

TIMES-MACRO Extension in ANSWER-TIMES

Introduction

The purpose of this note is to describe the mechanics of using ANSWER-TIMES to work with the TIMES-MACRO Extension.

The documentation for the TIMES-MACRO Extension that is available on the ETSAP website (<http://www.iea-etsap.org/web/Documentation.asp>) as at 31 January 2013 comprises:

- “Documentation of the TIMES-MACRO model, Draft Version” (authors Uwe Remme, Markus Blesl, February 1, 2006), which can be downloaded from the ETSAP website as *MACRO_Draft_010206.pdf*.
- ***Significant enhancements to TIMES-MACRO were completed by Antti Lehtila in December 2012. As at 31 January 2013 the ETSAP documentation available for TIMES-MACRO that is available for download from the ETSAP website is incomplete, and does not document the recent enhancements to TIMES-MACRO: it is expected that documentation of the recent enhancements will be available soon.***

In this documentation, the demonstration ANSWER-TIMES database ***TIMES-MACRO-DEMO.mdb*** is used to provide concrete examples illustrating how to work with the TIMES-MACRO Extension.

TIMES-MACRO Extension in ANSWER-TIMES - Overview

Assuming that you already have a Basic TIMES model, the following steps are required when working with the TIMES-MACRO Extension:

1. Specify **MACRO Data Parameters** in a non-BASE scenario.
2. Carry out a **MACRO Calibration Run**. (This Calibration run involves an iterative procedure that requires both an LP and an NLP solver.)
3. Create a non-BASE scenario specifying a **Policy Option** that you wish to investigate with MACRO.
4. Carry out a **MACRO Policy Run** to investigate the effect of the policy option. Two alternate MACRO Policy Run options are available:
 - A. The newly developed **MSA** MACRO Policy Run option. (This option involves an iterative procedure that requires both an LP and an NLP solver.)
 - B. The older **Standard** MACRO Policy Run option. (This option involves a single NLP run.)
5. Examine the **Results of the MACRO Policy Run** with special attention to the new MACRO Results Parameters.

The table on the following page provides an overview of the steps that are required when working with the TIMES-MACRO Extension, made specific by referring to scenarios and model runs in the demonstration database ***TIMES-MACRO-DEMO.mdb***:

Steps Required when working with TIMES-MACRO Extension	Scenarios in Demonstration Database	Demonstration Database Model Run, Run Scenarios, MACRO Option Button Selected
Specify a Basic TIMES model (to which you wish to add the TIMES-MACRO Extension).	Basic TIMES model is specified in the BASE scenario. (You might prefer to specify your Basic TIMES model across several scenarios.)	Model run BASIC-MODEL , Scenario BASE , Option button <input checked="" type="radio"/> No MACRO
1. Specify MACRO Data Parameters in a non-BASE scenario.	MACRO data parameters are specified in MACRO-PARAMS scenario.	
2. Carry out a MACRO Calibration Run .		MACRO Calibration run MACRO-CALIB , Scenarios BASE + MACRO-PARAMS , Option button <input checked="" type="radio"/> MACRO Calibration
3. Specify a policy option to be investigated with MACRO in a non-BASE scenario.	Policy option is specified in MACRO-POLICY scenario. (It is a bound on CO2 emissions.)	
4A. Carry out an MSA MACRO Policy Run . (Or instead carry out step 4B.)		MSA MACRO Policy Run MACRO-POL-MSA , Scenarios BASE + MACRO-PARAMS + MACRO-POLICY , Option button <input checked="" type="radio"/> Policy Run (MACRO MSA)
4B. Carry out a Standard MACRO Policy Run . (Or instead carry out step 4A.)		Standard MACRO Policy Run MACRO-POL-STD , Scenarios BASE + MACRO-PARAMS + MACRO-POLICY , Option button <input checked="" type="radio"/> Policy Run (Standard MACRO)
5. Examine the Results of the MACRO Policy Run with special attention to the new MACRO Results Parameters		(Examine Results for MSA or Standard MACRO Policy Run, as appropriate.)

