Building and Solving Macroeconomic Models using WinSolve:
Forecasting and Simulation[*]

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1 Introduction

This tutorial illustrates forecasting and simulation of a model using *Win-Solve*. It makes use of a small quarterly model of the Philippines developed by the *Asian Development Bank* (*ADB*) and described in Cagas *et al.* (2006). Section 2 presents the model and uses it to produce a forecast over the period 2005:4 to 2010:4. Section 3 conducts two simulations with the model: an oil proice shock and a hypothetical experiment in which the Philippine government tackles the budget deficit problem by reducing government expenditure and/or increasing tax collection.

2 Forecasting with the Philippines model

In this tutorial we look at a small model of the Philippinnes, built by the *Asian Development Bank* and described in Cagas *et al.* (2006). The model was developed using the equilibrium correction methodology (*ECM*) due originally to Sargan (1964) but popularised by Hendry (1995) and (2002). In this methodology, sensible long-run properties are imposed on the model equations (although restrictions are data-permissible) while allowing short-run dynamics to be freely estimated from the data. Most equations in the

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model are demand-oriented, especially in the short run, but several of the long run equilibrium relationships represent supply-side equations. Since the fiscal sector is one of the most crucial in the Philippine economy, this is treated in detail and is well integrated with the other sectors. The model consists of eight blocks: private consumption, investment, government, trade, production, prices, monetary and labour sectors. There are 48 behavioural and technical equations, 17 identities, and 81 variables. In the private consumption block, real private consumption in the long run is a homogeneous function of income and wealth and is also affected by the deposit rate and the unemployment rate. Real investment has a long run unit elasticity with respect to gross domestic product and in the short run is also influenced by changes in the real domestic lending rate and the total government debt to GDP ratio (proxying risk). Central government debt is modelled as two separate components: foreign debt and domestic debt. In the long run, the change in both domestic and foreign debt is a linear function of the government deficit. In the short run the acceleration of domestic debt depends on changes in the government debt and in the 91 day Treasury bill rate while the acceleration of foreign debt depends on changes to the US lending rate, the interest differential between domestic and US lending rates and the exchange rate. Imports in the long run are a homogeneous function of domestic demand and external demand while also depending on relative prices between domestic and foreign products. Exports are a function of world trade. Primary sector output is a function of the weather (the rainfall index) and the sum of output of the secondary and tertiary sectors. Secondary sector output is formulated in the long run as a homogeneous production function and in the short run is also influenced by changes in private consumption, the share of exports to GDP and relative deflators among sectors. Tertiary sector real output depends on real GNP and relative deflators. The GDP deflator is a function of the deflators of expenditure side components. The consumer price index (CPI) is modelled in the long run as a homogeneous function of the delators of the secondary and tertiary sectors and the narrow money (M1) to GDP ratio. In the short run, changes in the CPI depend on changes in the delators of the three sectors and the import price index. M1 follows a money demand function with long-run unit elasticity with respect to GNP and also depends on the overnight borrowing rate. This interest rate depends on past inflation rates and the US interest rate, following a Taylor rule. Other interest rates depend on the overnight borrowing rate and the depreciation rate of the domestic currency. The labour force is a linear function of population but also is influenced by the share of the employed in the population. In the short run, employment growth affects labour force growth. In the long run, total employment is a homogeneous function of real output and also

depends on the real wage and the share of the primary sector in total GDP. In the short run, employment growth is affected by primary sector output growth and changes in the share of primary and tertiary sectors in total GDP. Employment in the secondary sector is modelled by a factor demand relationship in terms of secondary sector output and the wage rate. In the short run, changes in the secondary sector deflator and the share of the primary sector in total employment also matter. Employment in the tertiary sector is linear with respect to secondary and tertiary sector output and also depends on the real wage rate.

2.1   Opening the model
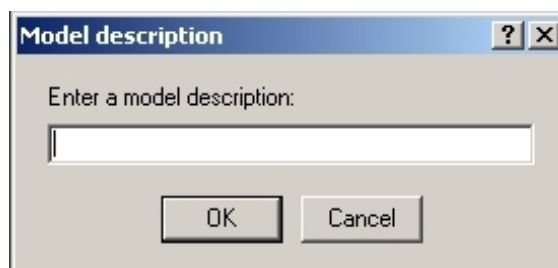
Figure 1: Model description box

Figure 2: The model object

The first step is to open the file that contains the definition of the model equations. Click on the open a model icon or select the *Open model* option from the *File* menu. A dialog box opens to allow you to select a model. Select the file *phi model-Nov_ 2005.txt*, and click *OK*. A dialog box will be displayed, Figure 1, allowing you the opportunity to enter a description to give the model. You can type anything here or choose to leave the description blank. Click the *OK* button to exit. A new window will appear on the

desktop representing the model object (Figure 2). The icon in this window is a link to the model equations and double clicking the icon will open an editor to view the equations.

