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A Small Macroeconometric Model for the Cyprus Economy

Aris Spanos* Niki Papadopoulou**

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Abstract

The single most crucial weakness of current macroeconometric modeling stems from the fact that modelers 'quantify/estimate' their structural model directly, ignoring the fact that behind every structural model there is a statistical model whose validity vis-a-vis the data underwrites the reliability of all inferences. This practice gives rise to two important inadequacies. *First*, the estimated model largely ignores the gap between theory data. *Second*, the estimated structural models do not properly account for the statistical information in the data. These failings render the reliability of any inference based on such models doubtful and their forecasting ability questionable. The main objective of this paper is to construct a small macroeconometric model for the Cyprus economy that pays due attention to statistical model validation and the gap between theory and data. It is shown that one can secure reliable inferences, including sensible forecasts and dependable policy simulations, despite the serious limitations arising from the small sample size [1995:1-2012:4] and the number of variables (28) involved. The estimated model, after validation, is used to forecast for the period 2013:1-2020:4 and its forecasts are compared with those published troika. A key difference between the two forecasts is the time profile of the recession.

Keywords: structural vs. statistical model, statistical adequacy, statistical model validation, misspecification testing

JEL Classification: C32, C51, C52, C53, E17, E27, E60

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1 Introduction

The construction of macroeconometric models to be used for forecasting and policy analysis has developed significantly since the 1930s; see Bodkin, Klein and Marwah (1991). Despite the enormous advances, however, certain aspects of empirical modeling, including statistical model validation and bridging the gap between theory and data, have been largely neglected; see Favero (2001), Spanos (2006). As a result the reliability of inferences based on such models has been in question; see Spanos (1990).

The single most crucial weakness of current macroeconometric modeling is the direct 'quantification/estimation' of the structural model directly (Canova, 2007, DeJong and Dave, 2011), ignoring the fact that behind every such model there is a statistical model whose validity vis-a-vis the data underwrites the reliability of all inferences based on it. This practice induces two important weaknesses into the overwhelming majority of macroeconometric models. *First*, the estimated models largely ignore the gap between theory variables and the observed data. *Second*, these model do not properly account for the chance regularities in the data; see Spanos (1999). These weaknesses render any inferences based on such models unreliable and their forecasting ability doubtful.

The main objective of this paper is to construct a small macroeconometric model using time series data for the Cyprus economy that addresses the above weaknesses. In light of the fact that the observation period 1995Q1-2012Q4 yields a sample size of n=72, and there are m=8 endogenous and k=18 exogenous variables, the feasible options for model construction are highly restricted. Despite these limitations, an attempt is made to demonstrate that by paying due attention to statistical model validation one can secure reliable inferences, including sensible forecasts and dependable policy simulations.

In light of the serious data limitations, the macroeconometric model for Cyprus focuses more on *accounting for the probabilistic structure of the observed data*, and less on whether the estimated coefficients can be identified on theoretical Aggregate Demand/Aggregate Supply (AD/AS) grounds. The gap between the variables as envisaged by the theory and what actually the data measure is another key problem because the former invariably denote intentions but the latter refer to realizations. Indeed, any theory model that results of any form of optimization will give rise to structural equations that refer to plans or intentions; see Spanos (1989). In contrast, the observed data measure realizations at a highly aggregate level. Hence, the estimated equations for the Cyprus model will be interpreted in terms of *quantity and price adjustment equations.* The latter often include influences from both AD/AS sides, as well as inventories and other potentially relevant variables. This implies that one needs to temporarily suspend any prejudicial views as to the 'correct' sign of coefficients in the behavioral equations.

The construction of the model takes the form of dynamic Seemingly Unrelated Regression Equations (SURE), which is treated as a system for both estimation and forecasting purposes. To account for the feedbacks among the endogenous variables, the forecasting takes two different forms: (i) using the estimated SURE system, and (ii) system stochastic forecasting that accounts for the dynamics of the system.

The constructed CBC model is then used to forecast for the period 2013:1-2020:4 and the results are compared with the projections published by troika (European Commission, European Central Bank and International Monetary Fund).

The remainder of this paper is organized as follows. Section 2, below, describes the data used, sets up the model and its statistical validation. Section 3 describes the macroeconomic framework used for forecasting and compares the forecasts of the model with trooika projections. Section 4 evaluates debt sustainability, while section 5 summarizes and concludes. The appendix includes details of the estimation of the model and further misspecification tests.

