

Uses `close` 215, `mce_run` 97, `mcz_armijo` 133, `mcz_derivs` 125, `mcz_equalopt` 111a,
 `mcz_hasopt` 111b, `mcz_lmr` 131, `mcz_solvit` 123, and `shiftright` 167.

6.2.9 solve model consistent instrument values

```

123  <solve model consistent instrument values 123>≡ (209)
      subroutine mcz_solvit

      ' This subroutine first sets the MCE instrument values based on the current
      ' optimal direction and choice of step size, and then solves the models

      %mcz_solvit = "ok"

      ' update instrument values based on current direction and step size
      if !mcetry > 1 then
        mce_sim_stats(!mcetry+2,4) = !mcz_step
        _$_mce_instru_vec = _$_instru_prev + !mcz_step*$_mce_direction
        matrix _$_tmp_mat = @unvec(_$_mce_instru_vec,!nqtrs)
        mtos(_$_tmp_mat,_$_mce_instrus)
      endif

      ' solve lag model
      smpl %mcestart %mceend
      !err_before = @errorcount
      {$_$_mod_b}.solve
      !err_after = @errorcount
      if !err_after > !err_before then
        if %dontstop = "yes" then
          %mcz_solvit = "err"
          return
        else
          @uiprompt("Error in solving lag model: execution terminating")
          stop
        endif
      endif

      ' optionally set terminal conditions on first iteration
      if !mcetry = 1 and %terminal = "yes" then
        call mcz_terminal
      endif

      ' solve lead model
      smpl %mcestart %mceend
      !err_before = @errorcount
      {$_$_mod_f}.solve
      !err_after = @errorcount
      if !err_after > !err_before then
        if %dontstop = "yes" then
          %mcz_solvit = "err"

```

```

        return
    else
        @uiprompt("Error in solving lead model: execution terminating")
        stop
    endif
endif

' create group of the solution values of the mce target variables
' on the first iteration
if !mcetry = 1 then
    {%$_mod_f}.makegroup $_mce_errs_sols {%mce_targ_names}
endif

' compute mce error functions
$_mce_targ_vec = @vec(@convert($_mce_errs_sols))
$_mce_gap_vec = $_mce_targ_vec
!nloss = @norm($_mce_gap_vec,2)^2
mce_sim_stats(!mcetry+2,3) = !nloss
$_mce_loss_vec(!mcetry) = !nloss
!nconv = @max(@abs($_mce_gap_vec))
$_mce_conv_vec(!mcetry) = !nconv
if !mcetry > 1 then
    !gamma = !nloss/$_mce_loss_vec(!mcetry-1)
endif

if !mceshow = 2 then
    show mce_sim_stats
endif

endsub

```

Defines:

`mcz.solvit`, used in chunks 95, 112, 114, 131, and 133.

Uses `mcz_terminal` 134 and `solve` 215.

6.2.10 compute derivatives of mce targets wrt mce instruments

```

125  <compute derivatives of mce targets wrt mce instruments 125>≡ (209)
      subroutine mcz_derivs

' This subroutine computes the derivatives of the mce targets wrt the mce instruments

      mce_sim_stats(!mcestry+2,6) = "yes"
      matrix _$_mce_der_mat = @filledmatrix(!nmceinstrus*!nqtrs,!nmcetargs*!nqtrs,0)

      if !mcestry > 1 then
        '$_mce_ptrb_mat = @abs(@unvec(!mcz_step*$_mce_direction,!nqtrs)) + 1e-6
        _$_mce_ptrb_mat = @abs(@unvec(!mcz_step*$_mce_direction,!nqtrs)) + 1e-4
      endif

      smpl %mcestart %mceend
      _$_mce_targ_vec = @vec(@convert(_$_mce_errs_sols))

      !maxlead = 1

      ' *****
      ' construct vector that determines when exact derivatives
      ' need to be computed

      ' _$_dvec > 0 => period in which derivatives are to be simulated
      ' _$_dvec = 1 => but derivatives do not have to be spread/interpolated forward or back
      ' _$_dvec = 2 => and derivatives have to be spread forward down diagonals
      ' _$_dvec = 3 => and derivatives have to be spread backward up diagonals
      ' _$_dvec = 4 => and derivatives have to be interpolated backward along diagonals
      ' _$_dvec = 5 => hybrid
      vector(!nqtrs) _$_dvec = 0

      ' *****
      if %jinit = "every" then
        _$_dvec = _$_dvec + 1
      endif

      ' *****
      if %jinit = "interp" then
        _$_dvec(1) = 1
        _$_dvec(!nqtrs-!maxlead) = 4
        for !ij0 = (1+!nskip) to (!nqtrs-!maxlead-1) step !nskip
          _$_dvec(!ij0) = 4
        next
        if !maxlead > 0 then

```

```

        for !ij0 = (!nqtrs-!maxlead+1) to !nqtrs
            _$_dvec(!ij0) = 1
        next
    endif
    if _$_dvec(!nqtrs-!maxlead-1) = 4 then
        _$_dvec(!nqtrs-!maxlead) = 1
    endif
endif

' *****
if %jinit = "bd" then
    !bd_col = @floor(!nqtrs/2)
    _$_dvec(!bd_col) = 5
endif

' *****
' code modified 5/27/10 to reduce the number of derivative
' sims by 1 per mc variable -- will work only when
' maxlead = 1
if %jinit = "linear" then
    _$_dvec(1) = 2
    _$_dvec(!nqtrs) = 3
    ' _$_dvec(!nqtrs-!maxlead) = 3
    'for !ij0 = !nqtrs - !maxlead + 1 to !nqtrs
    '    _$_dvec(!ij0) = 1
    ' next
endif

' *****
' *****
' Outer loop: specifies which instrument is shocked
for !ij1 = 1 to !nmceinstrus
    %instru_name = _$_mce_instrus.@seriesname(!ij1)
    statusline computing MCE derivatives for instrument %instru_name

' *****
' Middle loop: simulates effects of instrument shock for selected time periods
!skip = 0
for !ij2 = 1 to !nqtrs
    !skip = !skip + 1
    if _$_dvec(!ij2) > 0 then
        !perturbit = _$_mce_ptrb_mat(!ij2,!ij1)
        !col = (!ij1-1)*!nqtrs + !ij2
        smpl %mcestart + !ij2-1 %mcestart + !ij2-1
        {%instru_name} = {%instru_name} + !perturbit
    end
endfor
endfor

```

```

    smpl %mcestart %mceend
    {%_$_mod_b}.solve
    {%_$_mod_f}.solve
    $_mce_targ_dvec = @vec(@convert($_mce_errs_sols))
    matplace($_mce_der_mat,($_mce_targ_dvec-$_mce_targ_vec)/!perturbit,1,!col)
    smpl %mcestart + !ij2-1 %mcestart + !ij2-1
    {%instru_name} = {%instru_name} - !perturbit

' *****
' Inner loop: place and/or interpolates derivatives
if %jinit <> "every" then
    for !ij3 = 1 to !nmceinstrus
        !row = (!ij3-1)*!nqtrs + 1
        matrix $_tempa = @subextract($_mce_der_mat,!row,!col,!row+!nqtrs-1,!col)

' *****
        if %jinit = "linear" then

' forward loop moves the derivative diagonally down to the right
' when $_dvec = 2
        if $_dvec(!ij2) = 2 then
            for !ij4 = 1 to (!nqtrs - !maxlead - 1)
                matrix $_tempb = @subextract($_tempa,1,1,!nqtrs-!ij4,1)
                matplace($_mce_der_mat,$_tempb,!row+!ij4,!col+!ij4)
            next
        endif

' backward loop moves the derivative diagonally up to the left
' when $_dvec = 3
        if $_dvec(!ij2) = 3 then
            !ij5 = !nqtrs - !maxlead - 1
            for !ij4 = 1 to !ij5
                matrix $_tempb = @subextract($_tempa,(1+!ij4),1,!nqtrs-!maxlead,1)
                matplace($_mce_der_mat,$_tempb,!row,!col-!ij4)
            next
        endif

' fill unassigned elements of last !maxlead rows with zeros when $_dvec = 3
        if $_dvec(!ij2) = 3 then
            !ij5 = !nqtrs - 2
            matrix(1,!ij5) $_tempc = 0
            for !ij4 = 1 to !maxlead
                matplace($_mce_der_mat,$_tempc,!row+!nqtrs-!ij4,!col-!nqtrs+2)
            next
        endif
    endfor
endfor

```

```

endif

' *****
if (%jinit = "interp") and (_$_dvec(!ij2) = 4) then
!nn2 = !nqtrs-!skip+1
'fill in columns between current and previous derivative
'$_tempa holds current derivative, $_tempb holds previous derivative

matrix $_tempa1 = @subextract($_tempa,1,1,!skip,1)
matrix $_tempa2 = @subextract($_tempa,!skip+1,1,!nqtrs,1)

'previous derivative
matrix $_tempb = @subextract($_mce_der_mat,!row,!col-!skip,!row+!nqtrs,1)
matrix $_tempb1 = @subextract($_tempb,1,1,!nn2-1,1)
matrix $_tempb2 = @subextract($_tempb,!nn2,1,!nqtrs,1)

'forward loop moves lower (ie, nonoverlapping) portion of $_tempb diag
for !ij4 = 1 to !skip-1
matrix $_tempb2a = @subextract($_tempb2,1,1,!skip-!ij4,1)
matplace($_mce_der_mat,$_tempb2a,!row+!nn2-1+!ij4,!col-!skip+!ij4)
next

'backward loop moves upper (ie, nonoverlapping) portion of $_tempa diag
for !ij4 = 1 to !skip-1
matrix $_tempa1a = @subextract($_tempa1,1+!ij4,1,!skip,1)
matplace($_mce_der_mat,$_tempa1a,!row,!col-!ij4)
next

'overlap loop interpolates upper part of $_tempb and lower part of $_tempa
for !ij4 = 1 to !skip-1
matrix $_tempc = ((!skip-!ij4)/!skip)*$_tempb1 + (!ij4/!skip)*$_tempa1a
matplace($_mce_der_mat,$_tempc,!row+!ij4,!col-!skip+!ij4)
next

'optionally interpolate elements of last !maxlead rows across each row
!qqqq = 0
if !qqqq = 1 then
!nn3 = !nqtrs - !maxlead + 1
matrix $_tempa3 = @subextract($_tempa,!nn3,1,!nqtrs,1)
matrix $_tempb3 = @subextract($_tempb,!nn3,1,!nqtrs,1)
for !ij4 = 1 to !skip-1
matrix $_tempc = ((!skip-!ij4)/!skip)*$_tempb3 + (!ij4/!skip)*$_tempa3
matplace($_mce_der_mat,$_tempc,!row+!nn3-1,!col-!skip+!ij4)
next
endif
endif

```

```

endif

'*****
'The bd method takes account of only two own-derivative elements --
'one on the diagonal and one on the first super diagonal. The latter is
'important for one-lead euler equations.
',
'there is some crude coding here, reflecting the fact that the full column
'of the derivatives matrix has already been filled in and needs to be
'zeroed out

if (%jinit = "bd") and (_$dvec(!ij2) = 5) and (!ij1=!ij3) then
  matplace(_$mce_der_mat,0*$_mce_targ_dvec,1,!col)
  !diag = $_tempa(!bd_col,1)
  vector(!nqtrs-1) $_tempb = $_tempa(!bd_col-1,1)
  'vector(!nqtrs-1) $_tempb1 = $_tempa(!bd_col+1,1)
  matrix(!nqtrs,!nqtrs) $_tempc
  matrix $_tempc = !diag*@identity(!nqtrs) + @makediagonal($_tempb,1)
  'matrix $_tempc = !diag*@identity(!nqtrs) + @makediagonal($_tempb,1) + @makediagonal
  $_tempc = @inverse($_tempc)
  matplace(_$mce_der_mat,$_tempc,!row,!row)
endif

'*****

  next
  !skip = 0
endif
endif
next
next
' *****

delete(noerr) $_tempa $_tempb $_tempc $_tempd

'recalculate current solution
smpl %mcestart %mceend
{$_$_mod_b}.solve
{$_$_mod_f}.solve

' *****
' invert derivative matrix (unless using bd method, in which case
' it's already inverted)
if %jinit <> "bd" then

```

```
statusline inverting MCE derivative matrix
_$_mce_der_mat = @inverse(_$_mce_der_mat)
endif
```

```
endsub
```

Defines:

`mcz.derivs`, used in chunks 112 and 114.

Uses `left` 216 and `solve` 215.

6.2.11 model consistent coefficient non-monotone step-length procedure

131 \langle model consistent coefficient non-monotone step-length procedure 131 $\rangle \equiv$ (209)

```

subroutine mcz_lmr

    %mcz_lmr = "ok"

    !step_pos = !mcz_step
    !step_neg = !mcz_step
    %line_converge = "no"
    !nk = _$_mce_loss_vec(1)/(!mcetry)^2
    !loss_prev = _$_mce_loss_vec(!mcetry-1)
    if !mhistory >= (!mcetry-1) then
        vector losshist = @subextract(_$_mce_loss_vec,1,1,!mcetry-1,1)
    else
        vector losshist = @subextract(_$_mce_loss_vec,!mcetry-!mhistory,1,!mcetry-1,1)
    endif
    !fkbar = @max(losshist)
    for !j = 1 to !mcelinemax
        if !j > 1 then
            !mcz_step = !step_pos
            call mcz_solvit
            if %mcz_solvit = "err" then
                %mcz_lmr = "err"
                return
            endif
        endif
        if !nloss <= (!fkbar + !nk - !gammak*!step_pos^2*!loss_prev) then
            %line_converge = "yes"
            exitloop
        else
            !nloss_pos = !nloss
            !mcz_step = -!step_neg
            call mcz_solvit
            if %mcz_solvit = "err" then
                %mcz_lmr = "err"
                return
            endif
            if !nloss <= (!fkbar + !nk - !gammak*!step_neg^2*!loss_prev) then
                %line_converge = "yes"
                exitloop
            endif
            !nloss_neg = !nloss
        endif
        !alphan = !step_pos^2*!loss_prev/(!nloss_pos + (2*!step_pos-1)*!loss_prev)
    
```

```

if !alphan < (!tmin*!step_pos) then
  !step_pos = !tmin*!step_pos
else
  if !alphan > !tmax*!step_pos then
    !step_pos = !tmax*!step_pos
  else
    !step_pos = !alphan
  endif
endif
endif
!alphan = !step_neg^2*!loss_prev/(!nloss_neg + (2*!step_neg-1)*!loss_prev)
if !alphan < (!tmin*!step_neg) then
  !step_neg = !tmin*!step_neg
else
  if !alphan > !tmax*!step_neg then
    !step_neg = !tmax*!step_neg
  else
    !step_neg = !alphan
  endif
endif
endif
next
setcell(mce_sim_stats,!mcetry+2,5,!j,0)

endsub

```

Defines:

`mcz_lmr`, used in chunk 114.

Uses `mcz_solvit` 123.

6.2.12 model consistent armijo optimization rule

133 $\langle \text{model consistent armijo optimization rule 133} \rangle \equiv$ (209)

```

subroutine mcz_armijo

  %mcz_armijo = "ok"

  !iarm = 0
  while ((!nloss > (1-.01*!mcz_step)*!loss_prev) and !iarm < !mcelinemax)
    !mcz_step = !lrat * !mcz_step
    call mcz_solvit
    if %mcz_solvit = "err" then
      %mcz_armijo = "err"
      return
    endif
    !iarm = !iarm + 1
  wend
  setcell(mce_sim_stats,!mcetry+2,5,!iarm,0)

endsub

```

Defines:
 mcz_armijo, used in chunk 114.
 Uses mcz_solvit 123.

6.2.13 variable terminal values

```

134  (variable terminal values 134)≡ (209)
      subroutine mcz_terminal

      ' Set terminal values for all variables in _$_mod_f that might
      ' appear with leads, based on the simulated values of the corresponding
      ' variables in _$_mod_b at the end of the simulation period.
      ' Terminal values of stationary variables equal their last simulated
      ' level. Terminal values of nonstationary are based on extrapolating their
      ' simulated growth rates.
      ,
      ' This subroutine is usually called only once per MCE simulation and only
      ' for MCE simulations of permanent shocks. Multiple calls to this
      ' subroutine may result in convergence problems as a result of terminal
      ' values that drift from iteration to iteration.

      ' %fvars (variables that are exogenous in _$_mod_f and
      ' also endogenous in _$_mod_b)

      {$_$_mod_b}.makegroup _$_fvars_sols {%fvars}

      for !ijj = 1 to @wcount(%fvars)
        %tmpa = @lower(@word(%fvars,!ijj))
        %tmpb = _$_fvars_sols.@seriesname(!ijj)
        smpl %mceend + 8 %mceend + 8
        !tmpmean = @abs(@mean{%tmpa})
        if !tmpmean > .001 then
          series _$_tmpgrowth = @abs(@movav(d{%tmpa},0,1)/{%tmpa}(-1),8)
        else
          series _$_tmpgrowth = 0
        endif
        !tmpscal = @mean(_$_tmpgrowth)
        if (!tmpscal < .001) then
          'stationary case
          smpl %mceend + 1 @last
          {%tmpb} = {%tmpb}(-1)
        else
          'nonstationary case
          smpl %mceend %mceend
          series _$_tmpgrowth = @movav(d{%tmpb},0,1)/{%tmpb}(-1),8)
          !tmpscal = @mean(_$_tmpgrowth) + 1
          smpl %mceend + 1 @last
          {%tmpb} = !tmpscal*{%tmpb}(-1)
        endif
      endfor
    
```

```

    {%tmpa} = {%tmpb}
next

' mcevars_f (mce variables in _$_mod_f, if any) have terminal conditions
' based on the values of mcevars_b (proxies for mce variables in _$_mod_b)

if @wcount(%mcevars_f) > 0 then
    {%$_mod_b}.makegroup _$_mcevars_b_sols {%mcevars_b}
    %mcevars_f1 = {%mcevars_f}
    for !ijj = 1 to @wcount(%mcevars_f1)
        %tmpa = @lower(@word(%mcevars_f1,!ijj))
        %tmpb = _$_mcevars_b_sols.@seriesname(!ijj)
        smpl %mceend + 8 %mceend + 8
        !tmpmean = @abs(@mean{%tmpa})
        if !tmpmean > .001 then
            series _$_tmpgrowth = @abs(@movav(d{%tmpa},0,1)/{%tmpa}(-1),8)
        else
            series _$_tmpgrowth = 0
        endif
        !tmpscal = @mean(_$_tmpgrowth)
        if (!tmpscal < .001) then
            'stationary case
            smpl %mceend + 1 @last
            {%tmpb} = {%tmpb}(-1)
        else
            'nonstationary case
            smpl %mceend %mceend
            series _$_tmpgrowth = @movav(d{%tmpb},0,1)/{%tmpb}(-1),8)
            !tmpscal = @mean(_$_tmpgrowth) + 1
            smpl %mceend + 1 @last
            {%tmpb} = !tmpscal*{%tmpb}(-1)
        endif
        smpl %mceend + 1 %mceend + 8
        {%tmpa} = {%tmpb}
    next
endif

mce_sim_text.append Terminal conditions set at iteration {%mctry}

' once terminal conditions have been set once, turn the switch that
' calls this subroutine off
%terminal = "no"

```

endsub

Defines:

mcz_terminal, used in chunk 123.