2.2   Viewing the model equations

Double click on the *phi model-Nov_2005.txt* icon in the model object window. This will open the editor you have set up to view files with suffix TXT. The first few lines of the file will look something like Figure 3.

```
@WinSolve code

@ PHI MODEL FOR 2005 ADO Conference

@ ====================== Income & Consumption ========================

@ Private Consumption in constant price (demand function)

*M dlog(PCONc_PHI) = 0.1227 - 0.2611*seas(1) - 0.0474*seas(2)
      - 0.1168*seas(3) + 0.0906*(NFIA_PHI/GNP_PHI)
      - 0.0634*( log(PCONc_PHI(-1)) - 0.8*log( GNPc_PHI(-1)
      - GTAX_PHI(-1)/(GNP_PHI(-1)/GNPc_PHI(-1)) )
      - 0.2*log(( DDEBT_PHI(-2) + MO_PHI(-2) + NFA_PHI(-2))/P#C_PHI(-2))
       + 0.05*( 0.5*( UEMP%_PHI + UEMP%_PHI(-1) ) )
      + 0.005*( IRD%_PHI(-1) - 100*d4log(P#C_PHI(-1)) ) );

@Private Consumption in current price via deflator

*M d4log(PCON_PHI) = d4log(PCONc_PHI) + 0.978* d4log(P#C_PHI)
      + 0.0249* dlog(P#M_PHI(-1)) - 0.033446 * d4log(P#M_PHI)
      - 0.164* ( log(PCON_PHI(-4)/PCONc_PHI(-4))
      - 0.86 * log(P#C_PHI(-4)) - 0.07 * log(P#M_PHI(-5)));
```

Figure 3: A section of model code from the Philippine model

These lines define the equations for the variables *PCONc_PHI* (private consumption in constant prices) and *PCON_PHI* (private consumption in current prices). In this model, the variable name convention is generally followed of using a country suffix *_PHI* to indicate The Philippines and a lower-case suffix *c* to indicate a constant price (as opposed to current price) variable. Note the use in the first equation of the *WinSolve* functions *dlog*, *d4log* and the seasonal dummy function *seas*. The **M* code before the start of
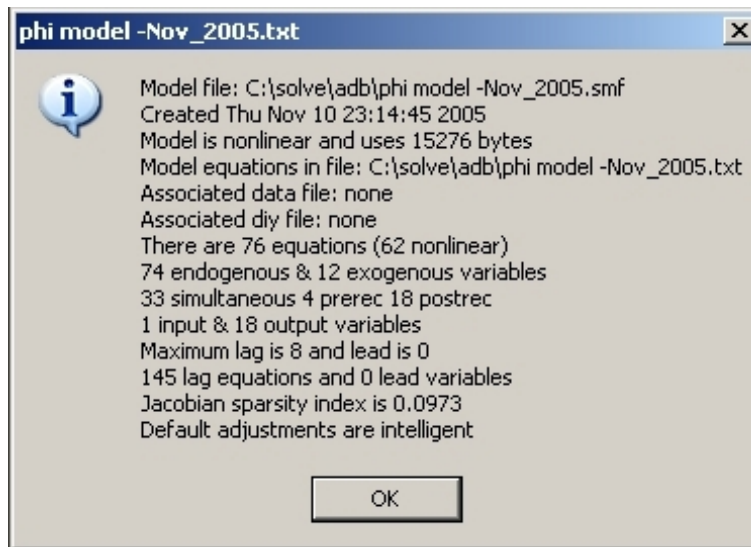
Figure 4: Model information box

each equation indicates that both these equations are to have multiplicative adjustments. This is appropriate given their log-linear form.

If any changes are made to the model equations while in the editor and the file then saved, *WinSolve* will automatically recompile the model equations to incorporate the changes. In this case, when you have finished looking at the model equations, simply close the editor without saving and return to *WinSolve.*

You can find out some of the properties of the model by clicking on the *i* icon or selecting the *Model info* option from the *File* menu. This opens an information box as in Figure 4. You will see that the model has 76 equations with 74 endogenous variables and 12 exogenous variables, with a maximum lead on any equation of 0 and a maximum lag of 8. It uses 15276 bytes of storage. The fact that the maximum lead is zero reflects the fact that this model contains no forward-looking expectations. Why does the model have more equations than endogenous variables? This is because there are two variables in the model (*GPAY_PHI* and *GTAX_PHI*) for which there are two alternative equations. In both cases, the first of the two equations is the forecasting equation and this is used by default. The second equation will be ignored for now although later it will be used in a simulation exercise to be discussed below. Click the *OK* button to exit.