2 A macroeconometric model for Cyprus

A key lesson that we never learned in the 1990s was the main reason for the demise of the macroeconometric models in the 1980s. Their demise began when they were compared to data-driven ARIMA(p,d,q) models and they were found wanting; see Cooper (1972). The better forecasting performance of the ARIMA models was due to the fact that they were making a better job in eliminating most of the heterogeneity and accounting better for the temporal structure in the data; see Granger and Newbold (1976). One can do much better than any ARIMA type model by accounting for the probabilistic structure of the data without ignoring the structural information. The latter, however, does not mean that one should foist such information on the data at the outset. Substantive information should be imposed only after it has been properly tested and validated in the context of a validated statistical model.

An attempt is made in what follows to construct a small macroeconometric model that takes into consideration the restrictions imposed by the sample size and the number of relevant variables [endogenous and exogenous], but at the same time pays due attention to securing statistical adequacy as well as bridging the gap between theory and data.

2.1 Relevant variables and data

The basic endogenous variables of the model are given in table 1. Their choice was based mainly on constructing basic macroeconomic relationships as they relate to key variables of interest in the troika review.

The t-plots of the data for the period 1995Q1-2012Q4 are given in figure 1. These t-plots indicate that the relevant data exhibit both complicated heterogeneity, in the form of trends and seasonal patterns, as well as temporal dependence in the form of cycles. To account for these features the estimated equations include:

(a) three seasonal dummy variables (D_1, D_2, D_3),

(b) orthogonal trend polynomials:

Chebyshev: $t_o = t$, $t_o^2 = 2t^2 - 1$, $t_o^3 = 4t^3 - 3t$, $t_o^4 = 8t^4 - 8t^2 + 1$, $t_o^5 = 16t^5 - 20t^3 + 5t$,

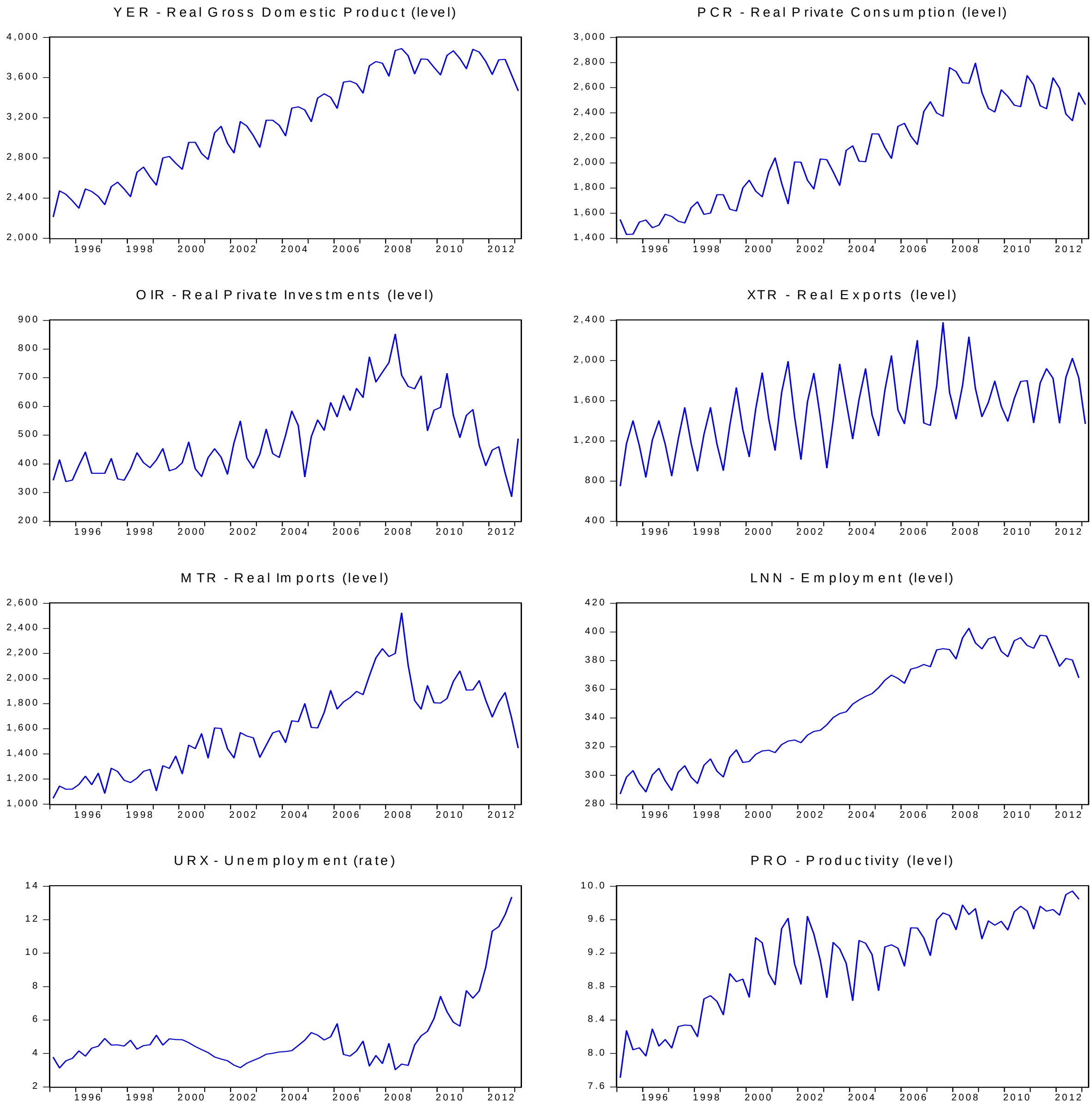
(c) lags in both endogenous and exogenous variables.