6.2.14 set options based on defaults and overrides

```

136  <set options based on defaults and overrides 136>≡ (209)
      subroutine mcz_opt_setup(string mcz_opt_options, group mcz_opt_instrus, group mcz_opt_instrus

      statusline mcz_opt_setup

      ' *****
      ' set up values of options based on defaults and overrides in string mcz_opt_options

      mcz_opt_options = @lower(mcz_opt_options)
      mcz_opt_options = @replace(mcz_opt_options," ","")
      mcz_opt_options = @replace(mcz_opt_options,",",", ")
      mcz_opt_options = " " + mcz_opt_options + " "

      ' default values for options

      if %simtype <> "opttc" then
        !optmaxiter = 15
        !optconv = 1e-05
      else
        !optmaxiter = 50
        !optconv = 1e-06
        !tcdamp = 1
      endif

      !optlinemax = 10
      !optptrb = .01
      !opt_step_max = 1.0
      !optshow = 3
      !mceshow = 3

      %evlstart = %mcestart
      %drvstart = %mcestart
      %freq = @pagefreq
      %evlend = @datestr(@dateadd(@dateval(%evlstart),59,%freq))
      %drvend = @datestr(@dateadd(@dateval(%drvstart),39,%freq))

      %ideriv = "yes"
      %xopen = "yes"
      %xclose = "yes"

      ' if imposing constraints (mcz_opt_qp)
      %qpswitch = "r"

```

```

' are there overrides to defaults?
if @len(mcz_opt_options) > 0 then
    %opts = "yes"
else
    %opts = "no"
endif

if %opts = "yes" then
    call mcz_equalopt("m",mcz_opt_options)
    if @len(%temp)>0 then
        !optmaxiter = @val(%temp)
    endif
    call mcz_equalopt("d",mcz_opt_options)
    if @len(%temp)>0 then
        !tcdamp = @val(%temp)
    endif
    call mcz_equalopt("c",mcz_opt_options)
    if @len(%temp)>0 then
        !optconv = @val(%temp)
    endif
    call mcz_equalopt("lmax",mcz_opt_options)
    if @len(%temp)>0 then
        !optlinemax = @val(%temp)
    endif
    call mcz_equalopt("p",mcz_opt_options)
    if @len(%temp)>0 then
        !optptrb = @val(%temp)
    endif
    call mcz_equalopt("stepmax",mcz_opt_options)
    if @len(%temp)>0 then
        !optstepmax = @val(%temp)
    endif
    call mcz_equalopt("oo",mcz_opt_options)
    if @len(%temp)>0 then
        !optshow = @val(%temp)
        !mceshow = @val(%temp)
    endif
    call mcz_equalopt("lstart",mcz_opt_options)
    if @len(%temp)>0 then
        %evlstart = @lower(%temp)
    endif
    call mcz_equalopt("lend",mcz_opt_options)
    if @len(%temp)>0 then
        %evlend = @lower(%temp)
    endif
    call mcz_equalopt("istart",mcz_opt_options)

```

```

    if @len(%temp)>0 then
        %drvstart = @lower(%temp)
    endif
    call mcz_equalopt("iend",mcz_opt_options)
    if @len(%temp)>0 then
        %drvend = @lower(%temp)
    endif
    call mcz_equalopt("ideriv",mcz_opt_options)
    if @len(%temp)>0 then
        %ideriv = @lower(%temp)
    endif
    call mcz_hasopt("terminal",mcz_opt_options)
    if !hasflag = 1 then
        %terminal = "yes"
    endif
    call mcz_hasopt("matlab",mcz_opt_options)
    if !hasflag = 1 then
        %qpswitch = "matlab"
    endif
    call mcz_hasopt("/xopen",mcz_opt_options)
    if !hasflag = 1 then
        %xopen = "no"
    endif
    call mcz_hasopt("/xclose",mcz_opt_options)
    if !hasflag = 1 then
        %xclose = "no"
    endif

endif

' *****
' Some preliminaries

' copy group subroutine arguments into objects with fixed names so that they can be
' easily accessed by other subroutines
copy mcz_opt_instrus    _$_opt_instrus
copy mcz_opt_targs      _$_opt_targs

smpl %evlstart %evlend
!nevl = @obssmpl
smpl %drvstart %drvend
!ndrv = @obssmpl

' *****

```



```

' Examine the inequality constraints, put them in a table,
' and, if necessary, augment the list of target variables to
' include all constraint variables
if %cnstrflag = "yes" then
    svector _$opt_cnstr = mcz_opt_cnstr.@svectornb
    !nconstraints = @rows(_$opt_cnstr)
    if !nconstraints > 0 then
        table(1,1) _$opt_cnstr_tab
        string _$opt_cnstr_vars = " "
        call mcz_constraints(_$opt_cnstr, _$opt_cnstr_tab, _$opt_cnstr_vars)
        %extra_targets = @wnotin(@upper(_$opt_cnstr_vars), _$opt_targs.@members)
        %extra_targets = @wunique(%extra_targets)
        !nextra = @wcount(%extra_targets)
        if !nextra > 0 then
            for !qq = 1 to !nextra
                %newtarg = @word(%extra_targets, !qq)
                _$opt_targs.add {%newtarg}
                %newtarg_t = %newtarg + "_t"
                %newtarg_w = %newtarg + "_w"
                smpl @all
                series {%newtarg_t} = 0
                series {%newtarg_w} = 0
            next
        endif
    else
        @uiprompt("Error: The cnstr keyword is assigned to an empty text file")
        stop
    endif
endif

' *****
' More preliminaries

!noptinstrus = _$opt_instrus.@count
!nopttargs = _$opt_targs.@count

!topttargs = !nopttargs * !nevl
!toptinstrus = !noptinstrus * !ndrv
if !topttargs < !toptinstrus then
    statusline Error: more instruments than targets
    stop
endif

matrix _$opt_ptrb_mat = @filledmatrix(!ndrv, !noptinstrus, !optptrb)

```

```

vector(!optmaxiter+1) _$_opt_loss_vec

if %ideriv <> "no" then
    matrix _$_opt_der_mat = @filledmatrix(!toptinstrus,!topttargs,0)
endif

$_opt_targ_names = _$_opt_targs.@members
$_opt_des_names = @wcross($_opt_targ_names,"_t")
group _$_opt_des {$_opt_des_names}
smpl %evlstart %evlend
matrix _$_opt_des_vec = @vec(@convert(_$_opt_des))

' if number of instruments and targets is the same, the optimal loss is zero,
' shortcut formulas can be used, and weights are not necessary
if !toptinstrus = !topttargs then
    !zero_loss = 1
    matrix _$_opt_wt_mat = @identity(!topttargs)
else
    !zero_loss = 0
    smpl %evlstart %evlend
    $_opt_wt_names = @wcross($_opt_targ_names,"_w")
    group _$_opt_wts {$_opt_wt_names}
    matrix _$_opt_wt_mat = @makediagonal(@vec(@convert(_$_opt_wts)))
endif

' *****
' text file

text mce_opt_text

if %cnstrflag = "yes" then
    mce_opt_text.append constrained optimization using {%qpswitch}: xopen = {%xopen}
else
    mce_opt_text.append unconstrained optimization (EViews)
endif

if %simtype = "opt" then
    mce_opt_text.append optimization type = committment
    mce_opt_text.append simulation period: {%mcestart} - {%mceend}
    mce_opt_text.append loss evaluation period: {%evlstart} - {%evlend}
    mce_opt_text.append instrument setting period: {%drvstart} - {%drvend}
    mce_opt_text.append max number of optimization iterations = !optmaxiter
    mce_opt_text.append max number of line search steps per iteration = !optlinemax
endif

```

```

if %simtype = "opttc" then
    mce_opt_text.append optimization type = time-consistent nash (discretion)
    mce_opt_text.append first instrument setting period: {%drvstart}
    mce_opt_text.append first simulation period: {%mcestart} - {%mceend}
    mce_opt_text.append first loss evaluation period: {%evlstart} - {%evlend}
    mce_opt_text.append last instrument setting period: {%drvend}
    mce_opt_text.append max number of backward-induction iterations = !optmaxiter
endif
mce_opt_text.append convergence criteria = !optconv
mce_opt_text.append output control parameter = !optshow
mce_opt_text.append compute instrument derivs? = {%ideriv}
mce_opt_text.append instrument perturbation factor = !optptrb

' *****
' table of iteration-by-iteration statistics

if @isobject("mce_opt_stats") then
    delete mce_opt_stats
endif
table(!optmaxiter+2,7) mce_opt_stats
mce_opt_stats.setwidth(1:1) 5
mce_opt_stats.setwidth(1:5) 12
mce_opt_stats.setlines(a2:g2) +b
setcell(mce_opt_stats,1,1,"iter")
setcell(mce_opt_stats,1,2,"f(x)")
setcell(mce_opt_stats,1,3,"step size")
setcell(mce_opt_stats,1,4,"convergence")
setcell(mce_opt_stats,2,4,"statistic")
setcell(mce_opt_stats,1,5,"linearity")
setcell(mce_opt_stats,2,5,"statistic")

' *****
' call appropriate optimization subroutine

if %simtype = "opt" and %cnstrflag = "no" then
    call mcz_opt
endif
if %simtype = "opt" and %cnstrflag = "yes" then
    call mcz_opt_qp
endif
if %simtype = "opttc" then
    call mcz_opt_tc
endif

```

```

', *****
', spool
  if @isobject("mce_opt_spool") then
    delete mce_opt_spool
  endif
  spool mce_opt_spool
  if %simtype = "opt" then
    mce_opt_spool.append mce_opt_stats
    mce_opt_spool.append mce_opt_text
    mce_opt_spool.name untitled01 mce_opt_stats
    mce_opt_spool.name untitled02 mce_opt_text
  endif
  if %simtype = "opttc" then
    mce_opt_spool.append mce_opt_text
    mce_opt_spool.name untitled01 mce_opt_text
  endif

  if !optshow <> 4 then
    show mce_opt_spool
    close mce_opt_stats
  endif

  if %cleanup = "yes" then
    delete(noerr) _$_*
  endif

endsub

```

Defines:

`mce_opt_setup`, used in chunk 97.

Uses `close` 215, `mce_constraints` 164, `mce_equalopt` 111a, `mce_hasopt` 111b, `mce_opt` 143, `mce_opt_qp` 147, and `mce_opt_tc` 152.

6.2.15 main unconstrained optimal control simulation

```

143  <main unconstrained optimal control simulation 143>≡ (209)
      subroutine mcz_opt

      'Main subroutine for unconstrained optimal control simulations

      ' *****
      ' initialize counters and switches

      !opttry = 0
      %opt_converge = "no"
      !optnonlin = 0
      !optpchloss = 100

      ' *****
      ' initial solution

      smpl %mcestart %mceend
      !opt_step = 0
      !opt_step_prev = 0
      call mcz_opt_solve
      if !opttry = 0 and !optloss = 0 then
        %opt_converge = "yes"
        mce_opt_text.append At iteration {!opttry}, convergence
      endif

      ' *****
      ' iterate to minimize loss
      smpl %mcestart %mceend
      while !opttry <= !optmaxiter and %opt_converge = "no"

        !opttry = !opttry + 1

        ' *****
        ' compute instrument derivatives, hessian, gradient, direction, and
        ' predicted loss assuming the model is linear
        if (%ideriv <> "no" and (!opttry = 1 or @abs(!optnonlin) > .1)) then
          call mcz_opt_deriv
        endif
        if !zero_loss = 0 then

```

```

        matrix _$_opt_hess = 2*$_opt_der_mat*$_opt_wt_mat*@transpose(_$_opt_der_mat)
    else
        matrix _$_opt_hess = 2*@transpose(_$_opt_der_mat)
    endif
    if @issingular(_$_opt_hess) = 1 then
        %errstring = "Hessian is singular at iteration " + @str(!opttry)
        @uiprompt(%errstring)
        stop
    endif
    matrix _$_opt_hessinv = @inverse(_$_opt_hess)
    if !zero_loss = 0 then
        matrix _$_opt_grad = 2*$_opt_der_mat*$_opt_wt_mat*$_opt_gap_vec
    else
        matrix _$_opt_grad = 2*$_opt_gap_vec
    endif
    vector _$_opt_direction = _$_opt_hessinv*$_opt_grad
    matrix _$_opt_gap_vec_p = _$_opt_gap_vec - @transpose(_$_opt_der_mat) * _$_opt_d
    !optloss_p = @sum(@transpose(_$_opt_gap_vec_p)*$_opt_wt_mat*$_opt_gap_vec_p)

' *****
' solve model and compute loss
!opt_step = !opt_step_max
!opt_step_prev = 0
call mcz_opt_solve

' *****
' test for nonlinearity
' !optnonlin is the ratio of the actual to predicted percentage reduction in loss
' the closer the model is to being linear, the closer !optnonlin is to zero
!ddloss = (_$_opt_loss_vec(!opttry)-$_opt_loss_vec(!opttry+1))
if !ddloss <> 0 then
    !optnonlin = (_$_opt_loss_vec(!opttry+1)-!optloss_p) / !ddloss
else
    !optnonlin = 100
endif
mce_opt_stats(!opttry+3,5) = !optnonlin

' *****
' Search for a better a step size (Armijo condition and backtracking)
!opt_loss_nderiv = -@transpose(_$_opt_grad)*$_opt_direction
!kk = .01
!iarm = 0
while (_$_opt_loss_vec(!opttry+1) > _$_opt_loss_vec(!opttry) + !kk*!opt_step*!opt
    and !iarm < !optlinemax
    !iarm = !iarm + 1
    !opt_step_prev = !opt_step

```

```

!opt_step = .5*!opt_step
call mcz_opt_solve
wend

' *****
' Test for convergence
if !zero_loss = 1 then
' equal number of targets and controls, full rank derivative matrix
' => loss has to be less than !optconv
mce_opt_stats(!opttry+3,4) = _$opt_loss_vec(!opttry+1)
if _$opt_loss_vec(!opttry+1) < !optconv then
    %opt_converge = "yes"
endif
else
' !zero_loss = 0 => percentage change in loss from previous iteration has
' to be less than !optconv
!optpchloss = 1-(_$opt_loss_vec(!opttry+1)/_$opt_loss_vec(!opttry))
mce_opt_stats(!opttry+3,4) = !optpchloss
if !optpchloss < !optconv then
    %opt_converge = "yes"
    mce_opt_text.append At iteration {!opttry}, convergence
endif
endif

if !opttry = 1 and @abs(!optnonlin) < 1e-7 and !opt_step = 1 then
    %opt_converge = "yes"
    mce_opt_text.append At iteration 1, convergence assumed because model is linear
endif

if !opttry = !optmaxiter then
    mce_opt_text.append At iteration {!opttry}, no convergence in {!optmaxiter} iterations
    !continue = @uiprompt("Maximum number of optimization iterations reached: Continue execu
    if !continue = 2 then
        stop
    else
        %opt_converge = "yes"
    endif
endif

if !optshow <> 4 then
    show mce_opt_stats
endif
wend

```

`endsub`

Defines:

`mcz_opt`, used in chunk 136.

Uses `mcz_opt_deriv` 160, `mcz_opt_solve` 162, and `solve` 215.