More information about the relationship betwen the model variables can be found from the *View Variable information* dialog box on the *Assump-*
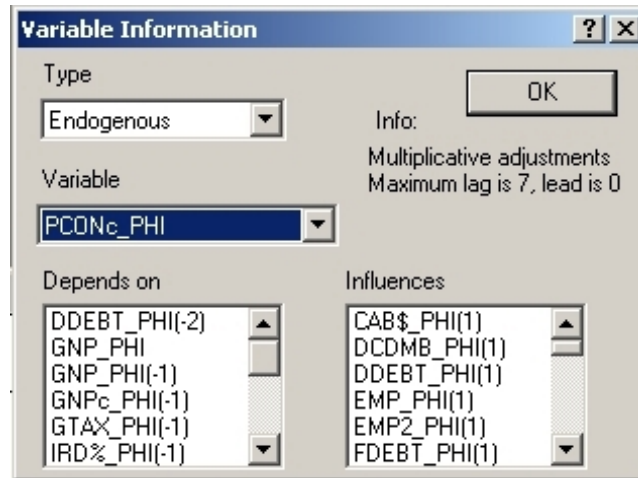
Figure 5: Variable information box

tions menu. Selecting the endogenous variable *PCONc_PHI* in this dialog box displays the information in Figure 5. This shows that the variable has multiplicative adjustments and appears in the model with a maximum lag of 7 periods. The *Depends on* box lists all the variables that appear on the right-hand side of the equation for *PCONc_PHI* and, therefore, on which it depends. The *Influences* box lists all the other equations in which the variable *PCONc_PHI* appears. A *(1)* in brackets indicates that, for example, employment (*EMP_PHI*) is only influenced by consumption after one period, because consumption appears in the employment equation with a one-period lag. By examining the information in this box, the complicated inter-relationships between model equations can be explored.

2.3 Adding Data

Before any forecast can be made with the model, we need to add a data set. This will define the maximum forecast period for the model and provide observations on the 12 exogenous variables, plus initial values for lagged endogenous variables. In this case, we have a data set in Excel spreadsheet format, *phi_data_Nov2005.xls*. Click on the (green) *open a data file* icon or select the *Open data file* option from the *Data* menu. A dialog box opens to allow a data file to be selected. Select the file *phi_data_Nov2005.xls* and click *OK.* to open the file.

The data file contains quarterly data on all model variables up to 2004:4 plus data on some endogenous variables up to 2005:3 and projections for

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the exogenous variables up to 2010:4. The fact that there is data for 2005:3 only for some variables illustrates the *ragged edge* typical of a forecast data set. Where data is not available, the model equation will be used to make a forecast, but where data is available, we will want to use this data observation instead of the model equation. *WinSolve* will do this automatically by allowing data to have precedence over the model equations. (This is the default option for an incomplete data set).
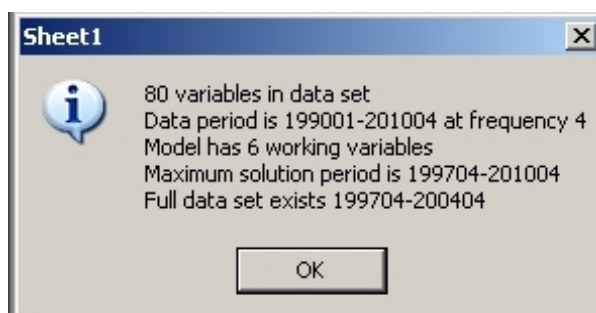

Figure 6: Data information box

Information about the data set may be displayed by selecting the *Data info* option on the *Data* menu or clicking on the (green) *data info* icon . A box appears with information about the data set, Figure 6. A box appears with information about the data set, Figure 6. Note that full data exists from 1997:4 to 2004:4 and that the maximum solution (forecast) period is from 1997:4 to 2010:4. There are 6 working variables. These are variables for which no data has been provided but for which no data is needed.

Notice that several new icons on the toolbar are now ungreyed, which indicates that they have become operational. This includes the (yellow) Solve model icon that allows the model to be solved.

2.4   Forecast evaluation

The within-sample predictive performance of the model will be evaluated by solving it over the historical period 1997:4–2004:4 in three different ways. Firstly, the equations will be solved singly, using actual historical values on the right-hand side of each equation. This will show how well each individual equation performs in isolation from the rest of the model. Secondly, the model will be solved as a system, but staticly, so that, in each period, actual historical values are used for lagged endogenous variables. In this way, errors do not cumulate dynamically and the forecast in each period is a one-step

ahead system forecast. Thirdly, the model will be solved dynamically to give true multi-step ahead forecasts.