1. Specifying TIMES-MACRO Data Parameters in ANSWER-TIMES

The TIMES-MACRO Extension involves 16 Data Parameters, as follows:

TIMES-MACRO Data Parameter and Arguments	Description
TM_ARBM	Multiplier for last period length
TM_DDF(REG,COM,ALLYEAR)	Demand decoupling factor
TM_DEPR(REG)	Depreciation rate
TM_DMTOL(REG)	Demand lower bound factor
TM_ESUB(REG)	Elasticity of substitution
TM_EXPBND(REG,PRC,ALLYEAR)	Market Penetration Cutoff for Applying Cost Penalty
TM_EXPF(REG)	Annual percent expansion factor
TM_GDP0(REG)	GDP in the first period
TM_GR(REG,ALLYEAR)	MACRO projected annual GDP growth
TM_IVETOL(REG)	Investment and energy tolerance
TM_KGDP(REG)	Initial capital to GDP ratio
TM_KPVS(REG)	Capital value share
TM_QFAC(REG)	Switch for market penetration penalty function
TM_SCALE_CST	Scaling factor for cost units
TM_SCALE_NRG	Scaling factor for demand units
TM_SCALE_UTIL	Scaling factor for utility function

Notes

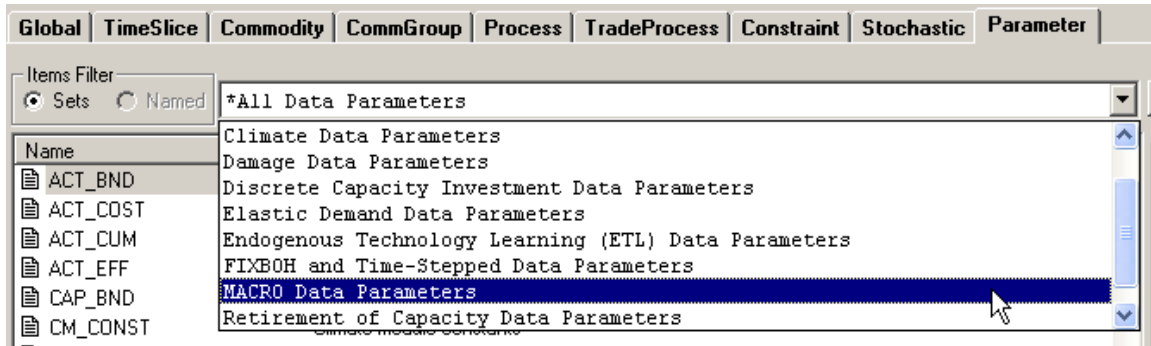
1. REG = internal region, COM = commodity, PRC = process, ALLYEAR = year
2. In the TIMES GAMS code, the order of arguments for TM_DDF is REG,ALLYEAR,COM.
3. In the TIMES GAMS code, the order of arguments for TM_EXPBND is REG,ALLYEAR,PRC.

All TIMES-MACRO Data Parameters may be specified on the Parameter tab, which is the most convenient place to specify them (see below).

- The TM_DDF and TM_EXPBND parameters may also be specified on the Commodity and Process tabs respectively.
- All MACRO parameters whose arguments are REG or REG,ALLYEAR may also be specified on the Global tab by selecting the specific region <REG> in the Regions listview.
- The scalar MACRO parameters TM_ARBM, TM_SCALE_CST, TM_SCALE_NRG, TM_SCALE_UTIL may also be specified on the Global tab by selecting the special _GLOBAL region in the Regions listview.