6.2.16 main optimal control simulation with inequality constraints

147 \langle main optimal control simulation with inequality constraints 147 $\rangle \equiv$ (209)

```

subroutine mcz_opt_qp

' Main subroutine for optimal control simulations with inequality constraints
' (requires either R or matlab)

' The original problem:
',
'   choose x to minimize  $z = (y-y^*)'W(y-y^*)$ 
'   under the constraint  $Cy \geq c$ 
',
'   where at each iteration the linearized relationship between
'   the target variables (y) and instrument variables (x) is
'   given by
',
'    $y = B'x + k$ 
',
' The transformed problem: Solve out y
',
'   choose x to minimize  $z = x'BWB'x + 2(k-y^*)'WB'x + \text{const}$ 
'   under the constraint  $CB'x \geq c - Ck$ 
',
' The R command -- quadprog::solve.QP(D,d,A,b) -- solves
',
'   min  $[0.5 * x' D x - d'x]$  with the constraint  $A'x \geq b$ 
',
' The matlab command -- x = quadprog(D,d,A,b) -- solves
',
'   min  $[0.5 * x' D x + d'x]$  with the constraint  $Ax \leq b$ 
',
',
',
'           R           matlab
'   D       2BWB'       same
'   d'        $2(k-y^*)'WB'$     $-2(k-y^*)'WB'$ 
'   A'       CB'         -CB'
'   b       c-Ck         -(c-Ck)
',
',
'   where  $k = y - B'x$ 
',
',
',
' *****
' Create constraint matrices (C,c)-- dimensions are based on the number
' of periods in which the instruments are set (!ndrv) not the number of

```

```

' periods in which the loss function is evaluated (!nevl)

if %cnstrflag = "yes" then
  matrix(!nevl * !nconstraints,!nevl*!nopttargs) _$_opt_cnstr_mat = 0
  matrix(!nevl * !nconstraints,1) _$_opt_cnstr_vec = 0
  for !i = 1 to !nconstraints
    !terms = @val(_$_opt_cnstr_tab(!i,1))
    for !k = 1 to !terms
      %var = @upper(_$_opt_cnstr_tab(!i,2*!k))
      !coef = @val(_$_opt_cnstr_tab(!i,2*!k+1))
      !j = @wfindnc(%opt_targ_names,%var)
      for !l = 1 to !nevl
        _$_opt_cnstr_mat((!i-1)*!nevl+!l,(!j-1)*!nevl+!l) = !coef
      next
    next
    for !l = 1 to !nevl
      !coef = @val(_$_opt_cnstr_tab(!i,2*!terms+2))
      _$_opt_cnstr_vec((!i-1)*!nevl+!l) = !coef
    next
  next
else
  !nconstraints = 1
  matrix(!nevl,!nevl*!nopttargs) _$_opt_cnstr_mat = 0
  matrix(!nevl,1) _$_opt_cnstr_vec = 0
endif

' *****
' initialize counters and switches

!opttry = 0
%opt_converge = "no"
!optnonlin = 0
!optpchloss = 100

if %qpswitch = "r" and %xopen = "yes" then
  xopen(type=r, case=lower)
endif
if %qpswitch = "matlab" and %xopen = "yes" then
  xopen(type=m, case=lower)
endif

' *****
' compute an initial solution, without reference to any constraints

```

```

    smpl %mcestart %mceend
    !opt_step = 0
    !opt_step_prev = 0
    call mcz_opt_solve

' *****
' iterate to minimize loss
    smpl %mcestart %mceend
    while !opttry <= !optmaxiter and %opt_converge = "no"

        !opttry = !opttry + 1

' *****
' compute instrument derivatives
    if %ideriv <> "no" then
        call mcz_opt_deriv
    endif

' *****
' compute qp matrices
    smpl %drvstart %drvend
    vector _$opt_instru_vec = @vec(@convert(_$opt_instrus))
    matrix _$qp_k_vec = _$opt_targ_vec - @transpose(_$opt_der_mat) * _$opt_instru_vec
    matrix qp_d_mat = 2 * _$opt_der_mat * _$opt_wt_mat * @transpose(_$opt_der_mat)
    matrix qp_d_vec = -2 * _$opt_der_mat * @transpose(_$opt_wt_mat) _
        * (_$qp_k_vec - _$opt_des_vec)

    matrix qp_a_mat = @transpose(_$opt_cnstr_mat * @transpose(_$opt_der_mat))
    matrix qp_b_vec = _$opt_cnstr_vec - _$opt_cnstr_mat _
        * (_$qp_k_vec - _$opt_des_vec)

    if !ndrv <> !nevl then
        qp_a_mat = @subextract(qp_a_mat,1,1,!ndrv,!ndrv)
        qp_b_vec = @subextract(qp_b_vec,1,1,!ndrv,1)
    endif

    xput qp_d_mat qp_a_mat qp_d_vec qp_b_vec

' *****
' *****
' R code

    if %qpswitch = "r" then
        if ((!ndrv = 1) and (!noptinstrus = 1)) then
            xrun "dim(qp_d_mat) <- c(1,1);"

```

```

        xrun "dim(qp_a_mat) <- c(1,1);"
        xrun "dim(qp_d_vec) <- c(1,1);"
        xrun "dim(qp_b_vec) <- c(1,1);"
    endif
    xrun "QP.results <- quadprog::solve.QP(qp_d_mat,qp_d_vec,qp_a_mat,qp_b_vec);"
    xrun "r_xhat <- QP.results$solution;"
    xrun "r_xhat <- as.matrix(r_xhat);"
    xget(type = matrix, name = _$qp_instru_vec) r_xhat
endif

' *****
' *****
' matlab code

if %qpswitch = "matlab" then
    xrun "qp_d_vec = -qp_d_vec;"
    xrun "qp_a_mat = -qp_a_mat;"
    xrun "qp_b_vec = -qp_b_vec;"
    xrun "aeq = [];"
    xrun "beq = [];"
    xrun "lb = [];"
    xrun "ub = [];"
    xrun "xx0 = [];"
    xrun "options = optimset('Algorithm','active-set','LargeScale','off');"
    xrun "matlab_xhat = quadprog(qp_d_mat,qp_d_vec,qp_a_mat,qp_b_vec,aeq,beq,lb,ub);"
    xget matlab_xhat
    %tmp = matlab_xhat.@type
    if %tmp = "SCALAR" then
        matrix(1,1) _$qp_instru_vec = matlab_xhat
    else
        matrix _$qp_instru_vec = matlab_xhat
        delete matlab_xhat
    endif
endif

' *****
' *****

' values of target variables in qp (linearized) solution
matrix _$qp_targ_vec = @transpose(_$opt_der_mat)*_$qp_instru_vec + _$qp_k_vec

' values of target variables in original model
smpl %drvstart %drvend
matrix _$tt1 = @unvec(@vec(_$qp_instru_vec),!ndrv)
mtos(_$tt1,_$opt_instrus)
smpl %mcestart %mceend

```

```

    call mcz_sim(" ")
    smpl %evlstart %evlend
    matrix _$_opt_targ_vec = @vec(@convert(_$_opt_targs_sols))
    matrix _$_opt_gap_vec = _$_opt_targ_vec - _$_opt_des_vec
    !optloss = @sum(@transpose(_$_opt_gap_vec)*_$_opt_wt_mat*_$_opt_gap_vec)
    setcell(mce_opt_stats,!opttry+2,1,!opttry,0)

' convergence test is based on the maximum difference between
' the target variable values in the linearized and original models
!conv_stat = @max(abs(_$_qp_targ_vec-_$_opt_targ_vec))
mce_opt_stats(!opttry+2,2) = !optloss
mce_opt_stats(!opttry+2,4) = !conv_stat

if !optshow <> 4 then
    show mce_opt_stats
endif

if !conv_stat < !optconv then
    %opt_converge = "yes"
else
    endif
endif

wend

delete(noerr) qp_d_mat qp_a_mat qp_d_vec qp_b_vec

endsub

```

Defines:

mcz_opt_qp, used in chunks 95 and 136.

Uses mcz_opt_deriv 160, mcz_opt_solve 162, mcz_sim 114, solve 215, xget 215, and xrun 215.

6.2.17 model consistent optimal time-consistent solution

152 *(model consistent optimal time-consistent solution 152)*≡

(209)

subroutine mcz_opt_tc

```

' 1. For a linear model, this code finds the exact time-consistent solution;
'   for a nonlinear model, the calculated solution is based on the
'   linearization of the model as given by the derivatives of the target
'   variables wrt the instrument variables along the baseline.
'
' 2. The basic data matrices include observations for (!nevl+!ndrv-1) periods,
'   which is also the interval over which tracking adds are required.
'
' 3. The simulation, derivative and evaluation periods are assumed to have the
'   same starting date
'
' 4. The solution method is backward induction; if there are no inequality constraints
'   the method executes in EViews (using matrices); if inequality constraints
'   are present, the method executes in EViews if there is a single
'   instrument and in Matlab or R (depending on the
'   setting of a switch) if there are multiple instruments (which requires
'   a quadratic programming algorithm),

' *****
' Create constraint matrices (C,c)-- dimensions are based on the fact that
' each policymaker sets the instruments for a single period

if %cnstrflag = "yes" then
  matrix(!nconstraints,!nopttargs) _$_opt_cnstr_mat = 0
  matrix(!nconstraints,1) _$_opt_cnstr_vec = 0
  for !i = 1 to !nconstraints
    !nterms = @val(_$_opt_cnstr_tab(!i,1))
    for !k = 1 to !nterms
      %var = @upper(_$_opt_cnstr_tab(!i,2*!k))
      !coef = @val(_$_opt_cnstr_tab(!i,2*!k+1))
      !j = @wfindnc(%opt_targ_names,%var)
      _$_opt_cnstr_mat(!i,!j) = !coef
    next
    !coef = @val(_$_opt_cnstr_tab(!i,2*!nterms+2))
    _$_opt_cnstr_vec(!i) = !coef
  next
endif

```

```

' *****
' initial solution, instrument derivatives, and data matrices

' initial simulation
  smpl %mcestart %mceend
  if %terminal = "yes" then
    call mcz_sim("terminal")
    %terminal = "no"
  else
    call mcz_sim(" ")
  endif
  {%$_mod_b}.makegroup $_opt_targs_sols {%opt_targ_names}
  !ntot = !ndrv + !nevl - 1

' derivative matrices and submatrices
' $_opt_der_mat (this is the basic matrix; tc_dmat is its transpose)
' tc_dmat          effect of !ndrv periods of instruments on !ntot periods of targets
' tc_dmat_short    effect of !ndrv periods of instruments on !nevl periods of targets
' tc_dmat1          effect of period 1 instrument on !nevl periods of targets
' tc_dmat2          effect of period 1 instrument on period 1 targets
  if %ideriv <> "no" then
    !opttry = 1
    matrix $_opt_der_mat = @filledmatrix(!toptinstrus,!nopttargs*!ntot,0)
    %evlend_b = %evlend
    %freq = @pagefreq
    !ntot1 = !ntot-1
    %evlend = @datestr(@dateadd(@dateval(%simstart),!ntot1,%freq))
    'call dateshift(%simstart,%evlend,!ntot-1)
    call mcz_opt_deriv
    %evlend = %evlend_b
    matrix tc_dmat = @transpose($_opt_der_mat)
    matrix tc_dmat_short = @filledmatrix(!nevl*!nopttargs,!ndrv*!noptinstrus,0)
    for !i = 1 to !toptinstrus
      for !j = 1 to !nopttargs
        !r1 = !ntot*(!j-1)+1
        !r2 = !r1 + !nevl - 1
        matplace(tc_dmat_short,@subextract(tc_dmat,!r1,!i,!r2,!i),!nevl*(!j-1)+1,!i)
      next
    next
    matrix tc_dmat1 = @filledmatrix(!nevl*!nopttargs,!noptinstrus,0)
    for !i = 1 to !noptinstrus
      matplace(tc_dmat1,@columnextract(tc_dmat_short,(!i-1)*!ndrv+1),1,!noptinstrus)
    next
    matrix tc_dmat2 = @filledmatrix(!noptinstrus,!nopttargs,0)
    for !i = 1 to !noptinstrus

```

```

        for !j = 1 to !nopttargs
            tc_dmat2(!i,!j) = tc_dmat1((!j-1)*!nevl+1,!i)
        next
    next
endif

' initial simulation again (is this necessary)
call mcz_sim(" ")

' data matrices
smp1 %simstart {%evlend} + !ndrv - 1
stom(_$opt_targs_sols,tc_ymat)
stom(_$opt_des,tc_ystarmat)
stom(_$opt_instrus,tc_xmat)
matrix tc_wmat = _$opt_wt_mat

' (no constraints) => eviews;
' (1 constraint -- single period) => eviews
' (multiple constraints) => R or Matlab
if %cnstrflag = "no" then
    %iii = "eviews"
else
    if !noptinstrus = 1 then
        %iii = "eviews"
    else
        %iii = %qpswitch
    endif
endif

scalar tc_iter = 0
scalar tc_stat = 100
scalar tc_itmax = !optmaxiter
scalar tc_conv = !optconv

' *****
' unconstrained backward induction => EViews

if %cnstrflag = "no" then
    while (tc_stat > tc_conv) and tc_iter <= tc_itmax

        matrix tc_xb = tc_xmat
        matrix tc_yb = tc_ymat

        for !i = !ndrv to 1 step -1
            !n1 = !i+!nevl-1

```



```

!n2 = !i+!ndrv-1
vector tc_y0v = @vec(@subextract(tc_ymat,!i,1,!n1,!nopttargs))
vector tc_ys0v = @vec(@subextract(tc_ystarmat,!i,1,!n1,!nopttargs))
vector tc_x0v = @vec(@subextract(tc_xmat,!i,1,!n2,!noptinstrus))
vector tc_x0_1v = @vec(@subextract(tc_xmat,!i,1,!i,!noptinstrus))
vector tc_xbv = @vec(@subextract(tc_xb,!i,1,!n2,!noptinstrus))

vector tc_y1v = tc_y0v + tc_dmat_short*(tc_x0v-tc_xbv)

matrix tc_g = @transpose(tc_dmat1)*tc_wmat*(tc_y1v-tc_ys0v)
matrix tc_h = @transpose(tc_dmat1)*tc_wmat*tc_dmat1
vector tc_x1_1v = tc_x0_1v - !tcdamp*@inverse(tc_h)*tc_g
matrix tc_x1_1 = @unvec(tc_x1_1v,!noptinstrus)
matplace(tc_xmat,tc_x1_1,!i,1)
next

vector tc_x0v = @vec(@subextract(tc_xmat,1,1,!ndrv,!noptinstrus))
vector tc_y0v = @vec(@subextract(tc_ymat,1,1,!ntot,!nopttargs))
vector tc_y1v = tc_y0v + tc_dmat*(tc_x0v-tc_xbv)
matrix tc_y1 = @unvec(tc_y1v,!ntot)
matplace(tc_ymat,tc_y1,1,1)

tc_iter = tc_iter + 1
if tc_iter > 1 then
    tc_stat = @max(@abs(tc_xmat-tc_xmatprev))
endif

matrix tc_xmatprev = tc_xmat
wend
endif

' *****
' constrained backward induction

if %cnstrflag = "yes" then

    matrix tc_cmat = _$_opt_cnstr_mat
    matrix tc_cvec = _$_opt_cnstr_vec

' *****
' single-period constraint => eviews
if %iii = "eviews" then

    statusline constrained TC optimization in EViews

```

```

matrix mat_a = tc_dmat2*@transpose(tc_cmat)

while (tc_stat > tc_conv) and tc_iter <= tc_itmax

    matrix tc_xb = tc_xmat
    matrix tc_yb = tc_ymat

    for !i = !ndrv to 1 step -1
        !n1 = !i+!nevl-1
        !n2 = !i+!ndrv-1

        ' vectors of observations in the current loss and instrument periods
        vector tc_y0v = @vec(@subextract(tc_yamat,!i,1,!n1,!nopttargs))
        vector tc_ys0v = @vec(@subextract(tc_ystarmat,!i,1,!n1,!nopttargs))
        vector tc_x0v = @vec(@subextract(tc_xmat,!i,1,!n2,!noptinstrus))
        vector tc_x0_1v = @vec(@subextract(tc_xmat,!i,1,!i,!noptinstrus))
        vector tc_xbv = @vec(@subextract(tc_xb,!i,1,!n2,!noptinstrus))

        ' vector of target variable values based on current instrument values
        ' (ie, solve model)
        vector tc_y1v = tc_y0v + tc_dmat_short*(tc_x0v-tc_xbv)

        ' unconstrained current optimal instrument value
        matrix tc_g = @transpose(tc_dmat1)*tc_wmat*(tc_y1v-tc_ys0v)
        matrix tc_h = @transpose(tc_dmat1)*tc_wmat*tc_dmat1
        vector tc_x1_1v = tc_x0_1v - @inverse(tc_h)*tc_g

        ' check constraint
        matrix tc_y1m = @unvec(tc_y1v,!nevl)
        matrix tc_ysm = @unvec(tc_ys0v,!nevl)
        matrix mattemp = @rowextract(tc_y1m,1) - (@transpose(tc_x0_1v)*tc_dmat2) -
        matrix mat_b = tc_cvec - tc_cmat*@transpose(mattemp)
        scalar testit = @sum(mat_b)/@sum(mat_a)
        if @sum(tc_x1_1v) < testit then
            tc_x1_1v = testit
            !tc_iter = tc_iter
        endif
        vector tc_x1_1v = (1-!tcdamp)*tc_x0_1v + !tcdamp* tc_x1_1v

        ' place current optimal instrument value in instrument matrix
        matrix tc_x1_1 = @unvec(tc_x1_1v,!noptinstrus)
        matplace(tc_xmat,tc_x1_1,!i,1)

    next