Click on the Solve model icon $\lightning$ or select the *Solve model* option from the *Solve* menu. Change the solution period to 199704 to 200404 and uncheck the *data has precedence over equations* box. (This last step ensures that the model equations will be used in each period). Select the *Single equation solution* option from the solution mode list box and type '*single*' in the run name box to give the run a sensible name. Then click *OK*. This initiates solution. The Solution status box displays information as the model solves. When model solution is complete, the status box can be closed by clicking on the *OK* button. Repeat the process twice more, this time choosing the *Static model solution* and *Dynamic model solution* options respectively in the solution mode list box and naming the runs '*static*' and '*dynamic*'.
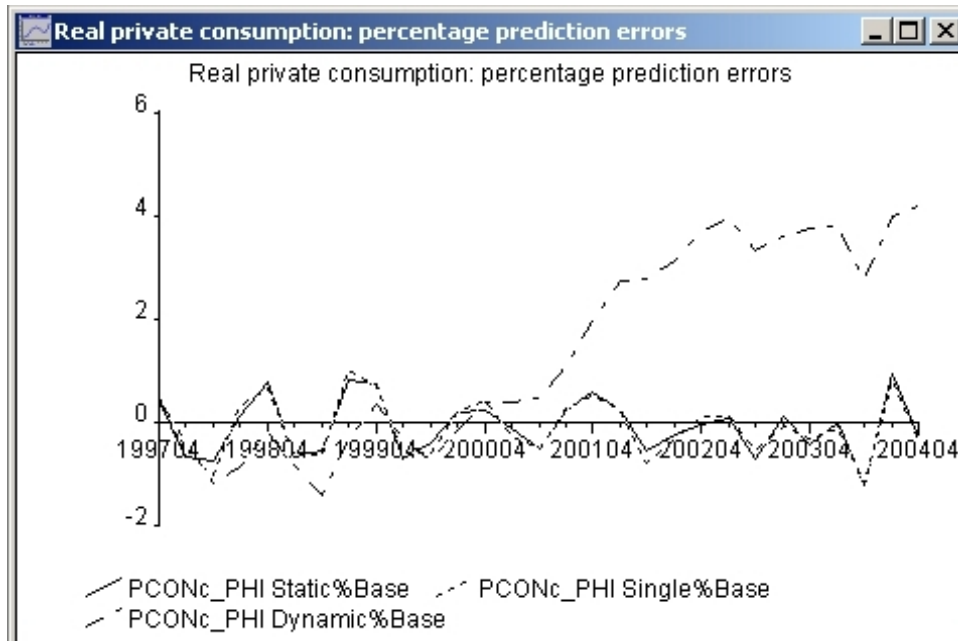

Figure 7: Percentage forecast errors: Real private consumption

The results can now be viewed in the *Results* menu. Select the *New table/graph* option in the *Results* menu or click on the graph icon ◰. In the dialog box, select the variable *PCONc_PHI* and the variable type *% changes from base*. Select each of the runs '*single*', '*static*' and '*dynamic*' in turn and click the *Add* button to add this item to the list of items to be viewed. Finally, click *OK* to finish. The percentage forecast errors for

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private consumption from each of the three runs will be graphed together (Figure 7). Note that both the single equation forecast errors and the static (one-step ahead) forecast errors are small and approximately of mean zero. In contrast, the dynamic forecast errors show a tendency to increase with the forecast horizon and (for this variable) are predominately positive, indicating an over-prediction of consumption of about 4%, 28 quarters into the 'future'. Of course it is a very severe test for any model to be expected to predict so far ahead. Typically, the forecast horizon of interest would be much shorter than this.

The information in (Figure 7) can also be viewed in different ways: as a tabular display or as summary statistics. To change the view, click on the system icon in the top left-hand corner of the window and choose either the '*View as table*' or the '*View summary statistics*' option.

Finally, a 'true' forecast can be run over the period 2005:1 to 2010:4. Click on the Solve model icon ⚡ or select the *Solve model* option from the *Solve* menu. Change the solution period to 200501 to 201004 and make sure that the *data has precedence over equations* box is now checked (so that *WinSolve* uses the data ragged edge correctly). Select the *Dynamic model solution* option from the solution mode list box (this is the only option available in a true forecast) and choose an appropriate name for the run such as '*forecast*'. Then click *OK*.
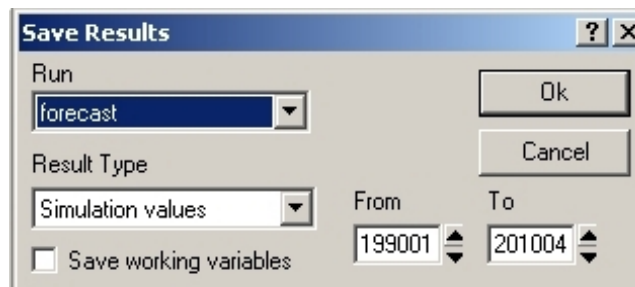

Figure 8: Save results dialog box

Once this forecast has been generated, it is possible to save it to file in any of the data formats supported by *WinSolve*. Select the *Save results in file* option from the *Results* menu or click on the (red) *Save Results* icon 🖼️. Select the run '*forecast*' and change the dates to 199001 to 201004 so that historical values are also saved. (See Figure 8). Click *OK* to exit. Enter a file name and file typefor the saved file when prompted.

3 Simulation with the Philippines model

In this section, two policy simulations are conducted with the *ADB* model of the Philippines. These replicate the simulations reported in Cagas *et al.* although the results will not be the same because the version of the model used here is slightly different to that reported in their paper. The first simulation is an oil price shock, looking at the effect of both an impulse and a step increase of 10% in the Brent oil price above its base price of $60 dollars per barrel. In the second simulation, two scenarios are explored, illustrating ways in which the government could tackle the budget deficit problem by reducing government expenditure and/or increasing tax collection.

3.1 Creating a base run

The first step in doing a simulation is to create a base run. The base run is a benchmark forecast against which the simulation runs will be compared, usually in terms of *changes from base* or *percentage changes from base*. The base run will incorporate projections for the exogenous variables and judgemental adjustments on the endogenous variables that represent a 'most likely' scenario. The simulations can then explore different types of alternative scenario, with which the base run is compared.