The basic exogenous variables of the model are given in table 2.

Table 1: Endogenous variables		
YER	=	Real GDP
PCR	=	Real private consumption
OIR	=	Real private investments
XTR	=	Real exports
MTR	=	Real imports
LNN	=	Employment
URX	=	Unemployment rate
PRO	=	Productivity

Table 2: Exogenous variables		
CR	=	Credit
LFN	=	Labour force
PDN	=	Household income tax and social security contributions
PYR	=	Real private sector disposable income; PYR=(WIN+TRN-PDN)/PCD
SCR	=	Real changes in inventories
TRN	=	Transfers from governments to households
WIN	=	Nominal Wages
WUN	=	Nominal wages per employee; WUN=WIN/LNN
GCR	=	Real government consumption
GIR	=	Real government investment
MTD	=	Imports deflator
PCD	=	Private consumption deflator
RPPI	=	Real estate property price index
XTD	=	Export deflator
CMD	=	Competitor's import prices
CXD	=	Competitor's export prices
EENM	=	Nominal effective exchange rate on the import side
LTI	=	Long-term interest rate
POIL	=	Price of Oil
WDR	=	World demand

Figure 1: t-plots of the data for the endogenous variables



For forecasting purposes is often preferable to use non-seasonally adjusted data because the various methods used to seasonally adjust the data often introduce distortions in both the heterogeneity and the temporal dependence of the data. The necessity to account for the heterogeneity in the data is particularly important because it represents a generic but statistically reliable way to capture the mean of all the times series involved. Without these trends, the estimated variances and covariances, which are based on deviations from the 'true' mean, will be inconsistent, giving rise to seriously spurious results in the context of regression and AutoRegressive (AR) type models. This undermines any attempt to construct and reliable model because the decision whether different explanatory variables are statistically significant or not is rendered questionable when the heterogeneity in the data is not modeled appropriately. This is because when the heterogeneity in the data is not properly accounted for the actual error probabilities differ significantly from the nominal ones, rendering any guidance from t-ratios highly questionable. Applying a .05 α-level test when the actual type I error probability is closer to .90, is very likely to lead to erroneous inferences. Indeed, any inference concerning the sign/magnitude and the significance of any coefficient, however informal, is called into question.