```

```

' solve model
vector tc_x0v = @vec(@subextract(tc_xmat,1,1,!ndrv,!noptinstrus))
vector tc_y0v = @vec(@subextract(tc_ymat,1,1,!ntot,!nopttargs))
vector tc_y1v = tc_y0v + tc_dmat*(tc_x0v-tc_xbv)
matrix tc_y1 = @unvec(tc_y1v,!ntot)
matplace(tc_ymat,tc_y1,1,1)

tc_iter = tc_iter + 1

if tc_iter > 1 then
    tc_stat = @max(@abs(tc_xmat-tc_xmatprev))
endif

matrix tc_xmatprev = tc_xmat
wend
endif

' *****
' multiple constraints => R or matlab

if %iii = "r" or %iii = "matlab" then

    scalar tc_noptinstrus = !noptinstrus
    scalar tc_nopttargs = !nopttargs
    scalar tc_nevl = !nevl
    scalar tc_ndrv = !ndrv
    scalar tc_damp = !tcdamp

    if %xopen = "yes" then
        if %iii = "r" then
            xopen(type=r)
            xrun library("quadprog")
            %wd = "" + %rpath + ""
            xrun setwd({%wd})
        else
            xopen(type=m)
            xrun addpath {%mpath}
        endif
    endif

    xput tc_ymat tc_ystarmat tc_xmat tc_wmat tc_cmat tc_cvec
    xput tc_nopttargs tc_noptinstrus tc_nevl tc_ndrv tc_itmax tc_conv
    xput tc_dmat tc_dmat1 tc_dmat2 tc_dmat_short tc_damp

```

```

    if %iii = "r" then
        xrun source("tcoc_r.R")
    else
        xrun tcoc_m
    endif

    xget tc_xmat
    xget tc_ymat
    xget tc_iter
    !tc_iter = tc_iter

    if %xclose = "yes" then
        xclose
    endif

    delete(noerr) tc_ystarmat tc_dmat tc_wmat tc_cmat tc_cvec
    delete(noerr) tc_nopttargs tc_noptinstrus tc_nevl tc_ndrv tc_conv
    delete(noerr) tc_damp tc_dmat1 tc_dmat2 tc_dmatshort

    endif
endif

' *****
' examine linearized solution

if tc_iter >= tc_itmax then
    @uiprompt("iteration limit reached:  time-consistent iterations did not converge")
    'stop
endif

' write instrument and target values back into their corresponding series
smpl %evlstart {%evlstart} + !nevl + !ndrv - 2
mtos(tc_xmat, $_opt_instrus)
mtos(tc_ymat, $_opt_targs_sols)

' value of loss function for linearized solution
smpl %evlstart %evlend
matrix $_opt_targ_vec = @vec(@convert($_opt_targs_sols))
matrix $_opt_gap_vec = $_opt_targ_vec - $_opt_des_vec
!optloss_lin = @sum(@transpose($_opt_gap_vec)*$_opt_wt_mat*$_opt_gap_vec)
stom($_opt_targs_sols, tc_ymat_lin)

' simulate EViews model
smpl %mcestart %mceend
call mcz_sim(" ")
smpl %evlstart %evlend

```

```

stom(_$opt_targs_sols,tc_ymat_ev)
!maxdiff = @max(@abs(tc_ymat_ev-tc_ymat_lin))
matrix _$opt_targ_vec = @vec(@convert(_$opt_targs_sols))
matrix _$opt_gap_vec = _$opt_targ_vec - _$opt_des_vec
!optloss_ev = @sum(@transpose(_$opt_gap_vec)*_$opt_wt_mat*$_$opt_gap_vec)

!tciter = tc_iter
mce_opt_text.append time-consistent solution
mce_opt_text.append --- backward-induction iterations = !tciter
mce_opt_text.append --- TC damping factor = !tcdamp
mce_opt_text.append --- linearized solution loss = !optloss_lin
mce_opt_text.append --- EViews solution loss = !optloss_ev
mce_opt_text.append --- max diff btwn target vars in linear and EViews sols = !maxdiff

delete(noerr) tc_ymat tc_xmat tc_iter tc_ymat_lin tc_ymat_ev
delete(noerr) tc_itmax tc_stat

endsub

```

Defines:

mcz_opt_tc, used in chunks 95 and 136.

Uses dateshift 87, mcz_opt_deriv 160, mcz_sim 114, solve 215, xget 215, and xrun 215.

6.2.18 compute derivatives of loss function targets wrt instruments

```

160  <compute derivatives of loss function targets wrt instruments 160>≡      (209)
      subroutine mcz_opt_deriv
      ,
      ' requires that the following be defined
      ,
      ' !optshow, mce_opt_stats, %evlstart, %evlend
      ' $_opt_targs_sols, !noptinstrus, $_opt_instrus, !drv,
      ' $_opt_ptrb_mat, $_opt_der_mat

      ' This subroutine computes the derivatives of the loss function targets wrt the instr

      smpl @all

      !optshow_bac = !optshow
      !optshow = 3

      'make a copy of the current values of the mce instruments;
      'they will be restored after each derivative is computed
      smpl %mcestart %mceend
      stom($_mce_instrus,$_instrus_bac)

      'do not reset terminal conditions when computing derivatives
      %set_terminal = "no"

      smpl %evlstart %evlend
      matrix $_opt_targ_vec = @vec(@convert($_opt_targs_sols))

      '*****
      'derivatives loop
      statusline computing instrument derivatives at optimization iteration !optry
      for !zi = 1 to !noptinstrus
        %instru_name = $_opt_instrus.@seriesname(!zi)
        for !zj = 1 to !ndrv
          !perturbit = $_opt_ptrb_mat(!zj,!zi)
          smpl %mcestart + !zj-1 %mcestart + !zj-1
          {%instru_name} = {%instru_name} + !perturbit
          call mcz_sim(" ")
          smpl %evlstart %evlend
          matrix $_opt_targ_dvec = @vec(@convert($_opt_targs_sols))
          matplace($_opt_der_mat,@transpose($_opt_targ_dvec-$_opt_targ_vec)/!perturbit
          smpl %mcestart + !zj-1 %mcestart + !zj-1
          {%instru_name} = {%instru_name} - !perturbit
        'restore the original values of the add factors on

```

```
        'the z variable equations
    smpl %mcestart %mceend
    mtos(_$instrus_bac,$_mce_instrus)
    next
next

smpl %mcestart %mceend

!optshow = !optshow_bac

endsub
```

Defines:

`mcz_opt_deriv`, used in chunks 143, 147, and 152.
Uses `mcz_sim` 114.

6.2.19 solve model consistent expectations model

162 *<solve model consistent expectations model 162>*≡

(209)

```

subroutine mcz_opt_solve

' This subroutine first sets the instrument values, based on the current
' optimal direction and choice of step size, and then solves the model

statusline optimization solution, iteration !opttry
smpl %mcestart %mceend

'compute instrument values based on current direction and step size
if !opttry > 0 then
    mce_opt_stats(!opttry+3,3) = !opt_step
    smpl %drvstart %drvend
    for !i = 1 to !noptinstrus
        vector _$_temp_adj = @subtract(_$_opt_direction,(!i-1)*!ndrv+1,1,!i*!ndrv,1)
        mtos(_$_temp_adj,_$_temp_ser)
        %y1 = _$_opt_instrus.@seriesname(!i)
        {%y1} = {%y1} - (!opt_step-!opt_step_prev)*_$_temp_ser
    next
endif

'solve model
if !opttry = 0 and %terminal = "yes" then
    call mcz_sim("terminal")
    %terminal = "no"
else
    call mcz_sim(" ")
endif

if !opttry = 0 then
    {%$_mod_b}.makegroup _$_opt_targs_sols {%opt_targ_names}
endif

'compute value of loss function
smpl %evlstart %evlend
matrix _$_opt_targ_vec = @vec(@convert(_$_opt_targs_sols))
matrix _$_opt_gap_vec = _$_opt_targ_vec - _$_opt_des_vec
!optloss = @sum(@transpose(_$_opt_gap_vec)*_$_opt_wt_mat*_$_opt_gap_vec)
setcell(mce_opt_stats,!opttry+3,1,!opttry,0)
mce_opt_stats(!opttry+3,2) = !optloss
_$_opt_loss_vec(!opttry+1) = !optloss

if !optshow = 2 then
    show mce_opt_stats

```


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endif

endsub

Defines:

`mcz_opt_solve`, used in chunks 143 and 147.

Uses `mcz_sim` 114.

6.2.20 convert mcz inequality constraints

```

164  <convert mcz inequality constraints 164>≡ (209)
      subroutine local mcz_constraints(svector sss, table ctable,string cvarnames)

      'This subroutine converts the inequality constraint text into a table

      ' subroutine arguments:
      ,
      ' inputs:
      ,
      '   sss                svector of constraint text
      ,
      ' outputs:
      ,
      '   $_opt_cnstr_tab    table of constraint variables and coefficients
      '   $_opt_cnstr_vars   string of names of variables in constraints

      ' *****

      !nconstraints = @rows(sss)
      scalar loc
      scalar sign

      for !i = 1 to !nconstraints
        %rrr = sss(!i)

        ' *****
        ' *****
        ' separate the left and right sides of each constraint

        !kk1 = @instr(%rrr,">=")
        if !kk1 = 0 then
          @uiprompt("each constraint must contain an ">=" term")
          stop
        endif
        %rrr1 = @left(%rrr,!kk1-1)
        if @isempty(%rrr1) = 1 then
          @uiprompt("each constraint must contain terms to the left of ">="")
          stop
        endif
        %rrrr = @mid(%rrr,!kk1+2)
        if @isempty(%rrrr) = 1 then
          @uiprompt("each constraint must contain a value to the right of ">="")
          stop

```

```

endif

' *****
' *****
' process the left side of each constraint
'
' 1. split %rrrl into individual terms (based on + and - characters);
'    the main challenge concerns the first term, which may or may not
'    have a leading + or - attached
' 2. then split each term into 2 parts (based on * character)
' 3. then identify which part is coefficient and which is variable

!zz = 0      'flag to indicate end of left hand side of a constraint
!nterms = 1
vector(100) split_locs = 0
vector(100) split_signs = 0
%rrrlx = %rrrl

' find boundaries and signs of each term
while !zz = 0

' first term: determine whether its sign is explicit or implicit
if !nterms = 1 then
    call find_next_delimit(%rrrlx,loc,sign)
    if loc = 0 then                'implicit leading sign
        split_locs(!nterms) = 0
        split_signs(!nterms) = 1
    else
        %rrrl1 = @left(%rrrlx,loc-1)
        if @isempty(%rrrl1) = 1 then    'explicit leading sign
            split_locs(!nterms) = loc
            split_signs(!nterms) = sign
            %rrrlx = @mid(%rrrlx,loc+1)
        else                            'implicit leading sign
            split_locs(!nterms) = 0
            split_signs(!nterms) = 1
        endif
    endif
endif
endif

call find_next_delimit(%rrrlx,loc,sign)
if loc = 0 then                'last term
    split_locs(!nterms+1) = @length(%rrrlx)
    !zz = 1
else

```

```

        split_locs(!terms+1) = loc
        split_signs(!terms+1) = sign
        %rrrlx = @mid(%rrrlx,loc+1)
    endif

    !terms = !terms + 1
wend

for !k = 2 to !terms
    split_locs(!k) = split_locs(!k-1) + split_locs(!k)
next

!terms = !terms - 1

' parse each term into coefficient times variable (they must
' appear in that order, although coefficients = 1 can be
' omitted), and store coefficient and variable in ctable
for !k = 1 to !terms
    %term = @mid(%rrrl,split_locs(!k)+1,split_locs(!k+1)-split_locs(!k)-1)
    if @isempty(%term) = 1 then
        @uiprompt("term is empty:  illegal constraint specification")
        stop
    else
        !ii = @instr(%term,"*")
        if !ii > 0 then
            %coef = @left(%term,!ii-1)
            !coef = split_signs(!k) * @val(%coef)
            %var = @mid(%term,!ii+1)
        else
            !coef = split_signs(!k)
            %var = %term
        endif
        %var = @trim(%var)
    endif

    ctable(!i,2*!k) = %var
    ctable(!i,2*!k+1) = !coef
    cvarnames = cvarnames + " " + %var
next

' *****
' *****
' process the right side of each constraint

```

```

        ctable(!i,2*!nterms+2) = @val(%rrrr)
        ctable(!i,1) = !nterms

    next

    cvarnames = @wunique(cvarnames)

endsub
Defines:
    mcz.constraints, used in chunk 136.
Uses find_next_delimit 168 and left 216.

```

6.2.21 shift left

167 $\langle \text{shift left 167} \rangle \equiv$ (209)

```

    subroutine local shiftleft(vector abc, scalar nshift)

        !rows = @rows(abc)
        vector v1 = @subextract(abc,1,1,nshift,1)
        vector v2 = @subextract(abc,nshift+1,1,!rows,1)
        matplace(abc,v2,1)
        matplace(abc,v1,!rows - nshift + 1)

    endsub
Defines:
    shiftleft, used in chunk 114.

```

6.2.22 find next delimiter

```

168  (find next delimiter 168)≡ (209)
      subroutine local find_next_delimit(string %instring,scalar loc,scalar sign)

          !ttp = @instr(%instring,"+")
          !ttm = @instr(%instring,"-")
          if !ttp= 0 or !ttm = 0 then
              loc = !ttp + !ttm
              if !ttp = 0 and !ttm = 0 then
                  sign = 1
              else
                  sign = (!ttp > 0) - (!ttm > 0)
              endif
          else
              loc = !ttp*(!ttp < !ttm) + !ttm*(!ttm < !ttp)
              sign = (!ttp < !ttm) - (!ttm < !ttp)
          endif

          endsub

Defines:
      find_next_delimit, used in chunk 164.

```

6.2.23 load frbus with transformed subsidiary model

```

169  <load frbus with transformed subsidiary model 169>≡ (209)
      subroutine mce_load_frbus(string frbus_opts)

      ' take two corresponding FRB/US models (eg, stdver and pfver) and make
      ' the transformations needed to the second model so that the pair of
      ' models can be used with the mcz_solve_subs programs

      ' parameters
      '   required:  mce_vars, mod_b, mod_f, path_b, path_f
      '   optional:  allbut, only
      ,

      !allbut = 0
      !only = 0

      frbus_opts = @lower(frbus_opts)
      frbus_opts = @replace(frbus_opts," ","")
      frbus_opts = @replace(frbus_opts,","," ")
      frbus_opts = " " + frbus_opts + " "

      if @isempty(frbus_opts) = 0 then
        call mcz_equalopt("mce_vars",frbus_opts)
        if @len(%temp)>0 then
          %mce_vars = @lower({%temp})
        else
          @uiprompt("Error:  mce_load_frbus sub requires the mce_vars argument")
          stop
        endif
        call mcz_equalopt("mod_b",frbus_opts)
        if @len(%temp)>0 then
          %mod_b = {%temp}
        else
          @uiprompt("Error:  mce_load_frbus sub requires the mod_b argument")
          stop
        endif
        call mcz_equalopt("mod_f",frbus_opts)
        if @len(%temp)>0 then
          %mod_f = {%temp}
        else
          @uiprompt("Error:  mce_load_frbus sub requires the mod_f argument")
          stop
        endif
        call mcz_equalopt("path_b",frbus_opts)
        if @len(%temp)>0 then

```

```

%path_b = {%temp}
else
@uiprompt("Error: mce_load_frbus sub requires the path_b argument")
stop
endif
call mcz_equalopt("path_f",frbus_opts)
if @len(%temp)>0 then
%path_f = {%temp}
else
@uiprompt("Error: mce_load_frbus sub requires the path_f argument")
stop
endif
call mcz_equalopt("allbut",frbus_opts)
if @len(%temp)>0 then
!allbut = 1
%allbut = {%temp}
else
call mcz_equalopt("only",frbus_opts)
if @len(%temp)>0 then
!only = 1
%only = {%temp}
endif
endif
endif
endif

' Added so that users may ask directly for a group of forward-looking equations instead
' passing in a list that may change in the future.

' Model consistent Asset Pricing
%s_mcap = " zdivgr zgap05 zgap10 zpi10f zpic30 zrff10 zrff5 zgap30 zrff30 zpi10 zpi10f"

' Wages and prices
%s_wp = " zpicxfe zpieci "

' Others - all PAC expectations
%s_other = " zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvps zvpi zxnfbd zxnfbz zxnfbz zynfbd zynfbz zynfbz zynfbz"

if %mce_vars = "-all" then
%mce_vars = %s_mcap + %s_wp + %s_other
endif
if %mce_vars = "-mcap" then
%mce_vars = %s_mcap
endif
if %mce_vars = "-wp" then
%mce_vars = %s_wp
endif

```



```

    if %mce_vars = "-mcap+wp" then
        %mce_vars = %s_mcap + %s_wp
    endif
    if @left(%mce_vars, 7) = "-allbut" then
        %tmp = %mce_vars
        %s_remove = @replace(%tmp, "-allbut", "")
        %mce_vars = @wnotin(%s_mcap + %s_wp + %s_other, %s_remove)
    endif
    string zvar_list = %mce_vars
    %zvars = %mce_vars

' backward-looking model

ld_frbus_cfs(modelname=%mod_b,modelpath=%path_b)
if !allbut = 1 then
    %tmp = "allbut " + %allbut
    ld_some_eqs(modelname=%mod_b,modelpath=%path_b,eqnames=%tmp)
endif
if !only = 1 then
    %tmp = %only
    ld_some_eqs(modelname=%mod_b,modelpath=%path_b,eqnames=%tmp)
endif
if !allbut = 0 and !only = 0 then
    ld_frbus_eqs(modelname=%mod_b,modelpath=%path_b)
endif

' model with mce equations and errors

ld_mce_eqs(pfname=%mod_f,pfpath=%path_f,mcename=%mod_f,mceeqs=%mce_vars)
ld_mce_cfs(pfname=%mod_f,pfpath=%path_f,mceeqs=%mce_vars)

!nmcevars = @wcount(%mce_vars)
%evars = @wcross("e",%mce_vars)
for !i = 1 to !nmcevars
    %tmp = @word(%mce_vars,!i)
    %tmpw = " w" + @mid(%tmp,2)
    if %tmp <> "zyh" and %tmp <> "zyhp" and %tmp <> "zyht" then
        %tmp1 = @word(%evars,!i) + "=" + @word(%mce_vars,!i) + "-" + %tmpw
    else
        %tmp1 = @word(%evars,!i) + "= log(" + @word(%mce_vars,!i) + "/" + %tmpw + ")"
    endif
    {%mod_f}.append {%tmp1}
next

endsub

```

Defines:

`mce_load_frbus`, used in chunks 7, 17, 23, 31, and 95.