In the case of the *ADB* model, an obvious choice for base run is the dynamic forecast over the period 2005:1 to 2010:4 that was constructed at the end of the last section. Once this base run has been generated, this forecast needs to become the data base to replace the forecast data base that we were using in the forecast exercises of the previous section. There are several alternative ways to do this in *WinSolve*. If the forecast has been saved to file, as at the end of the last section, then it can be read back in as a new data file to replace the existing data file. (Use the *Open data file* option to replace the old file). This is probably the best way to proceed when many simulations are to be conducted over an extended period, since, once the simulation base has been saved to file, it will not need to be recreated again and can just be read back from file in subsequent *WinSolve* sessions. A second way to replace the historical data set with a simulation data base is to use the *Reset data/adjustments* option on the *Data* menu to replace the data set with the solution from any previous run such as '*forecast*'. (Use *data* as the type and select the run that you want to use). The third, and probably the quickest way (but which is only available immediately after having constructed the base forecast) is to use the option *Set last solution as base* on the *Solve* menu.

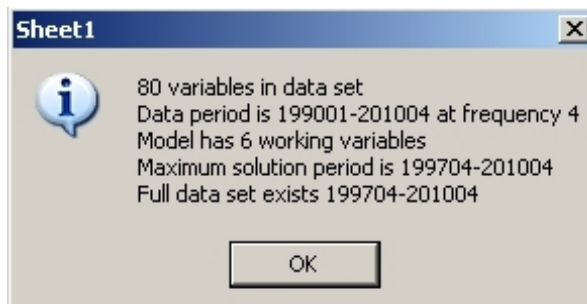Whichever method is chosen, the result should be the same. Checking

Figure 9: Data information box for simulation base

the *Data information* box in Figure 9, a full data set should now exist from 1997:4 to 2010:4.

3.2   Oil price shock simulation

The first simulation to be conducted considers the effect of a shock in the Brent oil price, which in the *ADB* model is the exogenous variable *P#OILS$*. In the base forecast, this is assumed to be constant at $60 a barrel from 2005:4 through to 2010:4. In the simulation we assume a 10% increase to $66 dollars a barrel. Two cases are considered: in the first case the increase is assumed to be temporary and the price reverts to its base price from 2006:2, in the second case the increase is permanent and continues to the end of the simulation period.
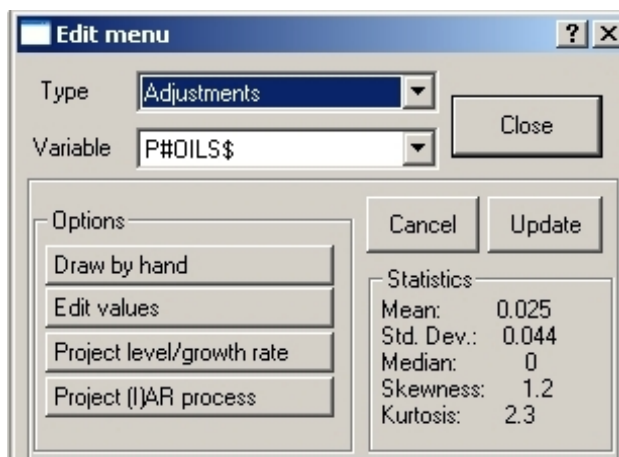
Figure 10: Data edit window

The shock is implemented by a multiplicative adjustment to the exogenous variable *P#OILS$*. This adjustment can be set through the *Edit data/adjustments* option on the *Data* menu or the icon 🖌. In the dialog box (Figure 10), select type *Adjustments* and variable *P#OILS$*. Then click on the *Project level/growth rate* button. This opens the dialog box in Figure 11. Select the projection period 200504 to 200601 for an impulse shock or 200504 to 201004 for a step change. Click on the *Constant* button and put the value 0.1 in the *a:* box. Then click *OK* to return to the edit dialog and click the *Update* button to update the adjustments. Finally click *OK* to leave the dialog box.

To run the simulations, click on the Solve model icon ⚡ or select the *Solve model* option from the *Solve* menu. Select the solution period as 199704 to 201004 and make sure that the *data has precedence over equations* box is unchecked, as in Figure 12. Then select the *Simulation* option from the solution mode list box and give the run a name such as '*oil_impulse*' or '*oil_step*'. Then click *OK*.

Figures 13 and 14 show the simulation results for *GDP* annual growth and *CPI* annual growth respectively (measured as delta logs) for the impulse shock (unbroken line) and the step shock (dotted line) simulations. The variables are graphed as changes from base and correspond closely to the results reported by Cagas *et al.* Note that, even with a temporary shock, the variables have not quite returned to base after five years.

3.3 Fiscal simulation

The second set of simulations to be conducted explore possible ways that the Philippine government could tackle its budget deficit problem by reducing government expenditure or increasing tax collection. This is rather different from the previous simulations in that it does not involve shocking a model equation or exogenous variable. Instead, the forecasting model equation for government non-interest payment expenditure *GPAY_PHI* is replaced by an alternative equation. This equation incorporates an expenditure reduction policy that comes into force whenever the debt to *GDP* ratio for the previous year (*TDEBTr_PHI*) goes above 75% or the government deficit to *GDP* ratio for the previous year (minus *GDEFr_PHI*) goes above *4%*. A second scenario additionally replaces the government tax collection equation *GTAX_PHI* by an alternative equation that allows for an additional 15% increase in tax collection.