2.2 Estimating a CBC model

In light of the sample size and the number of variables involved [n=72, m=8 endogenous ($\mathbf{y}_t$), k=18 exogenous ($\mathbf{X}_t$)] a VAR model is not estimable. This is because even for a VAR(1) model for $\mathbf{Z}_t$:=$(\mathbf{y}_t, \mathbf{X}_t)^\top$:

$$\mathbf{Z}_t{=}\mathbf{A}^\top\mathbf{Z}_{t-1} + \mathbf{E}_t,\ \ t{\in}\mathbb{N}{:=}(1, 2, ..., n, ...) \tag{1}$$

based on the conditional distribution $D(\mathbf{Z}_t|\mathbf{Z}_{t-1};\boldsymbol{\phi})$, is not estimable because the number of unknown parameters in $\mathbf{A}$ and $\Omega{=}Cov(\mathbf{Z}_t|\mathbf{Z}_{t-1})$ is greater than n. A way to proceed is to reduce the dimensionality of the VAR model by reparameterizing it using the decomposition of the distribution:

$$D(\mathbf{Z}_t|\mathbf{Z}_{t-1};\boldsymbol{\phi}) = D(\mathbf{y}_t|\mathbf{X}_t, \mathbf{Z}_{t-1};\boldsymbol{\phi}_1) \cdot D(\mathbf{X}_t|\mathbf{Z}_{t-1};\boldsymbol{\phi}_2). \tag{2}$$

The model relating to $D(\mathbf{y}_t|\mathbf{X}_t, \mathbf{Z}_{t-1};\boldsymbol{\phi}_1)$ is known are a multivariate Dynamic Linear Regression model (DLR):

$$\mathbf{y}_t = \mathbf{B}^\top\mathbf{X}_t + \mathbf{C}^\top\mathbf{Z}_{t-1} + \mathbf{u}_t,\quad t{\in}\mathbb{N}, \tag{3}$$

which can be viewed as the reduced form of a Dynamic Simultaneous Equations (DSE) model. However, neither the DLR nor the DSE are estimable without imposing additional restrictions.

In the present case such restrictions will take the form of excluding certain variables from particular regressions. Hence, the underlying statistical model for the macroeconometric model in question will be a restricted form of the DLR for the endogenous variables and a restricted/modified VAR for the exogenous variables based on $D(\mathbf{X}_t|\mathbf{Z}_{t-1};\boldsymbol{\phi}_2)$:

$$\mathbf{X}_t = \mathbf{D}^\top\mathbf{Z}_{t-1} + \mathbf{v}_t,\quad t{\in}\mathbb{N}. \tag{4}$$

In essence, the restricted DLR will be a Seemingly Unrelated Regression Equations (SURE) system; see Greene (2011).

The macroeconometric model will take the form of 6 behavioral equations of the form (3) and two identities, supplemented with 18 restricted/modified AR models

(4) for the exogenous variables. The behavioral equations are constructed using basic theoretical considerations concerning the potential relevance of key variables, as suggested by economic theory, with the final form of these equations being primarily guided by statistical adequacy requirements: the estimated equation accounts for the statistical regularities in the data. A key difference with the traditional macro-modeling is that these behavioral equations are not interpreted as decision functions representing intentions or plans that stem from some intertemporal optimization of particular representative agents, but as market adjustment equations. The reason is that the data do not refer to any intentions but to actual realizations at a highly aggregate level; see Spanos (1995).

Estimated behavioral equations. Note that the L before the symbol of the different variables denotes the natural log (ln) transformation.

$$\begin{aligned} LYER_t = {} & \beta_1+\beta_2 D_1+\beta_3 D_2+\beta_4 D_3+\beta_5 D_{982}+\beta_6 D_{013}+\beta_7 LYER_{t-1}+ \\ & +\beta_8(LYER_{t-4}-LYER_{t-5})+\beta_9 LPCR_{t-4}+\beta_{10}(LPCR_{t-2}-LPCR_{t-3})+ \\ & +\beta_{11} LOIR_t+\beta_{12} LXTR_t+\beta_{13}(LLNN_t-LLNN_{t-1})+ \\ & +\beta_{14}(LURX_t-LURX_{t-1})+\beta_{15}(LGCR_{t-3}+\beta_{16}(LGCR_t-LGCR_{t-1})+ \\ & +\beta_{17}(LGIR_t-LGIR_{t-1})+\beta_{18}(LWDR_t-LWDR_{t-1})+ \\ & +\beta_{19} LYEA_{t-1}+\beta_{20} LCR_{t-2}+\beta_{21}(LCR_{t-3}-LCR_{t-4})+ \\ & +\beta_{22}(LRPPI_{t-1}-LRPPI_{t-6})+\beta_{23}(LRPPI_{t-2}-LRPPI_{t-4}) \end{aligned} \tag{5}$$