Parameter Tab

The Parameter tab offers the convenience of being able to see all instances of TIMES-MACRO parameters in the database (for the currently selected scenarios) and also provides a convenient way of adding these parameters. On the Parameter tab, drop down the long combobox, and select the **MACRO Data Parameters** setting:





This provides the convenience of displaying just those Data Parameters that are specific to the TIMES-MACRO Extension:

Name	Description	Status
TM_ARBM	Multiplier for last period length	M
TM_DDF	Demand decoupling factor	
TM_DEPR	Depreciation rate	M
TM_DMTOL	Demand lower bound factor	
TM_ESUB	Elasticity of substitution	M
TM_EXPBND	Market Penetration Cutoff for Applying Cost Penalty	
TM_EXPF	Annual percent expansion factor	
TM_GDPO	GDP in the first period	M
TM_GR	MACRO projected annual GDP growth	M
TM_IVETOL	Investment and energy tolerance	M
TM_KGDP	Initial capital to GDP ratio	M
TM_KPVS	Capital value share	M
TM_QFAC	Switch for market penetration penalty function	
TM_SCALE_CST	Scaling factor cost units	M
TM_SCALE_NRG	Scaling factor demand units	
TM_SCALE_UTIL	Scaling factor utility function	

Now use the AddRow facility to specify MACRO Data Parameter instances as required.

For the demonstration ANSWER-TIMES database ***TIMES-MACRO-DEMO.mdb***:

- If you make non-BASE scenario **MACRO-PARAMS** the editable scenario, move to the Parameter tab, select the MACRO Data Parameters setting and click on the  button (and change the setting to ) , you will see displayed all of the MACRO Data Parameter instances in the **MACRO-PARAMS** scenario:

Global TimeSlice Commodity CommGroup Process TradeProcess Constraint Stochastic Parameter

Items Filter: Sets Named MACRO Data Parameters Sets Filter... Named Filter...

Name	Description	Status
TM_ARBM	Multiplier for last period length	M
TM_DDF	Demand decoupling factor	
TM_DEPR	Depreciation rate	M
TM_DMTOL	Demand lower bound factor	
TM_ESUB	Elasticity of substitution	M
TM_EXPBND	Market Penetration Cutoff for Applying Cost Penalty	
TM_EXPF	Annual percent expansion factor	
TM_GDP0	GDP in the first period	M
TM_GR	MACRO projected annual GDP growth	M
TM_IVETOL	Investment and energy tolerance	M
TM_KGDP	Initial capital to GDP ratio	M
TM_KPVS	Capital value share	M
TM_QFAC	Switch for market penetration penalty function	
TM_SCALE_CST	Scaling factor cost units	M

Item Management: All 16 items selected Sets? New... Copy... Delete Browse Select All Items Move... RES

TS, TID data

Scenario	Parameter	Region	Process	Commo	I/E	1990	2000	2010	2020
M	MACRO-PARAMS	TM_GR	? REG	-	0	2.5000	2.2500	2.0000	1.7500
Add	MACRO-PARAMS		?						

Scenario	Parameter	Region	Value
M	MACRO-PARAMS	TM_ARBM	? _GLOBAL 1.0000
M	MACRO-PARAMS	TM_DEPR	? REG 5.0000
M	MACRO-PARAMS	TM_ESUB	? REG 0.2500
M	MACRO-PARAMS	TM_GDP0	? REG 8,629.7000
M	MACRO-PARAMS	TM_IVETOL	? REG 0.5000
M	MACRO-PARAMS	TM_KGDP	? REG 2.5000
M	MACRO-PARAMS	TM_KPVS	? REG 0.2500
M	MACRO-PARAMS	TM_SCALE_CST	? _GLOBAL 0.001000
Add	MACRO-PARAMS		?

2. Carrying out an ANSWER-TIMES MACRO Calibration Model Run

To carry out an ANSWER-TIMES **MACRO Calibration** model run:

- Invoke Run Model to display the Run Model form and use the **Change Run...** button to select a run of your Basic TIMES model (if your Basic TIMES model is specified in several scenarios this has the advantage of populating the **Scenarios comprising this run:** listview with all of these scenarios), and change the run Name (and Description), e.g. perhaps change the run Name to **MACRO-CALIB**.
- Click on the **Specify Model Variant...** button to display the Model Variant Specification form.