The problem faced by the government is illustrated in Figure 15, which plots simulation base values of the debt to *GDP* ratio for the previous year
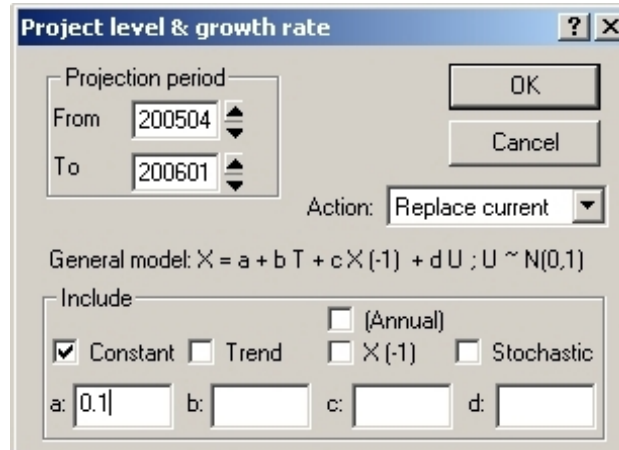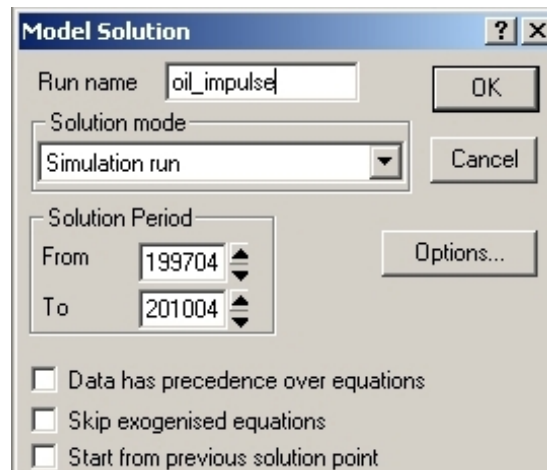
Figure 11: Projecting adjustments for *P#OILS$*

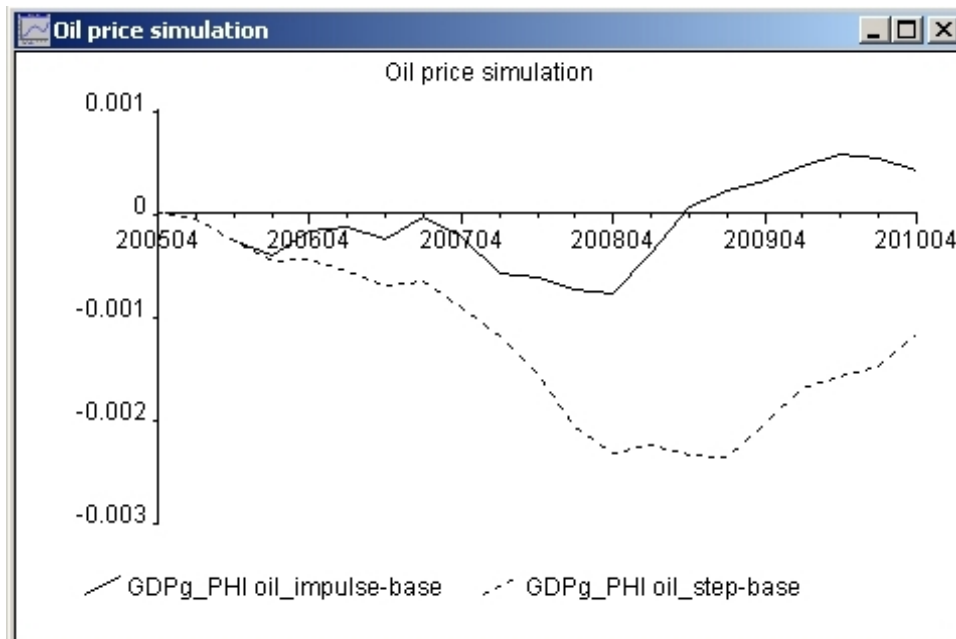Figure 12: Solution dialog box for oil simulation