Uses `ld_frbus_cfs` 177a 177b, `ld_frbus_eqs` 178b 179, `ld_mce_cfs` 180b 181,
`ld_mce_eqs` 183 184, `ld_some_eqs` 188 189, `mcz_equalopt` 111a, `zdivgr` 216, `zecd` 216,
`zeco` 216, `zeh` 216, `zgap05` 216, `zgap10` 216, `zgap30` 216, `zgapc2` 216, `zlhp` 216, `zpi10` 216,
`zpi10f` 216, `zpi5` 216, `zpib5` 216, `zpic30` 216, `zpic58` 216, `zpicxfe` 216, `zpieci` 216,
`zrff10` 216, `zrff30` 216, `zrff5` 216, `zvdp` 216, `zvpi` 216, `zvps` 216, `zyh` 216, `zyhp` 216,
`zyht` 216, and `zynid` 216.

6.2.24 create wage and expectation variables in forward looking model

```

173  <create wage and expectation variables in forward looking model 173>≡      (209)
      subroutine make_frbus_mcevars(string frbus_mcevars)

      ' Create data for the w and e variables in the operational forward looking
      ' model over the workfile sample currently in effect
      ,
      ' The input string contains the names of the expectations variables that
      ' are to have MC solutions

      %mce_vars = frbus_mcevars

      ' The user may ask directly for a group of forward-looking equations instead of
      ' passing in a list that may change in the future.

      ' Model consistent Asset Pricing
      %s_mcap = " zdivgr zgap05 zgap10 zpi10f zpic30 zrff10 zrff5 zgap30 zrff30 zpi10 zpib5 zpic58"

      ' Wages and prices
      %s_wp = " zpidxfe zpieci "

      ' Others - all PAC expectations
      %s_other = " zecd zeco zeh zgapc2 zlhp zpi5 zvpd zvps zvpi zxnfbd zxnfbz zxnfbz zyh zyhp zyht

      if %mce_vars = "-all" then
        %mce_vars = %s_mcap + %s_wp + %s_other
      endif
      if %mce_vars = "-mcap" then
        %mce_vars = %s_mcap
      endif
      if %mce_vars = "-wp" then
        %mce_vars = %s_wp
      endif
      if %mce_vars = "-mcap+wp" then
        %mce_vars = %s_mcap + %s_wp
      endif
      if @left(%mce_vars, 7) = "-allbut" then
        %tmp = %mce_vars
        %s_remove = @replace(%tmp, "-allbut", "")
        %mce_vars = @wnotin(%s_mcap + %s_wp + %s_other, %s_remove)
      endif

      ' Data for extra variables associated with MC expectations

```

```

smpl @all
for !i = 1 to @wcount(%mce_vars)
    %tmp = @word(%mce_vars,!i)
    %wtmp = "w" + @mid(%tmp,2)
    %wtmp_aerr = %wtmp + "_aerr"
    %etmp = "e" + @word(%mce_vars,!i)
    series {%wtmp} = {%tmp}
    series {%wtmp_aerr} = 0
    series {%etmp} = 0
next

```

endsub

Defines:

make_frbus_mcevars, used in chunks 7, 17, 23, 31, and 95.

Uses zdivgr 216, zecd 216, zeco 216, zeh 216, zgap05 216, zgap10 216, zgap30 216, zgapc2 216, zlhp 216, zpi10 216, zpi10f 216, zpi5 216, zpib5 216, zpic30 216, zpic58 216, zpicxfe 216, zpieci 216, zrff10 216, zrff30 216, zrff5 216, zvpd 216, zvpi 216, zvps 216, zyh 216, zyhp 216, zyht 216, and zynid 216.

File Contents

Notice that I've had to change underscores in file and directory names when I create them with noweb. I use the "setup.sh" bash script to create the directory structure, and the "check.sh" bash script to compare the renamed Eview files to the originals. I have to ignore white space in the comparison because the original source files are not consistent with using either Microsoft or Linux line ending characters.

6.3 scripts

6.3.1 setup script

175

<setup.sh 175>≡

```
mkdir -p srcEview/{frbus.package,mce.solve.package,state.space.package}
```

```
mkdir -p srcEview/frbus.package/{addins,programs,subs}
```

```
mkdir -p srcEview/frbus.package/addins/{ld.frbus.cfs,ld.frbus.eqs,ld.mce.cfs,ld.mce.eqs,ld.some
```

This code is written to file `setup.sh`.

Uses `solve 215`.

6.3.2 check script

176 *<check.sh 176>*≡

```
cfile=frbus_package/mods/stdver_coeffs.txt; ofile=stdver.coeffs.txt; echo "XX $cfile
cfile=frbus_package/mods/stdver_eqs.txt; ofile=stdver.eqs.txt; echo "XX $cfile XX"; c
cfile=frbus_package/mods/stdver_varinfo; ofile=stdver.varinfo; echo "XX $cfile XX"; c
cfile=data_only_package/variables.txt; ofile=variables.txt; echo "XX $cfile XX"; diff
```

```
cfile=frbus_package/addins/ld_frbus_cfs/ld_frbus_cfs.prg; ofile=srcEview/frbus.packag
cfile=frbus_package/addins/ld_frbus_eqs/ld_frbus_eqs.prg; ofile=srcEview/frbus.packag
cfile=frbus_package/addins/ld_mce_cfs/ld_mce_cfs.prg; ofile=srcEview/frbus.package/ac
cfile=frbus_package/addins/ld_mce_eqs/ld_mce_eqs.prg; ofile=srcEview/frbus.package/ac
cfile=frbus_package/addins/ld_some_eqs/ld_some_eqs.prg; ofile=srcEview/frbus.package/
cfile=frbus_package/addins/ld_varinfo/ld_varinfo.prg; ofile=srcEview/frbus.package/ac
cfile=frbus_package/addins/regadd.prg; ofile=srcEview/frbus.package/addins/regadd.prg
cfile=frbus_package/programs/example1.prg; ofile=srcEview/frbus.package/programs/exar
cfile=frbus_package/programs/example2.prg; ofile=srcEview/frbus.package/programs/exar
cfile=frbus_package/programs/example3.prg; ofile=srcEview/frbus.package/programs/exar
cfile=frbus_package/programs/example4.prg; ofile=srcEview/frbus.package/programs/exar
cfile=frbus_package/programs/ocpolicy.prg; ofile=srcEview/frbus.package/programs/ocp
cfile=frbus_package/programs/pings.prg; ofile=srcEview/frbus.package/programs/pings.p
cfile=frbus_package/programs/plot_resids.prg; ofile=srcEview/frbus.package/programs/p
cfile=frbus_package/programs/stochsim.prg; ofile=srcEview/frbus.package/programs/stoc
cfile=frbus_package/subs/master_library.prg; ofile=srcEview/frbus.package/subs/master
cfile=frbus_package/subs/mce_solve_library.prg; ofile=srcEview/frbus.package/subs/mce
cfile=mce_solve_package/example1.prg; ofile=srcEview/mce.solve.package/example1.prg;
cfile=mce_solve_package/example2.prg; ofile=srcEview/mce.solve.package/example2.prg;
cfile=mce_solve_package/example3.prg; ofile=srcEview/mce.solve.package/example3.prg;
cfile=mce_solve_package/example4.prg; ofile=srcEview/mce.solve.package/example4.prg;
cfile=mce_solve_package/example5.prg; ofile=srcEview/mce.solve.package/example5.prg;
cfile=mce_solve_package/mce_solve_library.prg; ofile=srcEview/mce.solve.package/mce.s
cfile=state_space_package/data_transformations.prg; ofile=srcEview/state.space.packag
cfile=state_space_package/estimation_code.prg; ofile=srcEview/state.space.package/est
cfile=state_space_package/frbus_supply_estimation.prg; ofile=srcEview/state.space.pac
cfile=state_space_package/frbus_supply_filter.prg; ofile=srcEview/state.space.package
cfile=state_space_package/initial_values.prg; ofile=srcEview/state.space.package/init
```

This code is written to file *check.sh*.

Uses *data_transformations* 213c, *estimation_code* 213d, *example1* 194c 212a, *example2* 194d 212b, *example3* 195a 212c, *example4* 195b 212d, *example5* 213a, *frbus_supply_estimation* 213e, *frbus_supply_filter* 214a, *initial_values* 81 214b, *ld_frbus_cfs* 177a 177b, *ld_frbus_eqs* 178b 179, *ld_mce_cfs* 180b 181, *ld_mce_eqs* 183 184, *ld_some_eqs* 188 189, *ld_varinfo* 192 193, *master_library* 207a, *mce_solve_library* 208 213b, *ocpolicy* 195c, *pings* 195d, *plot_resids* 201, *regadd* 194b, *solve* 215, and *stochsim* 205a.

6.4 frbus package

6.4.1 srcEview/frbus.package/addins/ld.frbus.cfs/ld.frbus.cfs.prg

177a `<srcEview/frbus.package/addins/ld.frbus.cfs/ld.frbus.cfs.prg 177a>≡`
`<load frbus coefficients 177b>`

`<load frbus coefficients call 178a>`

This code is written to file `srcEview/frbus.package/addins/ld.frbus.cfs/ld.frbus.cfs.prg`.

Defines:

`ld.frbus.cfs`, used in chunks 3, 11, 40, 169, 176, 178a, 194b, and 202.

177b `<load frbus coefficients 177b>≡` (177a)
`subroutine ld_frbus_cfs(string %mname, string %mpath)`

`'Load coefficients for frbus version %mname from a text file in directory %mpath`
`'that has been previously created by the script eq_docs2evIEWS.`

```
%cpath = %mpath + %mname + "_coeffs.txt"
delete(noerr) coefpath
text coefpath
coefpath.append(file) %cpath
svector coefpathv = coefpath.@svectornb
```

```
for !i = 1 to 900
  svector cofname = @wsplit(coefpathv(!i))
  %y1 = cofname(1)
  if @left(%y1,6) = "theend" then
    exitloop
  endif
  %y2 = cofname(2)
  %y3 = cofname(3)
  coef({%y2}) {%y1}
  {%y1}.fill {%y3}
next
```

`endsub`

Defines:

`ld.frbus.cfs`, used in chunks 3, 11, 40, 169, 176, 178a, 194b, and 202.

```

178a  <load frbus coefficients call 178a>≡ (177a)
      if @len(@option(1)) < 1 or @len(@option(2)) < 1 then
        @uiprompt("Error: ld_frbus_cfs requires model name and model path")
        stop
      endif

      %temp = @equaloption("modelname")
      if @len(%temp)>0 then
        %mname = %temp
      endif
      %temp = @equaloption("modelpath")
      if @len(%temp)>0 then
        %mpath = %temp
      endif

      call ld_frbus_cfs(%mname, %mpath)
Uses ld_frbus_cfs 177a 177b.

```

6.4.2 srcEview/frbus.package/addins/ld.frbus.eqs/ld.frbus.eqs.prg

```

178b  <srcEview/frbus.package/addins/ld.frbus.eqs/ld.frbus.eqs.prg 178b>≡
      <load frbus equations 179>

```

```

      <load frbus equations call 180a>

```

This code is written to file `srcEview/frbus.package/addins/ld.frbus.eqs/ld.frbus.eqs.prg`.

Defines:

```

      ld_frbus_eqs, used in chunks 3, 11, 40, 169, 176, 180a, 194b, and 202.

```



```

179  (load frbus equations 179)≡ (178b)
      subroutine ld_frbus_eqs(string %mname, string %mpath)

      'Create evIEWS model %mname and load it with the equations for frbus version
      '%mname that are in a text file in directory %mpath that was previously created
      'by the script eq_docs2evIEWS.

      %epath = %mpath + %mname
      if @fileexist(%epath) <> 1 then
        %epath = %mpath + %mname + "_eqs.txt"
      endif
      delete(noerr) eqtext
      text eqtext
      eqtext.append(file) %epath
      svector eqtextv = eqtext.@svectornb

      model {%mname}

      !eqnum = 0
      %eqcode = " "

      for !i = 1 to 3000
        %y = eqtextv(!i)
        if @isempty(%y) = 0 then
          'string is not blank
          if @left(%y,6) = "theend" then
            %x = @replace(%eqcode," _"," ")
            {%mname}.append {%x}
            exitloop
          endif

          !k = @instr(%y,":")
          if !k > 0 then
            'string contains the start of a new equation
            !eqnum = !eqnum + 1
            if !eqnum > 0 then
              %x = @replace(%eqcode," _"," ")
              {%mname}.append {%x}
            endif
            %eqcode = @mid(%y,!k+1)

          else
            'string contains the continuation of an equation
            %eqcode = %eqcode + %y
          endif
        endif
      endfor

```

```

        endif
    next

```

```

endsub

```

Defines:

ld_frbus_eqs, used in chunks 3, 11, 40, 169, 176, 180a, 194b, and 202.

```

180a  <load frbus equations call 180a>≡ (178b)
      if @len(@option(1)) < 1 or @len(@option(2)) < 1 then
          @uiprompt("Error: ld_frbus_eqs requires model name and model path")
          stop
      endif

      %temp = @equaloption("modelname")
      if @len(%temp)>0 then
          %mname = %temp
      endif
      %temp = @equaloption("modelpath")
      if @len(%temp)>0 then
          %mpath = %temp
      endif

      call ld_frbus_eqs(%mname, %mpath)

```

Uses ld_frbus_eqs 178b 179.

6.4.3 srcEview/frbus.package/addins/ld.mce.cfs/ld.mce.cfs.prg

```

180b  <srcEview/frbus.package/addins/ld.mce.cfs/ld.mce.cfs.prg 180b>≡
      <load mce coefficients 181>

      <load mce coefficients call 182>

```

This code is written to file srcEview/frbus.package/addins/ld.mce.cfs/ld.mce.cfs.prg.

Defines:

ld_mce_cfs, used in chunks 169, 176, 182, and 194b.

```

181  <load mce coefficients 181>≡ (180b)
      subroutine ld_mce_cfs(string %pfname, string %pfpath, string %mceeqs)

      'This subroutine is used for setting up the particular type of frbus simulations
      'with model-consistent expectations in which a separate model is created
      'containing only those expectations equations chosen to have model-consistent
      'solutions. For those expectations variables, the initial z character is replaced
      'with w.

      'Load coefficients for frbus version %pfname from a text file in directory %pfpath
      'that has been previously created by the script eq_docs2evIEWS. Only those
      'coefficient vectors whose names are in the string %mceeqs are stored.

      %cpath = %pfpath + %pfname + "_coeffs.txt"
      delete(noerr) coefpathpv
      text coefpathpv
      coefpathpv.append(file) %cpath
      svector coefpathv = coefpathpv.@svectornb

      for !i = 1 to 900
        svector cofname = @wsplit(coefpathv(!i))
        %y1 = cofname(1)
        if @left(%y1,6) = "theend" then
          exitloop
        endif
        %y2 = cofname(2)
        %y3 = cofname(3)
        for !j = 1 to @wcount(%mceeqs)
          %z = @lower(@word(%mceeqs,!j))
          %z1 = @mid(%y1,3)
          if %z = %z1 then
            %y1 = @replace(%y1,"z","w")
            coef({%y2}) {%y1}
            {%y1}.fill {%y3}
            exitloop
          endif
        next
      next

      endsub

Defines:
      ld_mce_cfs, used in chunks 169, 176, 182, and 194b.

```

```

182  (load mce coefficients call 182)≡ (180b)
      if @len(@option(1)) < 1 or @len(@option(2)) < 1 or @len(@option(3)) < 1 then
        @uiprompt("Error: ld_mce_cfs requires four parameters: pf model name, pf model pat
        stop
      endif

      %temp = @equaloption("pfname")
      if @len(%temp)>0 then
        %pfname = %temp
      endif
      %temp = @equaloption("pfpath")
      if @len(%temp)>0 then
        %pfpath = %temp
      endif
      %temp = @equaloption("mceeqs")
      if @len(%temp)>0 then
        %mceeqs = %temp
      endif
      '      ' Added so that users may ask directly for a group of forward-looking equations
      '      ' passing in a list that may change in the future.
      '      ' Model consistent Asset Pricing
      %s_mcap = " zdivgr zgap05 zgap10 zpi10f zpic30 zrff10 zrff5 zgap30 zrff30 zpi10
      '      ' Wages and prices
      %s_wp = " zpicxfe zpieci "
      '      ' Others - all PAC expectations
      %s_other = " zecd zeco zeh zgapc2 zlhp zpi5 zpi10 zpib5 zvpd zvps zvpi zxnfbd z
      '      if %mceeqs = "-all" then
      %mceeqs = %s_mcap + %s_wp + %s_other
      '      endif
      '      if %mceeqs = "-mcap" then
      %mceeqs = %s_mcap
      '      endif
      '      if %mceeqs = "-wp" then
      %mceeqs = %s_wp
      '      endif
      '      if %mceeqs = "-mcap+wp" then
      %mceeqs = %s_mcap + %s_wp
      '      endif
      '      if @left(%mceeqs, 7) = "-allbut" then
      %tmp = %mceeqs
      %s_remove = @replace(%tmp, "-allbut", "")
      %mceeqs = @wnotin(%s_mcap + %s_wp + %s_other, %s_remove)
      '      endif
      '      string zvar_list = %mceeqs
      '      scalar nzvars = @wcount(%mceeqs)
      '      group zvars {%mceeqs}

```

```
call ld_mce_cfs(%pfname, %pfpath, %mceeqs)
```

Uses `ld_mce_cfs` 180b 181, `zdivgr` 216, `zecd` 216, `zeco` 216, `zeh` 216, `zgap05` 216, `zgap10` 216, `zgap30` 216, `zgapc2` 216, `zlhp` 216, `zpi10` 216, `zpi10f` 216, `zpi5` 216, `zpib5` 216, `zpic30` 216, `zpicxfe` 216, `zpieci` 216, `zrff10` 216, `zrff30` 216, `zrff5` 216, `zvpd` 216, `zvpi` 216, `zvps` 216, `zyh` 216, `zyhp` 216, `zyht` 216, and `zynid` 216.