- On the Model Variant Specification form select the MACRO Calibration option button:

Model Variant and Objective Function Specification

TIMES Model Variants and Objective Function Options for Case 'MACRO-CALIB' are displayed in Edit mode.

Model Variants

No Elastic Demand Save Base Prices for Elastic Demand Elastic Demand (Reading Base Prices)

Climate

No Damages in Objective Damages in Objective LP Damages in Objective NLP

Discrete Capacity Investment

No Capacity Retirement Continuous Capacity Retirement Discrete Capacity Retirement

Endogenous Technology Learning (ETL)

No MACRO **MACRO Calibration** Policy Run (MACRO MSA) Policy Run (Standard MACRO)

No Stochastic/Tradeoff Stochastic Tradeoff/Sensitivity Analysis

Fix Initial Periods (FIXBOH) Fix Up To: Restart GD&X File:

Time-Stepped Solve TimeStep: Overlap:

Objective Function Options

OBJ Formulations: AUTO STD MOD ALT LIN

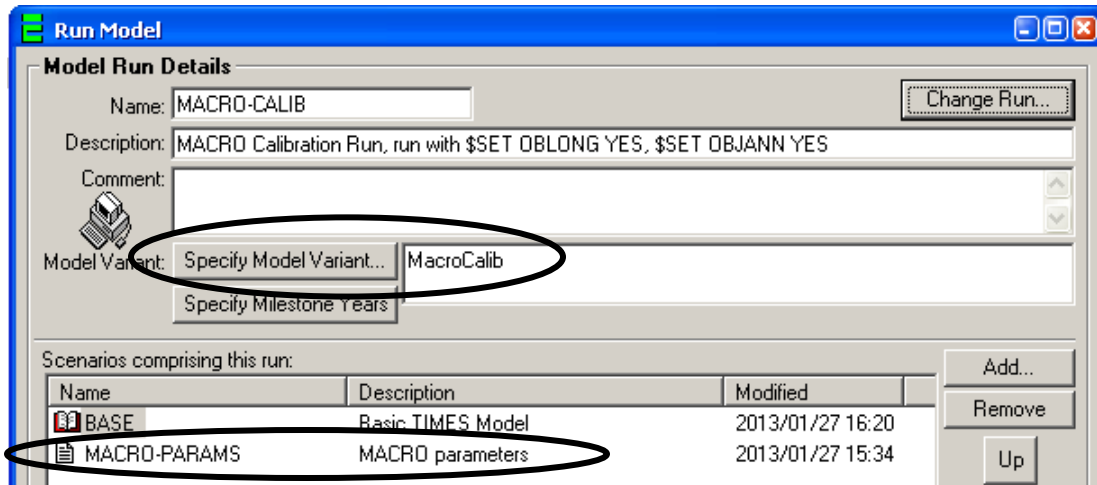
Discounting: Start of Year Middle of Year End of Year

Optimizer: Model Variant Description:

- Click the [OK] button on the Model Variant Specification form to return to the Run Model form.
- Use the button to add the non-BASE scenario containing MACRO Data Parameters to the **Scenarios comprising this run:** listview, e.g. add scenario **MACRO-PARAMS** if this was the scenario name that you used at step 1 above.
- Click the [OK] button on the Run Model form to initiate a MACRO Calibration model run that will determine calibrated values for assorted MACRO parameters and write them to file **MSADDF.DD** in the GAMS Work folder (from where they can subsequently be used for a Macro Policy run).

For the demonstration database **TIMES-MACRO-DEMO.mdb** if you invoke Run Model and use the button on the Run Model form to select Run **MACRO-CALIB**, what you will

see is the same as if you had selected the Basic TIMES model Run **BASIC-MODEL** and then carried out the steps specified in the 5 dot points above:



The textbox displaying **MacroCalib** indicates in ANSWER-TIMES that the model run will be a **MACRO Calibration** run.