Figure 13: Oil price simulation: annual *GDP* growth changes from base
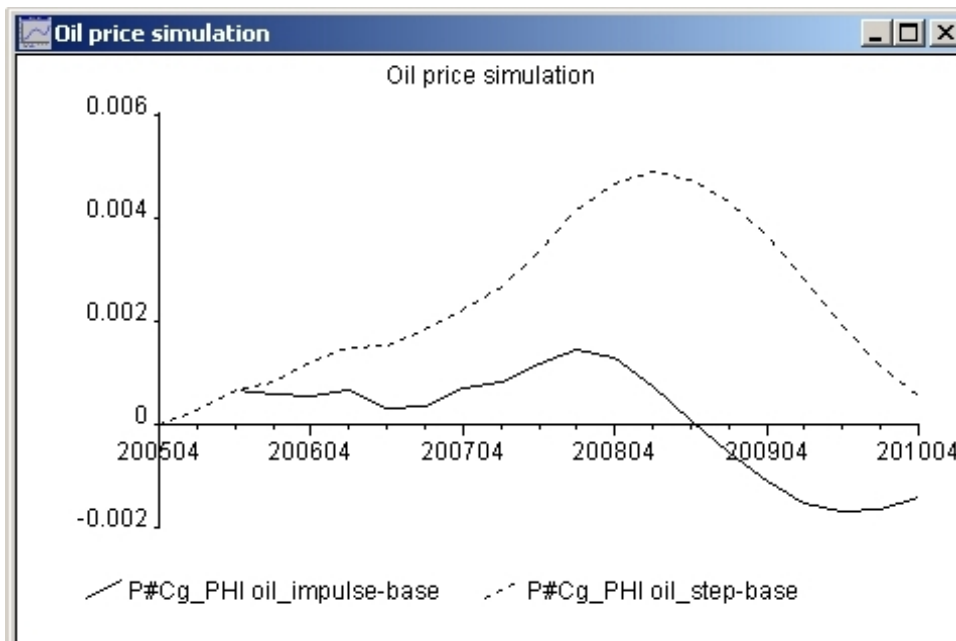

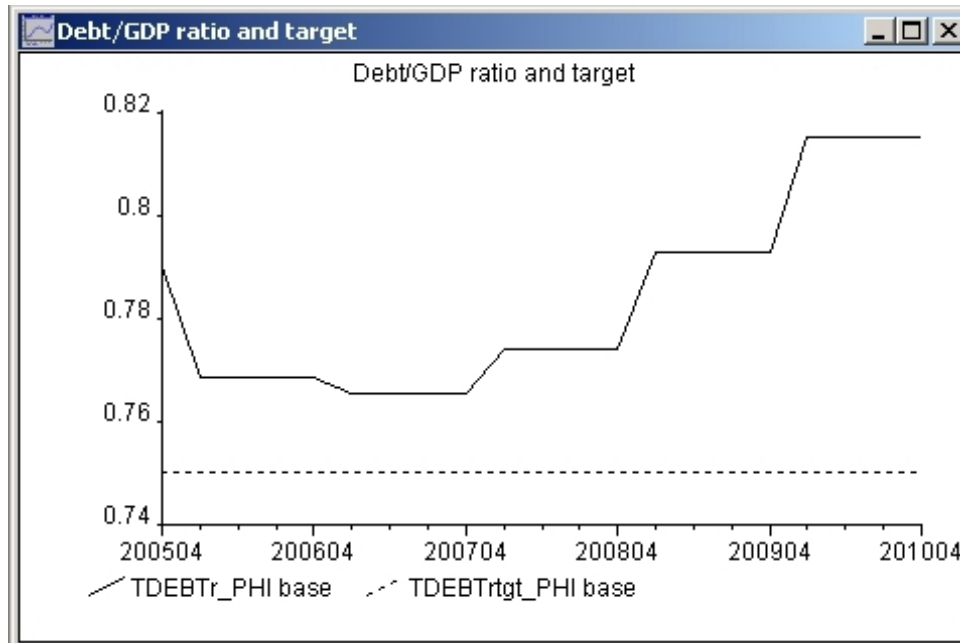Figure 14: Oil price simulation: annual *CPI* growth changes from base

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Figure 15: Simulation base $Debt/GDP$ ratio for previous year with target

along with the target upper bound of 0.75. It can be seen that in all periods in the base simulation, the ratio has been above the upper bound.
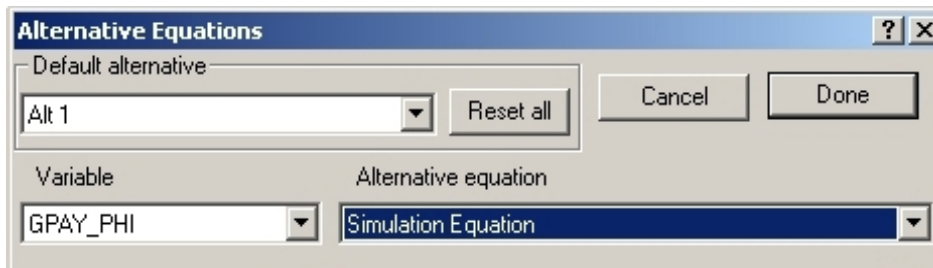