6.4.4 `srcEview/frbus.package/addins/ld.mce.eqs/ld.mce.eqs.prg`

183 `<srcEview/frbus.package/addins/ld.mce.eqs/ld.mce.eqs.prg 183>≡`
`<load mce equations 184>`
`<load mce equations call 187>`

This code is written to file `srcEview/frbus.package/addins/ld.mce.eqs/ld.mce.eqs.prg`.
 Defines:

`ld_mce_eqs`, used in chunks 169, 176, 187, and 194b.

```

184  (load mce equations 184)≡ (183)
      subroutine ld_mce_eqs(string %pfname, string %pfpath, string %mcename, string %mceeqs

      'This subroutine is used for setting up the particular type of frbus simulations
      'with model-consistent expectations in which a separate model is created
      'containing only those expectations equations chosen to have model-consistent
      'solutions. For those expectations variables, the initial z character is replaced
      'with w.

      'Create eviews model %mcename and load it with the equations for frbus version
      '%pfname that are in a text file in directory %pfpath that was previously created
      'by the script eq_docs2eviews. Only those equations whose names are in the
      'string %mceeqs are included.

      ' revised 2/11/13 to add a check that version %pfname contains an equation for each
      ' name in %mceeqs

      %epath = %pfpath + %pfname + "_eqs.txt"
      delete(noerr) eqtextp
      text eqtextp
      eqtextp.append(file) %epath
      svector eqtextpv = eqtextp.@svectornb

      %coded = " "

      model {%mcename}

      !eqnum = 0
      %eqnew = " "
      %eqold = " "
      %eqcode = " "
      %eqcodeold = " "

      for !i = 1 to 3000

          %appendit = "no"
          %exitloop = "no"
          %y = eqtextpv(!i)
          if @isempty(%y) = 0 then
              'string is not blank
              if @left(%y,6) = "theend" then
                  'string contains end-of-file flag
                  %appendit = "yes"
                  %exitloop = "yes"
                  %eqold = %eqnew

```

```

        %eqcodeold = %eqcode
    endif

    !k = @instr(%y,":")
    if !k > 0 then
        'string contains the start of a new equation
        %appendit = "yes"
        !eqnum = !eqnum + 1
        if !eqnum > 0 then
            %eqold = %eqnew
            %eqcodeold = %eqcode
        endif
        %eqnew = @left(%y,!k-1)
        %eqcode = @mid(%y,!k+1)
    else
        'string contains the continuation of an equation
        %eqcode = %eqcode + %y
    endif

    if %appendit = "yes" then
        'add equation to model only if it is one with mce expectations
        for !j = 1 to @wcount(%mceeqs)
            %z = @lower(@word(%mceeqs,!j))
            if %z = %eqold then
                %x = @replace(%eqcodeold," _"," ")
                %x = @replace(%x,"z","w")
                {%mcename}.append {%x}
                %coded = %coded + " " + %z
            exitloop
            endif
        next
    endif

    if %exitloop = "yes" then
        exitloop
    endif

    endif
next

' check that model %mcename contains an equation for each variable in %mceeqs
!j = @wcount(%mceeqs)
!k = @wcount(%coded)
if !j <> !k then
    %z = @wnotin(@lower(%mceeqs),@lower(%coded))
    %errstring = "Error in ld_mce_eqs addin: Model " + %mcename

```

```
%errstring = %errstring + " does not contain equation(s) for variable(s): " + %  
%errstring = %errstring + ". Execution stopped."  
@uiprompt(%errstring)  
stop  
endif
```

```
endsub
```

Defines:

`ld_mce_eqs`, used in chunks 169, 176, 187, and 194b.


```

187  <load mce equations call 187>= (183)
    if @len(@option(1)) < 1 or @len(@option(2)) < 1 or @len(@option(3)) < 1 or @len(@option(4)) < 1
        @uiprompt("Error: ld_mce_eqs requires five parameters: pf model name, pf model path, mce mod
        stop
    endif

    %temp = @equaloption("pfname")
    if @len(%temp)>0 then
        %pfname = %temp
    endif
    %temp = @equaloption("pfpath")
    if @len(%temp)>0 then
        %pfpath = %temp
    endif
    %temp = @equaloption("mcename")
    if @len(%temp)>0 then
        %mcename = %temp
    endif
    %temp = @equaloption("mceeqs")
    if @len(%temp) >0 then
        %mceeqs = %temp
    endif
    '      ' Added so that users may ask directly for a group of forward-looking equations instead of
    '      ' passing in a list that may change in the future.
    '      ' Model consistent Asset Pricing
    '      %s_mcap = " zdivgr zgap05 zgap10 zpi10f zpic30 zrff10 zrff5 zgap30 zrff30 zpi10 zpib5 "
    '      ' Wages and prices
    '      %s_wp = " zpicxfe zpieci "
    '      ' Others - all PAC expectations
    '      %s_other = " zecd zeco zeh zgapc2 zlhp zpi5 zpi10 zpib5 zvpd zvps zvpi zxbd zxbs zxbi zyh
    '      if %mceeqs = "-all" then
    '          %mceeqs = %s_mcap + %s_wp + %s_other
    '      endif
    '      if %mceeqs = "-mcap" then
    '          %mceeqs = %s_mcap
    '      endif
    '      if %mceeqs = "-wp" then
    '          %mceeqs = %s_wp
    '      endif
    '      if %mceeqs = "-mcap+wp" then
    '          %mceeqs = %s_mcap + %s_wp
    '      endif
    '      if @left(%mceeqs, 7) = "-allbut" then
    '          %tmp = %mceeqs
    '          %s_remove = @replace(%tmp, "-allbut", "")
    '          %mceeqs = @wnotin(%s_mcap + %s_wp + %s_other, %s_remove)

```

```

'    endif
'    string zvar_list = %mceeqs
'    scalar nzvars = @wcount(%mceeqs)
'    group zvars {%mceeqs}

```

```

call ld_mce_eqs(%pfname, %pfpath, %mcename, %mceeqs)

```

Uses `ld_mce_eqs` 183 184, `zdivgr` 216, `zecd` 216, `zeco` 216, `zeh` 216, `zgap05` 216, `zgap10` 216, `zgap30` 216, `zgapc2` 216, `zlhq` 216, `zpi10` 216, `zpi10f` 216, `zpi5` 216, `zpi5` 216, `zpic30` 216, `zpic3fe` 216, `zpieci` 216, `zrff10` 216, `zrff30` 216, `zrff5` 216, `zvpd` 216, `zvpi` 216, `zvps` 216, `zxbd` 216, `zxbi` 216, `zxls` 216, `zyh` 216, `zyhp` 216, `zyht` 216, and `zynid` 216.

6.4.5 srcEview/frbus.package/addins/ld.some.eq.s/ld.some.eq.s.prg

```

188 <srcEview/frbus.package/addins/ld.some.eq.s/ld.some.eq.s.prg 188>≡
    <load some equations 189>
    <load some equations call 191>

```

This code is written to file `srcEview/frbus.package/addins/ld.some.eq.s/ld.some.eq.s.prg`.
 Defines:

`ld.some_eqs`, used in chunks 169, 176, 191, and 194b.

```

189  (load some equations 189)≡ (188)
      subroutine ld_some_eqs(string %mname, string %mpath, string %eqnames)

      ' Create evIEWS model %mname and load it with selected equations for frbus version
      ' %mname that are in a text file in directory %mpath that was previously created
      ' by the script eq_docs2evIEWS. Only those equations whose names match or do not match the
      ' equation names in the string %eqnames are included. If the first "word" in %eqnames is
      ' "allbut", then all equations but those listed will be included.

      '*****
      'parse equation string and put equation names in a table

      %allbut = "no"

      string zlist = " "
      zlist = zlist + %eqnames
      zlist = @trim(zlist)
      if @isempty(zlist) = 1 then
        @uiprompt("Error: input string to subroutine load_selected_equtions is empty!!")
        stop
      endif

      if @wfind(@upper(zlist),"ALLBUT") = 1 then
        %allbut = "yes"
        zlist = @wdrop(zlist,"ALLBUT")
        zlist = @wdrop(zlist,"allbut")
      endif

      '*****
      'parse equation file

      %epath = %mpath + %mname + "_eqs.txt"
      delete(noerr) eqtext
      text eqtext
      eqtext.append(file) %epath
      svector eqtextv = eqtext.@svectornb

      model {%mname}

      !eqnum = 0
      %eqnew = " "
      %eqold = " "
      %eqcode = " "
      %eqcodeold = " "

```

```

for !i = 1 to 3000
  %appendit = "no"
  %exitloop = "no"
  %y = eqtextv(!i)
  if @isempty(%y) = 0 then
    'string is not blank
    if @left(%y,6) = "theend" then
      %appendit = "yes"
      %exitloop = "yes"
      %eqold = %eqnew
      %eqcodeold = %eqcode
    endif

    !k = @instr(%y,":")
    if !k > 0 then
      'string contains the start of a new equation
      %appendit = "yes"
      !eqnum = !eqnum + 1
      if !eqnum > 0 then
        %eqold = %eqnew
        %eqcodeold = %eqcode
      endif
      %eqnew = @left(%y,!k-1)
      %eqcode = @mid(%y,!k+1)

    else
      'string contains the continuation of an equation
      %eqcode = %eqcode + %y
    endif

    if %appendit = "yes" then
      'check whether equation should be added to model
      !zswitch = 0
      for !j = 1 to @wcount(zlist)
        %z = @lower(@word(zlist,!j))
        if %z = %eqold then
          !zswitch = 1
        endif
        if %allbut = "no" and !zswitch = 1 then
          %x = @replace(%eqcodeold," _"," ")
          {%mname}.append {%x}
          exitloop
        endif
        if %allbut = "yes" and !j = @wcount(zlist) and !zswitch = 0 then
          %x = @replace(%eqcodeold," _"," ")

```

```

        {%mname}.append {%x}
      endif
    next
  endif

  if %exitloop = "yes" then
    exitloop
  endif

endif
next

```

endsub

Defines:

ld_some_eqs, used in chunks 169, 176, 191, and 194b.

```

191  <load some equations call 191>≡ (188)
    if @len(@option(1)) < 1 or @len(@option(2)) < 1 or @len(@option(3)) < 1 then
      @uiprompt("Error: ld_some_eqs requires model name and model path and eqnames")
      stop
    endif

    %temp = @equaloption("modelname")
    if @len(%temp)>0 then
      %mname = %temp
    endif
    %temp = @equaloption("modelpath")
    if @len(%temp)>0 then
      %mpath = %temp
    endif
    %temp = @equaloption("eqnames")
    if @len(%temp)>0 then
      %eqnames = %temp
    endif

    call ld_some_eqs(%mname, %mpath, %eqnames)
  Uses ld_some_eqs 188 189.

```

6.4.6 `srcEview/frbus.package/addins/ld.varinfo/ld.varinfo.prg`

192 `<srcEview/frbus.package/addins/ld.varinfo/ld.varinfo.prg 192>≡`
 `<load variable information 193>`

`<load variable information call 194a>`

This code is written to file `srcEview/frbus.package/addins/ld.varinfo/ld.varinfo.prg`.
Defines:

`ld.varinfo`, used in chunks 40, 176, 194, and 202.

The ld_varinfo subroutine parses the frbus_package/mods/stdver_varinfo file.

```

193  <load variable information 193>≡ (192)
      subroutine ld_varinfo(string %pathname)

      'Load varinfo information from %pathname in strings

      text vinfo_text
      vinfo_text.append(file) %pathname
      svector varinfo = vinfo_text.@svectornb
      string vinfo_vname = " "
      string vinfo_vtype = " "
      string vinfo_vrule = " "
      string vinfo_sector = " "
      string vinfo_stoch = " "
      string vinfo_decomp = " "
      for !i = 1 to 900
        %y1 = varinfo(!i)
        !ss = @instr(%y1," ")
        %vname = @mid(%y1,!ss+1,8)
        %vname = @rtrim(%vname)
        %vtype = @mid(%y1,!ss+107,1)
        %vrule = @mid(%y1,!ss+109,1)
        if %vrule = " " then
          %vrule = "0"
        endif
        %sector = @mid(%y1,!ss+120,1)
        if %sector = " " then
          %sector = "0"
        endif
        %stoch = @mid(%y1,!ss+128,2)
        %decomp = @mid(%y1,!ss+135,2)
        if %vname = "ZZZBLANK" then
          scalar vinfo_size = !i-1
          exitloop
        endif
        vinfo_vname = vinfo_vname + " " + %vname
        vinfo_vtype = vinfo_vtype + " " + %vtype
        vinfo_vrule = vinfo_vrule + " " + %vrule
        vinfo_sector = vinfo_sector + " " + %sector
        vinfo_stoch = vinfo_stoch + " " + %stoch
        vinfo_decomp = vinfo_decomp + " " + %decomp
      next

      endsub

```

Defines:

ld_varinfo, used in chunks 40, 176, 194, and 202.

```
194a  <load variable information call 194a>≡ (192)
      if @len(@option(1)) < 1 then
        @uiprompt("Error: ld_varinfo requires varinfo path")
        stop
      endif

      %temp = @equaloption("pathname")
      if @len(%temp)>0 then
        %pathname = %temp
      endif
```

call ld_varinfo(%pathname)

Uses ld_varinfo 192 193.

6.4.7 srcEview/frbus.package/addins/regadd.prg

```
194b  <srcEview/frbus.package/addins/regadd.prg 194b>≡
      addin(proc="ld_frbus_eqs",desc="Load FRB/US equations") ".\ld_frbus_eqs/ld_frbus_eqs.prg"
      addin(proc="ld_frbus_cfs",desc="Load FRB/US coefficients") ".\ld_frbus_cfs/ld_frbus_cfs.prg"
      addin(proc="ld_mce_eqs",desc="Load MCE equations") ".\ld_mce_eqs/ld_mce_eqs.prg"
      addin(proc="ld_mce_cfs",desc="Load MCE coefficients") ".\ld_mce_cfs/ld_mce_cfs.prg"
      addin(proc="ld_some_eqs",desc="Load some FRB/US equations") ".\ld_some_eqs/ld_some_eqs.prg"
      addin(proc="ld_varinfo",desc="Load variable information file") ".\ld_varinfo/ld_varinfo.prg"
```

This code is written to file srcEview/frbus.package/addins/regadd.prg.

Defines:

regadd, used in chunk 176.

Uses ld_frbus_cfs 177a 177b, ld_frbus_eqs 178b 179, ld_mce_cfs 180b 181,
ld_mce_eqs 183 184, ld_some_eqs 188 189, and ld_varinfo 192 193.

6.4.8 srcEview/frbus.package/programs/example1.prg

```
194c  <srcEview/frbus.package/programs/example1.prg 194c>≡
      <frbus example1 3>
```

This code is written to file srcEview/frbus.package/programs/example1.prg.

Defines:

example1, used in chunk 176.

6.4.9 srcEview/frbus.package/programs/example2.prg

```
194d  <srcEview/frbus.package/programs/example2.prg 194d>≡
      <frbus example2 7>
```

This code is written to file srcEview/frbus.package/programs/example2.prg.

Defines:

example2, used in chunk 176.

6.4.10 srcEview/frbus.package/programs/example3.prg

195a $\langle \text{srcEview/frbus.package/programs/example3.prg } 195a \rangle \equiv$
 $\langle \text{frbus example3 } 11 \rangle$

This code is written to file srcEview/frbus.package/programs/example3.prg.

Defines:

example3, used in chunk 176.

6.4.11 srcEview/frbus.package/programs/example4.prg

195b $\langle \text{srcEview/frbus.package/programs/example4.prg } 195b \rangle \equiv$
 $\langle \text{frbus example4 } 17 \rangle$

This code is written to file srcEview/frbus.package/programs/example4.prg.

Defines:

example4, used in chunk 176.

6.4.12 srcEview/frbus.package/programs/ocpolicy.prg

195c $\langle \text{srcEview/frbus.package/programs/ocpolicy.prg } 195c \rangle \equiv$
 $\langle \text{frbus ocpolicy } 23 \rangle$

This code is written to file srcEview/frbus.package/programs/ocpolicy.prg.

Defines:

ocpolicy, used in chunk 176.