$$\begin{aligned} LPCR_t = {} & \beta_0+\beta_1 D_1+\beta_2 D_2+\beta_3 D_3+\beta_4 D_{972}+\beta_5 D_{013}+\beta_6 D_{031}+\beta_7 LPCR_{t-1}+ \\ & +\beta_8(LPCR_{t-3}-LPCR_{t-4})+\beta_9\,(LYER_{t-3}-LYER_{t-4})+\beta_{10} LXTR_{t-3}+ \\ & +\beta_{11}(LLNN_{t-1}-LLNN_{t-2})+\beta_{12}(LURX_t-LURX_{t-1})+ \\ & +\beta_{13} LPYR_{t-4}+\beta_{14}(LPYR_{t-2}-LPYR_{t-3})+\beta_{15} LCR_t+ \\ & +\beta_{16}(LCR_t-LCR_{t-3})+\beta_{17}(LPCD_t-LPCD_{t-1})+\beta_{18} t_0 \end{aligned} \tag{6}$$

$$\begin{aligned} LOIR_t = {} & \beta_1+\beta_2 D_1+\beta_3 D_2+\beta_4 D_3+\beta_5 D_{044}+\beta_6 LOIR_{t-1}+\beta_7(LOIR_{t-2}-LOIR_{t-3})+ \\ & +\beta_8 LOIR_{t-5}+\beta_9(LYER_t)+\beta_{10}(LYER_{t-2}-LYER_{t-5})+ \\ & +\beta_{11}(LRPPI_{t-2}-LRPPI_{t-3})+\beta_{12}(LLTI_t)+ \\ & +\beta_{13}(LLTI_{t-2}-LLTI_{t-5})+\beta_{14} t_0^2 \end{aligned} \tag{7}$$

$$
\begin{aligned}
LXTR_t \; &= \beta_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 D_3 + \beta_5 LXTR_{t-4} + \beta_6 LXTR_{t-5} + \\
&+ \beta_7 (LXTR_{t-1} - LXTR_{t-3}) + \beta_8 (LPRO_t - LPRO_{t-2}) + \\
&+ \beta_9 (LXTD_{t-1} - LXTD_{t-2}) + \beta_{10} (LWDR_{t-1} - LWDR_{t-2}) + \\
&+ \beta_{11} (LCXD_{t-2} - LCXD_{t-3}) + \beta_{12} LYEA_{t-4} + \beta_{13} t_0^3
\end{aligned} \tag{8}
$$

$$
\begin{aligned}
LMTR_t \; &= \beta_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 D_3 + \beta_5 LMTR_{t-1} + \beta_6 LYER_t + \\
&+ \beta_7 (LPCR_t - LPCR_{t-4}) + \beta_8 LOIR_t + \beta_9 (LGIR_t - LGIR_{t-1}) + \\
&+ \beta_{10} (LPYR_{t-2} - LPYR_{t-6}) + \beta_{11} (LMTD_t - LMTDTR_{t-1}) + \\
&+ \beta_{12} (LCMD_t - LCMD_{t-1}) + \beta_{13} (LEENM_{t-3} - LEENM_{t-4}) + \\
&+ \beta_{14} (LWDR_{t-5} - LWDR_{t-6}) + \beta_{15} LPOIL
\end{aligned} \tag{9}
$$

$$
\begin{aligned}
LLNN_t \; &= \beta_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 D_3 + \beta_5 LLNN_{t-1} + \beta_6 LLNN_{t-6} + \\
&+ \beta_7 (LLNN_{t-2} - LLNN_{t-5}) + \beta_8 (LPRO_{t-3} - LPRO_{t-4}) + \\
&+ \beta_9 (LLFN_t - LLFN_{t-1}) + \beta_{10} (LWUN_{t-2} - LWUN_{t-3}) + \beta_{11} LWDR_{t-1} + \\
&+ \beta_{12} t_0 + \beta_{13} t_0^2 + \beta_{14} t_0^3
\end{aligned} \tag{10}
$$

These behavioral equations are estimated using the Seemingly Unrelated Regression Equation (SURE) method for the equations:

$$y_{kt} = \beta_{0k} + \sum_{i=1}^{p_k} \beta_i x_{it} + u_{kt}, \; k{=}1, 2, ..., m.$$