You should carry out Run Model for Case **MACRO-CALIB** so that file **MSADDF.DD** containing calibrated values for assorted MACRO parameters (subsequently to be used for a Macro Policy run) is created in sub-folder *Gams_WrkTI* on your PC. You might like to check that:

- ANSWER-TIMES has inserted the line **\$SET MACRO 'CSA'** in the GEN file that controls the TIMES GAMS model run by opening the file MACRO-CALIB.GEN with a text editor; and
- File **MSADDF.DD** has been created in sub-folder *Gams_WrkTI* on your computer.

3. Specify a policy option to be investigated with MACRO in a non-BASE scenario

Before carrying out a meaningful **MACRO Policy Run** model run, it is necessary to add a “policy measure” (such as an emissions constraint) to the model, in addition to specifying MACRO Data Parameter instances.

For the demonstration database **TIMES-MACRO-DEMO.mdb**:

- In non-BASE scenario **MACRO-POLICY**, the “policy measure” is provided by using the COM_BNDNET data parameter to add a CO2 emissions constraint in the periods 2010 and 2020, as follows:

Scenario	Parameter	Region	Commo	TimeSlic	Limit	I/E	1990	2000	2010	2020
M	MACRO-POLICY	COM_BNDNET	REG	CO2	ANNUAL	UP	5		1,500,000.0000	1,100,000.0000
Add	MACRO-POLICY	COM_BNDNET	?				0			

4A. Carrying out an ANSWER-TIMES MACRO MSA Policy Model Run

To carry out an ANSWER-TIMES **MACRO MSA Policy** model run:

- Invoke Run Model to display the Run Model form and use the **Change Run...** button to select your MACRO Calibration model run, and change the run Name (and Description), e.g. perhaps change the run Name to **MACRO-POL-MSA**.
- Click on the **Specify Model Variant...** button to display the Model Variant Specification form.
- On the Model Variant Specification form select the **Policy Run (MACRO MSA)** option button:

Model Variant and Objective Function Specification

TIMES Model Variants and Objective Function Options for Case 'MACRO-POL-MSA' are displayed in Edit mode.

Model Variants

No Elastic Demand Save Base Prices for Elastic Demand Elastic Demand (Reading Base Prices)

Climate

No Damages in Objective Damages in Objective LP Damages in Objective NLP

Discrete Capacity Investment

No Capacity Retirement Continuous Capacity Retirement Discrete Capacity Retirement

Endogenous Technology Learning (ETL)

No MACRO MACRO Calibration Policy Run (MACRO MSA) Policy Run (Standard MACRO)

No Stochastic/Tradeoff Stochastic Tradeoff/Sensitivity Analysis

Fix Initial Periods (FIXBOH) Fix Up To: Restart GDx File:

Time-Stepped Solve TimeStep: Overlap:

Objective Function Options

OBJ Formulations: AUTO STD MOD ALT LIN

Discounting: Start of Year Middle of Year End of Year

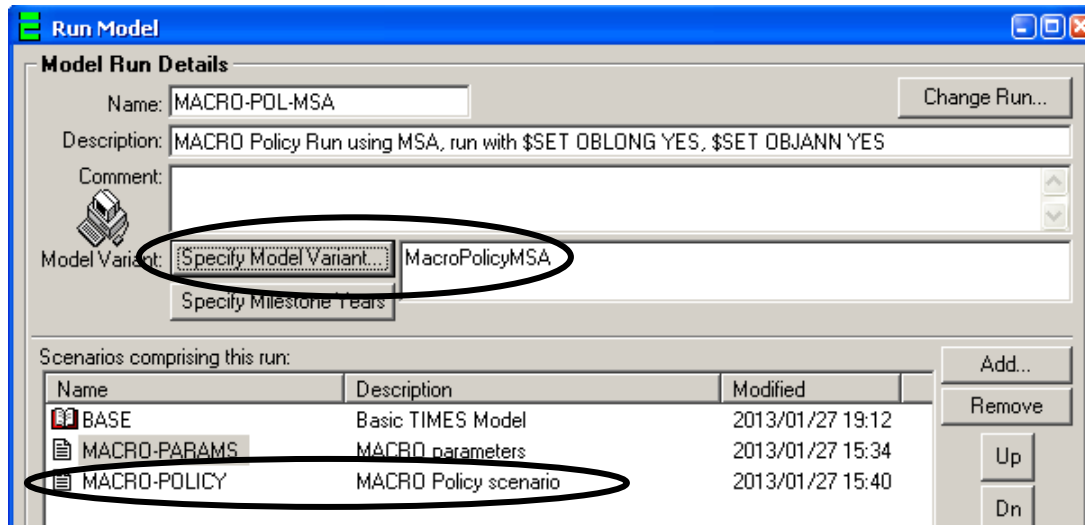
Optimizer: LP + NLP

Model Variant Description: MacroPolicyMSA

- Click the [OK] button on the Model Variant Specification form to return to the Run Model form.

- Use the **Add...** button to add the non-BASE scenario containing a policy option to the **Scenarios comprising this run:** listview, e.g. add scenario **MACRO-POLICY** if this was the scenario name that you used at step 3 above.
- Click the [OK] button on the Run Model form to initiate a MACRO MSA Policy model run.

For the demonstration database **TIMES-MACRO-DEMO.mdb** if you invoke Run Model and use the **Change Run...** button on the Run Model form to select Run **MACRO-POL-MSA**, what you will see is the same as if you had selected the MACRO Calibration model run **MACRO-CALIB** and then carried out the steps specified in the 5 dot points above:



The textbox displaying **MacroPolicyMSA** indicates in ANSWER-TIMES that the model run will be a **MACRO MSA Policy** run.

You should carry out Run Model for Case **MACRO-POL-MSA** on your PC. You might like to check that:

- ANSWER-TIMES has inserted the line **\$SET MACRO 'MSA'** in the GEN file that controls the TIMES GAMS model run by opening the file MACRO-POL-MSA.GEN with a text editor.

4B. Carrying out an ANSWER-TIMES Standard MACRO Policy Model Run

To carry out an ANSWER-TIMES **Standard MACRO Policy** model run proceed exactly similarly to 4a above, but perhaps change the run Name to **MACRO-POL-STD** and on the Model Variant

Specification form select the **Policy Run (Standard MACRO)** option button.

- ANSWER-TIMES will insert the line **\$SET MACRO 'YES'** in the GEN file that controls the TIMES GAMS model run.

5. Examining the Results of the MACRO Policy Run with special attention to the new MACRO Results Parameters

The TIMES-MACRO Extension involves 7 new Results Parameters, as follows:

TIMES-MACRO Results Parameter and Arguments	Description
TM_CONSUMPTION(REG,ALLYEAR)	Annual MACRO consumption by period
TM_ENERGYCOSTS(REG,ALLYEAR)	Annual energy system costs by period
TM_GDP-ACT(REG,ALLYEAR)	Actualized gross domestic product by period
TM_GDP-LOSS(REG,ALLYEAR)	Percentage GDP loss by period, compared to baseline (policy runs only)
TM_GDP-REF(REG,ALLYEAR)	Reference gross domestic product by period for baseline
TM_INVESTMENT (REG,ALLYEAR)	Annual MACRO investments by period
TM_PRODUCTION(REG,ALLYEAR)	Annual MACRO production by period