6.4.13 srcEview/frbus.package/programs/pings.prg

195d $\langle \text{srcEview/frbus.package/programs/pings.prg } 195d \rangle \equiv$
 $\langle \text{simulate six ping simulations, aka simple IRFs } 31 \rangle$
 ' *****
 ' *****
 ' *****
 $\langle \text{copy it } 196a \rangle$
 ' *****
 ' *****
 ' *****
 $\langle \text{plot it } 196b \rangle$
 ' *****
 ' *****
 ' *****
 $\langle \text{graph it } 197 \rangle$

This code is written to file srcEview/frbus.package/programs/pings.prg.

Defines:

pings, used in chunks 31 and 176.

196a $\langle copy\ it\ 196a \rangle \equiv$ (195d)
 subroutine copyit

```

smpl %simstart %simend
series picnia_{%ping} = picnia{%suf} - picnia
series pic4_{%ping} = pic4{%suf} - pic4
series picx4_{%ping} = picx4{%suf} - picx4
series picxfe_{%ping} = picxfe{%suf} - picxfe
series xgap2_{%ping} = xgap2{%suf} - xgap2
series lur_{%ping} = lur{%suf} - lur
series rff_{%ping} = rff{%suf} - rff

```

endsub

Defines:

copyit, used in chunk 31.

Uses lur 216, pic4 216, picnia 216, picx4 216, picxfe 216, rff 216, and xgap2 216.

196b $\langle plot\ it\ 196b \rangle \equiv$ (195d)
 subroutine plotit(string %grname, string %width, string %height, string %var1, str

```

graph {%grname}.line {%var1} zero
{%grname}.options size({%width},{%height}) -inbox
{%grname}.setelem(1) linewidth(3) linepattern(1) linecolor(black)
{%grname}.addtext(t,just(c),font(9)) %title
{%grname}.addtext(0,-.15,font(8),just("r")) %units
{%grname}.datelabel format(yyyy)
{%grname}.legend -display
{%grname}.axis(b) font(9)
{%grname}.axis(l) font(9)

```

endsub

Defines:

plotit, used in chunk 197.

```

197  <graph it 197>≡ (195d)
      subroutine graphit

      smpl %simstart %simstart + 39
      series zero = 0

      delete(noerr) gr_*

' RFF ping

      %ping = "rff"

      %name = %ping + "a"
      %var1 = "xgap2_" + %ping
      %tt = "Response of Output Gap\rto Funds Rate"
      call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

      %name = %ping + "b"
      %var1 = "picxfe_" + %ping
      %tt = "Response of Core Inflation\rto Funds Rate"
      call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

      %name = %ping + "c"
      %var1 = "rff_" + %ping
      %tt = "Response of Funds Rate\rto Funds Rate"
      call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

      graph gr_{%ping}.merge  {%ping}a {%ping}b {%ping}c
      gr_{%ping}.align(3,.40,.40)

' EGFO ping

      %ping = "eg"

      %name = %ping + "a"
      %var1 = "xgap2_" + %ping
      %tt = "Response of Output Gap\rto Federal Purch"
      call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

      %name = %ping + "b"
      %var1 = "picxfe_" + %ping
      %tt = "Response of Core Inflation\rto Federal Purch"

```

```

call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "egfn_shr_" + %ping
%tt = "Response of Federal Purch\erto Federal Purch"
call plotit(%name,"2","1.5",%var1,%tt,"percent of GDP")

graph gr_{%ping}.merge  {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)

' REQP ping

%ping = "reqp"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\erto Equity Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "b"
%var1 = "picxfe_" + %ping
%tt = "Response of Core Inflation\erto Equity Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "reqp_" + %ping
%tt = "Response of Equity Premium\erto Equity Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

graph gr_{%ping}.merge  {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)

' POILR ping

%ping = "oil"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\erto Oil Price"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "b"
%var1 = "picxfe_" + %ping

```

```
%tt = "Response of Core Inflation\rto Oil Price"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "poil_" + %ping
%tt = "Response of Oil Price\rto Oil Price"
call plotit(%name,"2","1.5",%var1,%tt,"dollars per barrel")

graph gr_{%ping}.merge {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)
```

’ HMFPT ping

```
%ping = "hmfp"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\rto MFP Growth"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "b"
%var1 = "picxfe_" + %ping
%tt = "Response of Core Inflation\rto MFP Growth"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "hmftp_" + %ping
%tt = "Response of MFP Growth\rto MFP Growth"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

graph gr_{%ping}.merge {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)
```

’ MFPT ping

```
%ping = "mfp"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\rto MFP Level"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")
```

```

%name = %ping + "b"
%var1 = "picxfe_" + %ping
%tt = "Response of Core Inflation\rto MFP Level"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "mfpt_" + %ping
%tt = "Response of MFP Level\rto MFP Level"
call plotit(%name,"2","1.5",%var1,%tt,"percent")

graph gr_{%ping}.merge {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)

%ping = "prem"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\rto Term Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "b"
%var1 = "picxfe_" + %ping
%tt = "Response of Core Inflation\rto Term Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "c"
%var1 = "rg10p_" + %ping
%tt = "Response of Term Premium (10-year) \rto Term Premium"
call plotit(%name,"2","1.5",%var1,%tt,"percent")

graph gr_{%ping}.merge {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)

%ping = "exch"

%name = %ping + "a"
%var1 = "xgap2_" + %ping
%tt = "Response of Output Gap\rto Exchange Rate"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

%name = %ping + "b"
%var1 = "picxfe_" + %ping
%tt = "Response of Core Inflation\rto Exchange Rate"
call plotit(%name,"2","1.5",%var1,%tt,"percentage points")

```

```

%name = %ping + "c"
%var1 = "fpxr_" + %ping
%tt = "Response of Exchange Rate \rto Exchange Rate"
call plotit(%name,"2","1.5",%var1,%tt,"percent")

graph gr_{%ping}.merge {%ping}a {%ping}b {%ping}c
gr_{%ping}.align(3,.40,.40)
endsub

```

Defines:

graphit, used in chunk 31.

Uses **plotit** 196b, **reqp** 216, and **rff** 216.

6.4.14 srcEview/frbus.package/programs/plot.resids.prg

201 \langle srcEview/frbus.package/programs/plot.resids.prg 201 $\rangle \equiv$
 \langle plot historical residuals of key equations 202 \rangle

```

' *****
' *****
 $\langle$ find variable description 204 $\rangle$ 

```

This code is written to file srcEview/frbus.package/programs/plot.resids.prg.

Defines:

plot_resids, used in chunk 176.

```

202  <plot historical residuals of key equations 202>≡ (201)
      ' Program to plot the historical residuals of key FRB/US equations
      ,
      ' Each residual has the same units of measurement as the
      ' the left hand side of its equation

      ' *****
      ' Initial filename and parameter settings
      ' *****

      ' Subroutines
      include ../subs/master_library

      ' Workfile
      %wfstart = "1975q1"
      %wfend = "2030q4"
      %mainpage = "main"
      wfcreate(wf=aaa,page={%mainpage}) q {%wfstart} {%wfend}

      ' FRB/US model name and location
      %varmod = "stdver"
      %varpath = "../mods/"
      %varinfo = "../mods/stdver_varinfo"

      ' Input database
      %dbin = "../data/longbase"

      ' Plot range
      %plotstart = "1980q1"
      %plotend = "2014q2"

      ' *****
      ' Retrieve data, model equations and coefficients
      ' *****

      ' Load equations and coefficients
      ld_frbus_eqs(modelname=%varmod,modelpath=%varpath)
      ld_frbus_cfs(modelname=%varmod,modelpath=%varpath)
      ld_varinfo(pathname=%varinfo)

      ' Load data
      dbopen %dbin as longbase
      smpl %plotstart-12 %plotend
      fetch(d=longbase) *

```



```

' Set _aerr variables to zero
  smpl @all
  {%varmod}.makegroup(a,n) endog @endog
  call groupnew("endog","_aerr")
  call group2zero("endog_aerr")

' Compute baseline tracking add factors
  smpl %plotstart %plotend
  {%varmod}.addassign @all
  {%varmod}.addinit(v=n) @all

' *****
' Plots
' *****

%plotvars = "eco ecd eh epd epi eps ki ex emo lfpr lhp leo lww"
%plotvars = %plotvars + " picxfe pieci pcer pcfr pcengr"
%plotvars = %plotvars + " rg5p rg10p rg30p rbbbp rcar rme rtbe rcgain"
%plotvars = %plotvars + " ynidn yniin yhibn"

smpl %plotstart %plotend
series zero = 0

spool plot_vars

!counter = 0
for !i = 1 to @wcount(%plotvars)
  %vname = @word(%plotvars,!i)
  call find_var_description
  !counter = !counter + 1
  graph gr_{%vname}.line zero {%vname}_a
  %title = %vname + ": " + %desc
  gr_{%vname}.addtext(t) %title
  gr_{%vname}.axis range(minmax)
  gr_{%vname}.options size(4,3)
  gr_{%vname}.legend -display

  plot_vars.append gr_{%vname}
  %index = "000" + @str(!counter)
  if !counter < 100 then
    %index = @right(%index,2)
  else
    %index = @right(%index,3)
  endif
  %name = "untitled" + %index
  plot_vars.name {%name} {%vname}

```

next

plot_vars.display

Uses dbopen 215, ecd 216, eco 216, eh 216, emo 216, epd 216, epi 216, eps 216, ex 216, fetch 215, find_var.description 204, group2zero 89a, groupnew 90, ki 216, ld_frbus_cfs 177a 177b, ld_frbus_eqs 178b 179, ld_varinfo 192 193, left 216, leo 216, lfpr 216, lhp 216, lww 216, master_library 207a, pcengr 216, pcer 216, pcfr 216, picxfe 216, pieci 216, rbbbp 216, rcar 216, rcgain 216, rg10p 216, rg30p 216, rg5p 216, rme 216, rtbe 216, wfcreate 215, yhibn 216, ynidn 216, and yniin 216.

This was originally written in Fortran! Look at the *ii*, *jj*, *kk* variable names. I had forgotten about that from when I briefly helped the programmer debug the original model some 45 years ago. Who would have expected nostalgia from something so prosaic. I never saw the original source code because I was working with only a hex dump.

204 $\langle \text{find variable description } 204 \rangle \equiv$ (201)

```
subroutine find_var_description

  for !j = 1 to 500
    %vline = vinfo_text.@line(!j)
    !eq = @instr(%vline,"=")
    !zz = !eq-4
    %name = @lower(@rtrim(@ltrim(@mid(%vline,4,!zz))))

    if %vname = %name then
      %desc = " "
      !ii = !eq + 1
      !kk = @instr(%vline,"sector_")
      if !kk = 0 then
        !kk = @instr(%vline,"X.")
        !jj = !kk - 1 - !ii
      else
        !jj = !kk - 7 - !ii
      endif
      %desc = @rtrim(@mid(%vline,!ii,!jj))
      exitloop
    endif
  next
endsub
```

Defines:

find_var.description, used in chunk 202.

6.4.15 srcEview/frbus.package/programs/stochsim.prg

205a *<srcEview/frbus.package/programs/stochsim.prg 205a>*≡
<stochastic simulations under variable expectations 40>

```

' *****
' *****
' *****
' *****
' Subroutines

' *****
' *****
<form table 205b>

' *****
' *****
<make statistics 206>

```

This code is written to file srcEview/frbus.package/programs/stochsim.prg.

Defines:

stochsim, used in chunk 176.

205b *<form table 205b>*≡ (205a)

```

subroutine tableform(string %tabname, string %nrows)

    table(@val(%nrows),9) {%tabname}

    {%tabname}.setwidth(1:9) 8
    {%tabname}.setjust(r1c1:r{%nrows}c9) right
    {%tabname}.setformat(r2c2:r{%nrows}c9) f.3
    {%tabname}(1,1) = "qtr"
    {%tabname}(1,2) = "baseline"
    {%tabname}(1,3) = "mean"
    {%tabname}(1,4) = "median"
    {%tabname}(1,5) = "stdev"
    {%tabname}(1,6) = "90%-low"
    {%tabname}(1,7) = "90%-hi"
    {%tabname}(1,8) = "70%-low"
    {%tabname}(1,9) = "70%-hi"

    endsub

```

Defines:

tableform, used in chunk 40.

```

206  <make statistics 206>≡ (205a)
      subroutine makestats(string %trkname)

          %trkmat = %trkname + "_mat"
          %statsmat = %trkname + "_stats"
          matrix(nqtrs,8) {%statsmat}

          smpl {%simstart} {%simend}

      ' loop over each simulation quarter
      for !ii2 = 1 to nqtrs
      ' put simulation replications for this quarter into matrix tempm1
      matrix tempm1 = @sort(@rowextract({%trkmat},!ii2))
      {%statsmat}(!ii2,1) = {%trkname}(!lqtr + !ii2)
      {%statsmat}(!ii2,2) = @mean(tempm1)
      {%statsmat}(!ii2,3) = tempm1(1,@floor(.50*nrepl))
      {%statsmat}(!ii2,4) = @stdev(tempm1)
      {%statsmat}(!ii2,5) = tempm1(1,@floor(.05*nrepl))
      {%statsmat}(!ii2,6) = tempm1(1,@floor(.95*nrepl))
      {%statsmat}(!ii2,7) = tempm1(1,@floor(.15*nrepl))
      {%statsmat}(!ii2,8) = tempm1(1,@floor(.85*nrepl))

      next

      ' also create individual series for each statistic
      series {%trkname}_base = 0
      series {%trkname}_mn = 0
      series {%trkname}_med = 0
      series {%trkname}_se = 0
      series {%trkname}_lo90 = 0
      series {%trkname}_hi90 = 0
      series {%trkname}_lo70 = 0
      series {%trkname}_hi70 = 0

      group {%trkname}_group {%trkname}_base {%trkname}_mn {%trkname}_med _
          {%trkname}_se {%trkname}_lo90 {%trkname}_hi90 {%trkname}_lo70 _
          {%trkname}_hi70
      mtos({%statsmat},{%trkname}_group)

      endsub

```

Defines:

makestats, used in chunk 40.

6.4.16 srcEview/frbus.package/subs/master.library.prg

207a *<srcEview/frbus.package/subs/master.library.prg 207a>*≡
<master library routines 207b>

This code is written to file `srcEview/frbus.package/subs/master.library.prg`.

Defines:

`master.library`, used in chunks 3, 7, 11, 17, 23, 31, 40, 176, and 202.

207b *<master library routines 207b>*≡ (207a)

```

1 *****
2 *****
3 *****
<quarterly date string shift 87>

1 *****
2 *****
3 *****
<copy series into group 88>
1 *****
2 *****
3 *****
<set group to zero 89a>
1 *****
2 *****
3 *****
<names of all series in group 89b>
1 *****
2 *****
3 *****
<create new group 90>
1 *****
2 *****
3 *****
<interpolate unavailable observations 91>
1 *****
2 *****
3 *****
<set fiscal policy option 92>
1 *****
2 *****
3 *****
<set monetary policy option 93>
1 *****
2 *****
3 *****
<set monetary policy fed funds rate 94>

```

6.4.17 `srcEview/frbus.package/subs/mce.solve.library.prg`

208 *<srcEview/frbus.package/subs/mce.solve.library.prg 208>*≡
 <mce solve library 209>

This code is written to file `srcEview/frbus.package/subs/mce.solve.library.prg`.
Defines:

`mce_solve_library`, used in chunks 7, 17, 23, 31, 49, 52, 55, 59, 62, and 176.

209 $\langle mce \text{ solve library } 209 \rangle \equiv$ (208 213b)
 $\langle mce \text{ solve library change history } 95 \rangle$

```
' *****
' *****
' *****
<run model consistent expectations 97>
```

```
' *****
' *****
' *****
<determine endogenous and exogenous variables 104>
```

```
' *****
' *****
' *****
<determine default method, linesearch, and other options 107>
```

```
' *****
' *****
' *****
<parse options containing equal signs 111a>
```

```
' *****
' *****
' *****
<parse options not containing equal signs 111b>
```

```
' *****
' *****
' *****
' *****
<create common variables, strings, matrices, vectors, and tables 112>
```

```
' *****
' *****
' *****
<model consistent coefficient simulation 114>
```

```

'*****
'*****
'*****
<solve model consistent instrument values 123>

```

```

'*****
'*****
'*****
<compute derivatives of mce targets wrt mce instruments 125>

```

```

'*****
'*****
'*****
<model consistent coefficient non-monotone step-length procedure 131>

```

```

'*****
'*****
'*****
<model consistent armijo optimization rule 133>

```

```

'*****
'*****
'*****
<variable terminal values 134>

```

```

'*****
'*****
'*****
<set options based on defaults and overrides 136>

```

```

'*****
'*****
'*****

```


⟨main unconstrained optimal control simulation 143⟩

```

' *****
' *****
' *****
⟨main optimal control simulation with inequality constraints 147⟩

```

```

' *****
' *****
' *****
⟨model consistent optimal time-consistent solution 152⟩

```

```

' *****
' *****
' *****
⟨compute derivatives of loss function targets wrt instruments 160⟩

```

```

' *****
' *****
' *****
⟨solve model consistent expectations model 162⟩

```

```

' *****
' *****
' *****
⟨convert mcz inequality constraints 164⟩

```

```

' *****
' *****
' *****
⟨shift left 167⟩

```

```

' *****
' *****
' *****
⟨find next delimiter 168⟩

```

```

' *****
' *****
' *****
<load frbus with transformed subsidiary model 169>

' *****
' *****
' *****
<create wage and expectation variables in forward looking model 173>

```

6.5 mce solve package

6.5.1 srcEview/mce.solve.package/example1.prg

212a `<srcEview/mce.solve.package/example1.prg 212a>≡`
`<mce example1 49>`

This code is written to file `srcEview/mce.solve.package/example1.prg`.
 Defines:
`example1`, used in chunk 176.