The only difference between the OLS and SURE estimates is that the latter take into account the estimated covariances $\widetilde{\Omega} = \left[\frac{1}{n} \sum_{t=1}^{n} \widehat{u}_{jt} \widehat{u}_{kt}\right]_{j,k=1}^{m}$ among the different equations. For $\mathbf{y}_k$ and $\mathbf{X}_m$ denoting the n observations for the endogenous and exogenous variables of the k-th equation, the SUR equations take the form:

$$
\underbrace{\begin{pmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_m \end{pmatrix}}_{\mathbf{y}^*} = \underbrace{\begin{pmatrix} \mathbf{X}_1 & \mathbf{0} & \cdots & \mathbf{0} \\ 0 & \mathbf{X}_2 & \mathbf{0} & \mathbf{0} \\ \vdots & \mathbf{0} & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{X}_m \end{pmatrix} \begin{pmatrix} \boldsymbol{\beta}_1 \\ \boldsymbol{\beta}_2 \\ \vdots \\ \boldsymbol{\beta}_m \end{pmatrix}}_{\mathbf{X}^* \boldsymbol{\beta}^*} + \underbrace{\begin{pmatrix} \mathbf{u}_1 \\ \mathbf{u}_2 \\ \vdots \\ \mathbf{u}_m \end{pmatrix}}_{\mathbf{u}^*}
$$

The OLS estimators for the coefficients are:

$$\widehat{\boldsymbol{\beta}}_k = \left(\mathbf{X}_k^\top \mathbf{X}_k\right)^{-1} \mathbf{X}_k^\top \mathbf{y}_k, \; k = 1, 2, .., m.$$

On the other hand the SURE estimator for the system takes the form:

$$\widetilde{\boldsymbol{\beta}}^{*} = \left(\mathbf{X}^{*\top}[\widetilde{\Omega}^{-1} \otimes \mathbf{I}_n]\mathbf{X}^{*}\right)^{-1} \mathbf{X}^{*\top}[\widetilde{\Omega}^{-1} \otimes \mathbf{I}_n]\mathbf{y}^{*}$$

As shown in figure 2, however, the OLS and SURE residuals largely coincide. The details of the estimated behavioral equations are reported in the Appendix.

For forecasting purposes the system dynamics are fully employed to capture the various feedbacks between different equations which also include two **identities**:

$$PRO_t = \frac{LYER_t}{LLNN_t} \tag{11}$$

$$URX_t = 100 \left(\frac{LLFN_t - LLNN_t}{LLFN_t}\right) \tag{12}$$

2.3 Statistical model validation

A particularly important aspect of model construction in this paper is that of statistical *model validation*: the probabilistic assumptions of the underlying statistical model are shown to be valid for the particular data. Statistical adequacy plays an important role in model constructions because it secures the reliability of inference by ensuring that the nominal error probabilities associated with different forms of inference (estimation, testing, prediction) are closely approximated by the actual ones. The presence of any form of statistical misspecification induces a discrepancy between the actual and nominal error probabilities, undermining the reliability of all inferences, including measures of goodness-of-fit/prediction.

The statistical model underlying the above behavioral equations can be viewed as a Linear Regression type model (table 3) that includes a number of lags among the regressors. To secure statistical adequacy one needs to thoroughly test the probabilistic assumptions [1]-[5] and find no departures.

The t-plots of the SURE and OLS residuals are shown in figure 2. The first impression is that these residual t-plots do not indicate the presence of any systematic statistical information, like trends or/and cycles, i.e. they seem to be *non-systematic* [white-noise]. This is confirmed by formal Mis-Specification (M-S) testing reported in table 4. The M-S tests employed are F-type for the joint significance of subsets of coefficients in an auxiliary regression that allows for potential departures from different model assumptions. The particular form of the Mis-Specification (M-S) tests in table 4 are designed to ensure feasibility under the serious constraints imposed by the sample size and the number of variables involved.

To motivate the particular form of these M-S tests consider the case of a Linear Regression (LR) model:

$$y_t = \beta_0 + \textstyle\sum_{i=1}^{p} \beta_i x_{it} + u_t = \beta_0 + \boldsymbol{\beta}_1^{\top}\mathbf{x}_t + u_t. \tag{13}$$

The complete specification of the LR model in terms of probabilistic assumptions relating to the observable processes $\{(y_t|\mathbf{X}_t{=}\mathbf{x}_t),\ t{\in}\mathbb{N}\}$ is given in table 3.