Figure 16: Alternative equation box

Two scenarios are considered. In the first the alternative equation for *GPAY_PHI* alone is used. In the second case, both alternative equations are used together. The alternative equations are switched in through the *switch alternate equations* option on the *Assumptions* menu as shown in Figure 16. Select the variable *GPAY_PHI* and choose the second alternative equation from the list, labelled '*Simulation equation*'. (For the second case simulation,

do the same for the variable *GTAX_PHI*). Then click *Done* to implement the changes and exit.
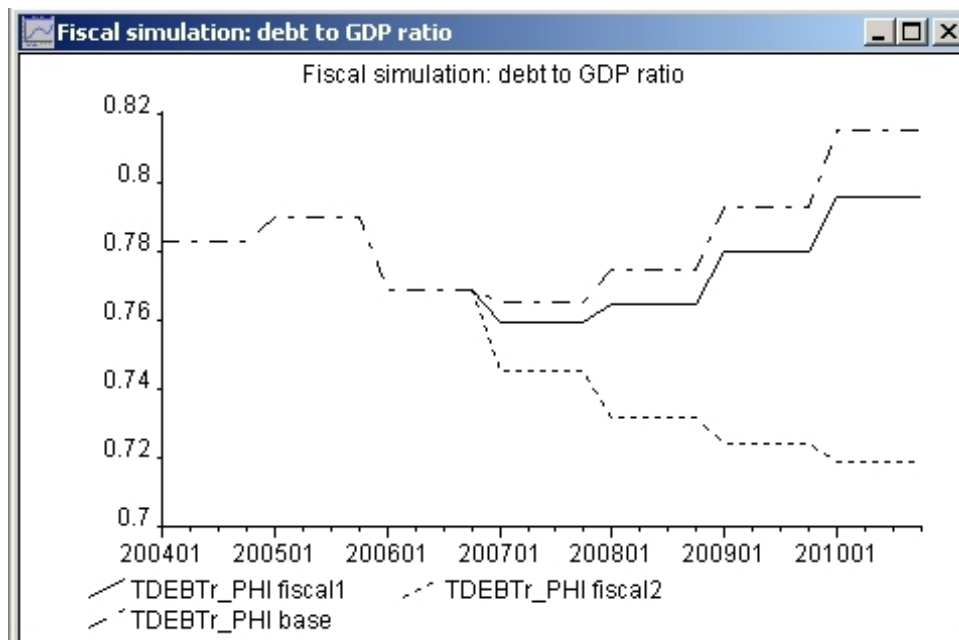

Figure 17: Fiscal simulations: debt to *GDP* ratio for previous year

Before running the simulations, ensure that any adjustments or other changes from previous simulations have been removed. A quick way to do this is to set all adjustments back to zero. This option is available within the *Reset data/adjustments* option on the *Data* menu. Then, to run the simulations, click on the Solve model icon [⚡] as before. This time select the *Dynamic model solution* option from the solution mode list box and set the solution period to be 2005:4 to 2010:4.

The simulation results are presented in Figures 17 and 18. The unbroken line is the first scenario simulation where government expenditure alone responds to an excess debt ratio. The dotted line is the second scenario simulation where tax revenue is also increased. In Figure 17, the broken line is the debt ratio in the simulation base. The patterns broadly follow those reported by Cagas *et al.* although the cross-over in the effect on *GDP* growth in Figure 18 is not apparent in their graphs. The increase in *GDP* growth in the two scenarios is explained by Cagas *et al.* as the result of increased investment.

References

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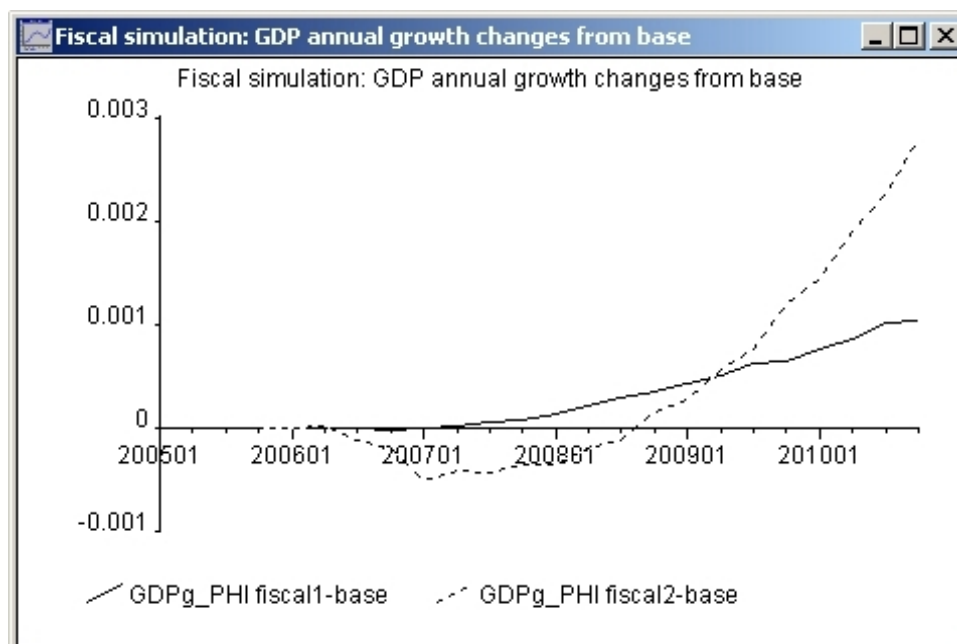
Figure 18: Fiscal simulations: *GDP* annual growth changes from base