6.5.2 srcEview/mce.solve.package/example2.prg

212b `<srcEview/mce.solve.package/example2.prg 212b>≡`
`<mce example2 52>`

This code is written to file `srcEview/mce.solve.package/example2.prg`.
 Defines:
`example2`, used in chunk 176.

6.5.3 srcEview/mce.solve.package/example3.prg

212c `<srcEview/mce.solve.package/example3.prg 212c>≡`
`<mce example3 55>`

This code is written to file `srcEview/mce.solve.package/example3.prg`.
 Defines:
`example3`, used in chunk 176.

6.5.4 srcEview/mce.solve.package/example4.prg

212d `<srcEview/mce.solve.package/example4.prg 212d>≡`
`<mce example4 59>`

This code is written to file `srcEview/mce.solve.package/example4.prg`.
 Defines:
`example4`, used in chunk 176.

6.5.5 srcEview/mce.solve.package/example5.prg

213a `<srcEview/mce.solve.package/example5.prg 213a>≡`
`<mce example5 62>`

This code is written to file `srcEview/mce.solve.package/example5.prg`.

Defines:

`example5`, used in chunk 176.

6.5.6 srcEview/mce.solve.package/mce.solve.library.prg

213b `<srcEview/mce.solve.package/mce.solve.library.prg 213b>≡`
`<mce solve library 209>`

This code is written to file `srcEview/mce.solve.package/mce.solve.library.prg`.

Defines:

`mce_solve_library`, used in chunks 7, 17, 23, 31, 49, 52, 55, 59, 62, and 176.

6.6 state space package

6.6.1 srcEview/state.space.package/data.transformations.prg

213c `<srcEview/state.space.package/data.transformations.prg 213c>≡`
`<data transformations 71>`

This code is written to file `srcEview/state.space.package/data.transformations.prg`.

Defines:

`data_transformations`, used in chunks 67, 71, 78, and 176.

6.6.2 srcEview/state.space.package/estimation.code.prg

213d `<srcEview/state.space.package/estimation.code.prg 213d>≡`
`<estimation code 74>`

This code is written to file `srcEview/state.space.package/estimation.code.prg`.

Defines:

`estimation_code`, used in chunks 67 and 176.

6.6.3 srcEview/state.space.package/frbus.supply.estimation.prg

213e `<srcEview/state.space.package/frbus.supply.estimation.prg 213e>≡`
`<estimation model 67>`

This code is written to file `srcEview/state.space.package/frbus.supply.estimation.prg`.

Defines:

`frbus_supply_estimation`, used in chunk 176.

6.6.4 `srcEview/state.space.package/frbus.supply.filter.prg`

214a $\langle \textit{srcEview/state.space.package/frbus.supply.filter.prg}$ 214a \equiv
 $\langle \textit{supply filter}$ 78 \rangle

This code is written to file `srcEview/state.space.package/frbus.supply.filter.prg`.
Defines:

`frbus_supply_filter`, used in chunks 78 and 176.

6.6.5 `srcEview/state.space.package/initial.values.prg`

214b $\langle \textit{srcEview/state.space.package/initial.values.prg}$ 214b \equiv
 $\langle \textit{initial values}$ 81 \rangle

This code is written to file `srcEview/state.space.package/initial.values.prg`.
Defines:

`initial_values`, used in chunks 67, 74, and 176.

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6.7 Evview Functions

215 \langle *Presumed Evview Functions* 215 $\rangle \equiv$

Defines:

close, used in chunks 67, 74, 78, 114, and 136.

dbopen, used in chunks 3, 7, 11, 17, 23, 31, 40, 67, 78, and 202.

fetch, used in chunks 3, 7, 11, 17, 23, 31, 40, 67, 78, and 202.

solve, used in chunks 3, 7, 11, 17, 23, 31, 40, 123, 125, 143, 147, 152, 175, and 176.

sspace, used in chunk 74.

wfclose, used in chunk 78.

wfcreate, used in chunks 3, 7, 11, 17, 23, 31, 40, 49, 52, 55, 59, 62, 67, 78, and 202.

wfopen, used in chunk 78.

wfsave, used in chunk 67.

xget, used in chunks 147 and 152.

xrun, used in chunks 147 and 152.

6.8 Series Names

216 \langle Model Data Series Names 216 $\rangle \equiv$

Defines:

ceng, never used.
 d01q4, never used.
 d2002, never used.
 d2003, never used.
 d69, never used.
 d79a, never used.
 d8095, never used.
 d81, never used.
 d83, never used.
 d86, never used.
 d87, never used.
 dcon, never used.
 ddockm, never used.
 ddockx, never used.
 delrff, used in chunk 23.
 deuc, never used.
 dfmpr, never used.
 dfpdbl, used in chunks 23 and 92.
 dfpex, used in chunks 23, 40, and 92.
 dfpsrp, used in chunks 3, 7, 11, 17, 31, and 92.
 dglprd, never used.
 dmpalt, used in chunk 93.
 dmpex, used in chunks 40 and 93.
 dmpgen, used in chunks 17 and 93.
 dmpintay, used in chunks 3, 7, 31, 40, and 93.
 dmprr, used in chunk 93.
 dmpstb, used in chunk 40.
 dmptay, used in chunks 23 and 93.
 dmptlr, used in chunk 93.
 dmptlur, never used.
 dmptmax, never used.
 dmptpi, never used.
 dmpttr, used in chunks 11 and 40.
 dmpttrsh, used in chunks 3, 7, 11, 17, 23, 31, and 40.
 dpadj, never used.
 dpgap, never used.
 drstar, used in chunks 3, 7, 11, 17, 23, 31, and 40.
 ec, used in chunk 74.
 ecd, used in chunk 202.
 ech, never used.
 ecnia, never used.
 ecnian, never used.
 eco, used in chunk 202.
 egf, never used.
 egfi, never used.
 egfin, never used.
 egfit, never used.
 egfl, never used.
 egfln, never used.
 egflt, never used.
 egfn, used in chunk 31.
 egfo, never used.
 egfon, used in chunk 31.

egfot, never used.
egpdin, never used.
egs, never used.
egsi, never used.
egsin, never used.
egsit, never used.
egsl, never used.
egsln, never used.
egslt, never used.
egsn, never used.
egso, never used.
egson, never used.
egsot, never used.
eh, used in chunk 202.
ehn, never used.
ei, never used.
ein, never used.
em, never used.
emn, never used.
emo, used in chunk 202.
emon, used in chunks 67 and 71.
emp, never used.
empn, never used.
empt, never used.
epd, used in chunk 202.
epdn, never used.
epi, used in chunk 202.
epin, never used.
eps, used in chunk 202.
epsn, never used.
ex, used in chunks 67, 78, and 202.
exn, never used.
fcbn, never used.
fcbrn, never used.
fgdp, never used.
fgdpt, never used.
fnicn, never used.
fniln, never used.
fnin, never used.
fnirn, never used.
fpc, never used.
fpcm, never used.
fpi10, never used.
fpi10t, never used.
fpic, never used.
fpitrg, never used.
fpx, never used.
fpxm, never used.
fpxr, used in chunk 31.
fpxrr, never used.
fpxrrt, never used.
frl10, never used.
frs10, never used.
frstar, never used.
ftcin, never used.
fxgap, never used.
fynicn, never used.

fyniln, never used.
 fynin, never used.
 gfdbtn, never used.
 gfdrt, never used.
 gfintn, never used.
 gfs, never used.
 gfsn, never used.
 gfsrpn, never used.
 gfsrt, never used.
 gfsub, never used.
 gfsubn, never used.
 gft, never used.
 gftn, never used.
 gfttrd, never used.
 gfttrt, never used.
 gsdbtn, never used.
 gsdrtr, never used.
 gsintn, never used.
 gssrpn, never used.
 gssrt, never used.
 gssub, never used.
 gssubn, never used.
 gst, never used.
 gstn, never used.
 gstrd, never used.
 gstrtr, never used.
 hgemp, never used.
 hggdp, used in chunk 40.
 hggdpt, never used.
 hgpcdr, never used.
 hgpdr, never used.
 hgpir, never used.
 hgpkir, never used.
 hgppsr, never used.
 hgvpd, never used.
 hgvpi, never used.
 hgvpv, never used.
 hgx, never used.
 hgynid, never used.
 hks, never used.
 hksr, never used.
 hlept, never used.
 hlprdt, never used.
 hmfpt, used in chunks 31, 67, and 78.
 hqlfpr, used in chunks 67 and 78.
 hqlww, used in chunks 67 and 78.
 huqpcr, never used.
 huxb, used in chunks 67 and 78.
 hxbt, never used.
 jccacn, never used.
 jccan, never used.
 jkcd, never used.
 jrcd, never used.
 jrh, never used.
 jrpd, never used.
 jrpi, never used.
 jrps, never used.

jygf~~en~~, never used.
jygf~~gn~~, never used.
jyg~~sen~~, never used.
jyg~~sgn~~, never used.
jync~~n~~, never used.
kcd, never used.
kh, never used.
ki, used in chunk 202.
kpd, never used.
kpi, never used.
kps, never used.
ks, used in chunks 67 and 71.
lef, never used.
left, used in chunks 23, 40, 125, 164, and 202.
leh, never used.
leo, used in chunk 202.
lep, used in chunks 67 and 71.
leppot, used in chunks 67 and 78.
les, never used.
lest, never used.
leuc, never used.
lf, used in chunks 67 and 71.
lfpr, used in chunks 71, 74, and 202.
lhp, used in chunks 67, 71, and 202.
lprdt, never used.
lqualt, used in chunks 67 and 71.
lur, used in chunks 3, 7, 11, 17, 23, 40, 67, 71, and 196a.
lurb~~ls~~, never used.
lurnat, used in chunks 23, 67, and 78.
lurtrsh, used in chunk 11.
lww, used in chunk 202.
mei, never used.
mep, never used.
mfpt, used in chunk 31.
n16, used in chunks 67, 71, and 78.
pcdr, never used.
pceng, never used.
pcengr, used in chunk 202.
pcer, used in chunks 67, 71, and 202.
pcfr, used in chunk 202.
pcf~~rt~~, never used.
pchr, never used.
pcnia, never used.
pcor, never used.
pcpi, never used.
pcpix, never used.
pcstar, never used.
pcxfe, used in chunks 67 and 71.
pgdp, used in chunk 67.
pgfir, never used.
pgfl, never used.
pgfor, never used.
pgsir, never used.
pgsl, never used.
pgsor, never used.
phouse, never used.
phr, never used.

pic4, used in chunks 3, 7, 11, 17, 23, and 196a.
picngr, never used.
picnia, used in chunks 40 and 196a.
picx4, used in chunks 17, 40, and 196a.
picxfe, used in chunks 40, 94, 196a, and 202.
pieci, used in chunk 202.
pigdp, never used.
pipl, never used.
pipxnc, never used.
pitarg, used in chunk 17.
pitrsh, used in chunk 11.
pkir, never used.
pkpdr, never used.
pl, never used.
plmin, never used.
plminr, never used.
pmo, used in chunks 67 and 71.
pmp, never used.
poil, used in chunk 31.
poilr, never used.
poilrt, never used.
ppdr, never used.
ppir, never used.
ppsr, never used.
ptr, used in chunks 17, 67, and 74.
pwstar, never used.
pxb, used in chunks 31, 67, and 71.
pxg, never used.
pxnc, never used.
pxp, never used.
pxr, never used.
qec, never used.
qecd, never used.
qeco, never used.
qeh, never used.
qepd, never used.
qepi, never used.
qeps, never used.
qkir, never used.
qleor, never used.
qlep, never used.
qlf, never used.
qlfpr, used in chunks 67 and 78.
qlhp, never used.
qlww, used in chunks 67 and 78.
qpcnia, never used.
qpl, never used.
qpmo, never used.
qpxg, never used.
qpxnc, never used.
qpxp, never used.
qynidn, never used.
rbbb, never used.
rbbbe, never used.
rbbbp, used in chunk 202.
rcar, used in chunk 202.
rccd, never used.

rcch, never used.
rcgain, used in chunk 202.
req, never used.
reqp, used in chunks 31 and 197.
rff, used in chunks 3, 7, 11, 17, 23, 31, 40, 94, 196a, and 197.
rffalt, used in chunks 11 and 94.
rffe, used in chunks 17, 40, and 94.
rfffix, used in chunk 94.
rffgen, used in chunks 11, 17, and 94.
rffintay, used in chunks 11, 31, 40, and 94.
rffmin, used in chunks 3, 7, 11, 17, 23, 31, and 40.
rffrule, never used.
rfftay, used in chunks 11 and 94.
rfft1r, used in chunks 11 and 94.
rfnict, never used.
rfrs10, never used.
rfynic, never used.
rfynil, never used.
rg10, used in chunks 3, 7, 11, 17, and 23.
rg10e, never used.
rg10p, used in chunks 31 and 202.
rg30, never used.
rg30e, never used.
rg30p, used in chunk 202.
rg5, never used.
rg5e, never used.
rg5p, used in chunk 202.
rgfint, never used.
rgw, never used.
rme, used in chunk 202.
rpd, never used.
rrffe, never used.
rrfix, used in chunk 94.
rrmet, never used.
rrtr, never used.
rspnia, never used.
rstar, never used.
rtb, never used.
rtbe, used in chunk 202.
rtinv, never used.
rtpd, never used.
rtpi, never used.
rtps, never used.
rtr, never used.
t47, never used.
tapdad, never used.
tapdd, never used.
tapddp, never used.
tapds, never used.
tapdt, never used.
tapsad, never used.
tapsda, never used.
tapssl, never used.
tfcin, never used.
tfdiv, never used.
tfibn, never used.
tfpn, never used.

tfsin, never used.
trfci, never used.
trfcim, never used.
trfib, never used.
trfp, never used.
trfpm, never used.
trfpt, never used.
trfptx, never used.
trfsi, never used.
trsci, never used.
trscit, never used.
trsib, never used.
trsibt, never used.
trsp, never used.
trsp, never used.
trsp, never used.
trsppt, never used.
trsppt, never used.
trspptx, never used.
trssi, never used.
trssit, never used.
tryh, never used.
tscin, never used.
tsibn, never used.
tspn, never used.
tssin, never used.
uces, used in chunks 67 and 71.
ucfs, never used.
uemot, never used.
uemp, never used.
ufcbr, never used.
ufnir, never used.
ufpcm, never used.
ufpxm, never used.
uftcin, never used.
ugfdbt, never used.
ugsdbt, never used.
ugsint, never used.
ugssub, never used.
ujcca, never used.
ujccac, never used.
ujygfe, never used.
ujygfg, never used.
ujygse, never used.
ujygsg, never used.
ulef, never used.
ules, never used.
upcpi, never used.
upcpix, never used.
upgfl, never used.
upgsl, never used.
upkpd, never used.
upmp, never used.
upxb, never used.
uqpct, never used.
uveoa, never used.
uvpd, never used.
uvpi, never used.
uvps, never used.

uxbt, used in chunks 67 and 78.
uxeng, never used.
uyd, never used.
uyhi, never used.
uyhln, never used.
uyhptn, never used.
uyhsn, never used.
uyhtn, never used.
uyl, never used.
uyni, never used.
uynicp, never used.
uyp, never used.
uysen, never used.
veo, never used.
veoa, used in chunks 67 and 71.
vpd, never used.
vpi, never used.
vps, never used.
wdnfcn, never used.
wpo, never used.
wpon, never used.
wps, never used.
wpsn, never used.
xb, used in chunks 67 and 71.
xbn, used in chunks 67 and 71.
xbo, never used.
xbt, used in chunks 67 and 78.
xeng, never used.
xfs, never used.
xfsn, never used.
xg, never used.
xgap, used in chunks 3, 7, 11, 17, 23, 31, and 40.
xgap2, used in chunks 17, 40, and 196a.
xgde, never used.
xgden, used in chunks 67 and 71.
xgdi, never used.
xgdin, used in chunks 67 and 71.
xgdo, used in chunks 67 and 78.
xgdp, used in chunks 40, 67, and 71.
xgdpn, used in chunks 31, 67, and 71.
xgdpt, used in chunks 67 and 78.
xgdptn, never used.
xgn, never used.
xgo, never used.
xgpot, never used.
xp, never used.
xpn, never used.
ycsn, never used.
ydn, never used.
ygfsn, never used.
ygssn, never used.
yh, never used.
yhgap, never used.
yhibn, used in chunk 202.
yhin, never used.
yhl, never used.
yhln, never used.

yhp, never used.
yhpcd, never used.
yhpgap, never used.
yhpntn, never used.
yhpshr, never used.
yhptn, never used.
yhshr, never used.
yhsn, never used.
yht, never used.
yhtgap, never used.
yhtn, never used.
yhtshr, never used.
ykin, never used.
ykpdn, never used.
ykpsn, never used.
ymsdn, never used.
ynicpn, never used.
ynidn, used in chunk 202.
yniin, used in chunk 202.
yniln, never used.
ynin, never used.
ynisen, never used.
ypn, never used.
zdivgr, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
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zeh, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
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zpieci, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zrff10, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zrff30, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zrff5, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zvdp, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zvpi, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zvps, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zxbd, used in chunks 7, 17, 23, 31, and 187.
zxbi, used in chunks 7, 17, 31, and 187.
zxbs, used in chunks 7, 17, 31, and 187.
zyh, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zyhp, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zyhpst, never used.
zyhst, never used.
zyht, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.
zyhtst, never used.
zynid, used in chunks 7, 17, 23, 31, 169, 173, 182, and 187.

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