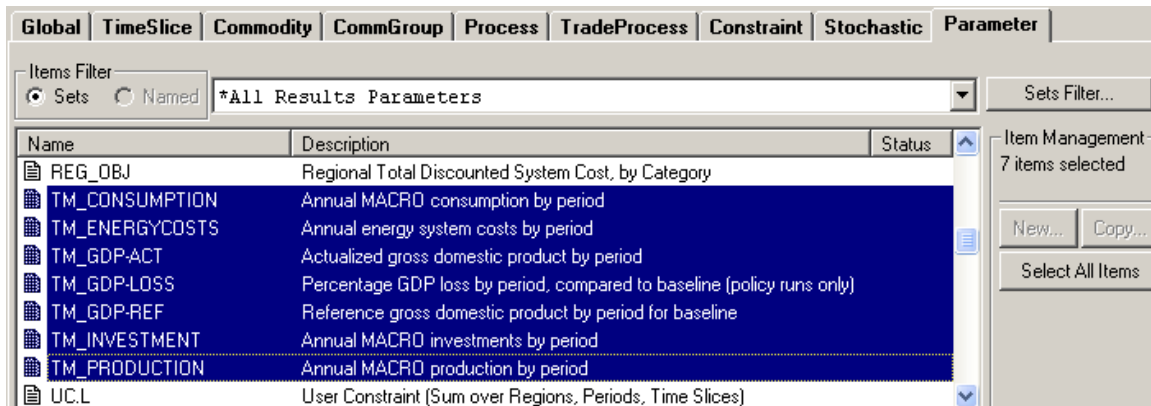
Notes

1. REG = internal region, ALLYEAR = year
2. Every MACRO Results Parameter is a TS Results Parameter; there are no TID MACRO Results Parameters.

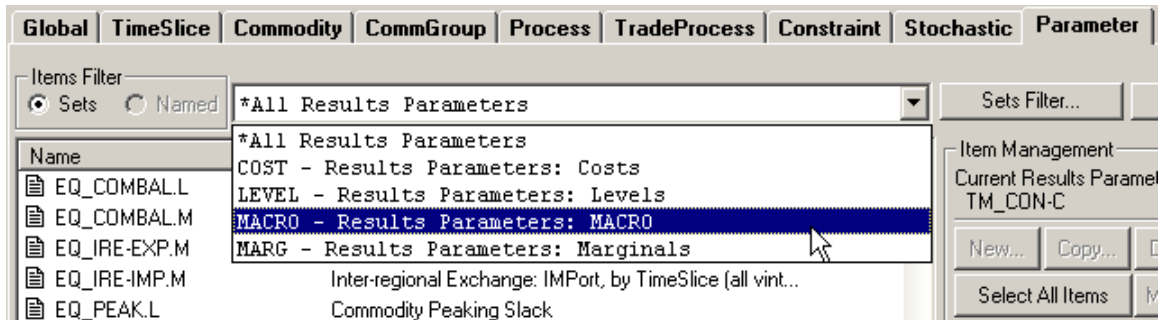
Parameter Tab – Examining the new MACRO Results Parameters

The new MACRO Results Parameters are displayed only on the Parameter tab. There are two ways of proceeding:

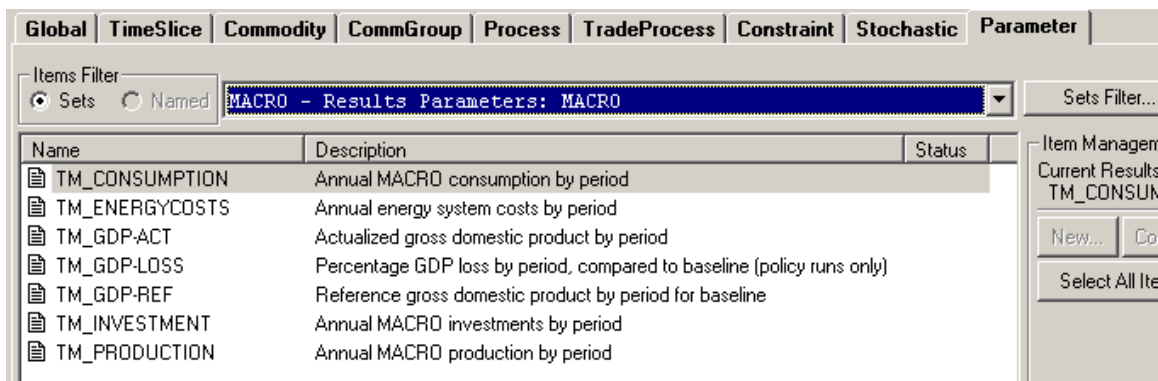
- Either use the setting for the long combobox and take advantage of the fact that all the MACRO Results Parameters are adjacent (since their names all begin with TM_) to multi-select them:



- Or drop down the long combobox, and select the **MACRO - Results Parameters** setting:



This provides the convenience of displaying just those Results Parameters that are specific to the TIMES-MACRO Extension:



Now use the  button to multi-select all of the MACRO Results Parameters.

Whichever of the two alternate approaches above is adopted, the end result is that the TS spread will display all of the MACRO Results Parameters (for each of the currently selected Cases that involves either a MACRO Calibration or a MACRO Policy Run).

- For the demonstration ANSWER-TIMES database **TIMES-MACRO-DEMO.mdb** the MACRO Results Parameter instances that are displayed in the TS spread when the selected Cases are BASIC-MODEL, MACRO-CALIB, MACRO-POL-MSA and MACRO-POL-STD are as follows:

				IS data			
Case	Parameter	Region		1990	2000	2010	2020
MACRO-CALIB	TM_CONSUMPTION	? REG		7,098.0190	8,741.1330	12,802.9300	14,732.2400
MACRO-POL-MSA	TM_CONSUMPTION	? REG		7,098.0190	8,743.6610	12,822.8900	14,605.8700
MACRO-POL-STD	TM_CONSUMPTION	? REG		7,098.0190	8,743.5350	12,823.1100	14,605.9300
MACRO-CALIB	TM_ENERGYCOSTS	? REG		677.8276	701.5594	754.4224	838.4441
MACRO-POL-MSA	TM_ENERGYCOSTS	? REG		677.8276	699.1139	733.5906	788.5932
MACRO-POL-STD	TM_ENERGYCOSTS	? REG		677.8276	699.5177	733.1368	789.3651
MACRO-CALIB	TM_GDP-ACT	? REG		8,629.7000	11,046.7500	13,799.6300	16,821.6700
MACRO-POL-MSA	TM_GDP-ACT	? REG		8,629.7000	11,043.6700	13,737.6100	16,643.2400
MACRO-POL-STD	TM_GDP-ACT	? REG		8,629.7000	11,043.8500	13,737.8200	16,643.4100
MACRO-POL-MSA	TM_GDP-LOSS	? REG		0.0000	0.0278	0.4495	1.0607
MACRO-POL-STD	TM_GDP-LOSS	? REG		0.0000	0.0262	0.4479	1.0597
MACRO-CALIB	TM_GDP-REF	? REG		8,629.7000	11,046.7500	13,799.6300	16,821.6800
MACRO-POL-MSA	TM_GDP-REF	? REG		8,629.7000	11,046.7500	13,799.6300	16,821.6800
MACRO-POL-STD	TM_GDP-REF	? REG		8,629.7000	11,046.7500	13,799.6300	16,821.6800
MACRO-CALIB	TM_INVESTMENT	? REG		1,531.6810	2,305.6210	996.7006	2,089.4340
MACRO-POL-MSA	TM_INVESTMENT	? REG		1,531.6810	2,300.0100	914.7150	2,037.3700
MACRO-POL-STD	TM_INVESTMENT	? REG		1,531.6810	2,300.3180	914.7124	2,037.4810
MACRO-CALIB	TM_PRODUCTION	? REG		9,307.5270	11,748.3100	14,554.0500	17,660.1200
MACRO-POL-MSA	TM_PRODUCTION	? REG		9,307.5270	11,742.7900	14,471.2000	17,431.8300
MACRO-POL-STD	TM_PRODUCTION	? REG		9,307.5270	11,743.3700	14,470.9600	17,432.7800

There are no MACRO Results Parameter instances for Case BASIC-MODEL because it does not involve a MACRO run. Also there is no TM_GDP-LOSS Results Parameter instance for Case MACRO-CALIB because this MACRO Results Parameter is created only for MACRO policy runs (MACRO-POL-MSA and MACRO-POL-STD), and is not created for MACRO calibration runs.