Table 3: Normal, Linear Regression Model

Statistical GM:	$y_t=\beta_0+\boldsymbol{\beta}_1^{\top}\mathbf{x}_t+u_t,\ t{\in}\mathbb{N},$
[1] **Normality:**	$(y_t|\mathbf{X}_t{=}\mathbf{x}_t)\backsim\mathsf{N}(.,.),$
[2] **Linearity:**	$E(y_t|\mathbf{X}_t{=}\mathbf{x}_t)=\beta_0+\boldsymbol{\beta}_1^{\top}\mathbf{x}_t$, linear in $\mathbf{x}_t$,
[3] **Homosk/city:**	$Var(y_t|\mathbf{X}_t{=}\mathbf{x}_t)=\sigma^2$, free of $\mathbf{x}_t$,
[4] **Independence:**	$\{(y_t|\mathbf{X}_t{=}\mathbf{x}_t),\ t{\in}\mathbb{N}\}$ independent process,
[5] **t-invariance:**	$\boldsymbol{\theta}{:=}(\beta_0,\boldsymbol{\beta}_1,\sigma^2)$ do not change with t.
$\beta_0{=}E(y_t){-}\boldsymbol{\beta}_1^{\top}E(\mathbf{X}_t)$	$\boldsymbol{\beta}_1{=}Cov(\mathbf{X}_t)^{-1}Cov(\mathbf{X}_t,y_t),\ \sigma^2{=}Var(y_t){-}Cov(y_t,\mathbf{X}_t)\boldsymbol{\beta}_1$

The particular feature of the SURE regressions that calls for special types of M-S testing is that the number of regressors p is large relative to the number of observations n. In such cases, one cannot use different powers and lags of the regressors $\mathbf{X}_t$, to test for departures from linearity and independence. To overcome that difficulty one can use of shortcuts based on the fitted values:

$$\widehat{y}_t=\widehat{\beta}_0+\sum\nolimits_{i=1}^{p}\widehat{\beta}_i x_{it},\ \text{ where } y_t=\widehat{y}_t+\widehat{u}_t, \tag{14}$$

in conjunction with the following orthogonal polynomials:

$$\text{Hermite:}\quad \widehat{y}_o{=}y,\quad \widehat{y}_o^2{=}\widehat{y}^2{-}1,\quad \widehat{y}_o^3{=}\widehat{y}^3{-}3\widehat{y}\quad \widehat{y}_o^4{=}\widehat{y}^4{-}6\widehat{y}^2{+}3\quad \widehat{y}_o^5{=}\widehat{y}^5{-}10\widehat{y}^3{+}15\widehat{y}, \tag{15}$$

to create orthogonal terms for higher powers of the fitted values. The choice of these polynomials is based on the fact that they can be used to approximate any well-behaved function that takes values on the real line ($\mathbb{R}$); see Spanos (1986). These polynomials can be viewed as a condensed form of higher powers of the regressors. Combining these with the Chebyshev polynomials for the trends one can construct the following auxiliary regressions to test the model assumptions:

$$\widehat{v}_t=\beta_{10}+\beta\widehat{y}_t+\overbrace{\sum\nolimits_{i=1}^{k}\delta_{1i}t_o^i}^{\overline{[5]}\text{-non-constancy}}+\overbrace{\sum\nolimits_{j=2}^{m}\gamma_{1j}\widehat{y}_{ot}^j}^{\overline{[2]}\text{-non-linearity}}+\overbrace{\sum\nolimits_{\ell=1}^{p}\alpha_{1\ell}\widehat{u}_{t-\ell}}^{\overline{[4]}\text{-non-independence}}+\varepsilon_{1t}, \tag{16}$$

$$H_0\text{: }\delta_{1i}{=}0,\ \gamma_{1j}{=}0,\ \alpha_{1\ell}{=}0,\ i{=}1,..,k,\ j{=}2,..,m,\ \ell{=}1,..,p$$

$$\widehat{v}_t^2=\delta_{20}+\overbrace{\sum\nolimits_{i=1}^{k}\delta_{2i}t_o^i}^{\overline{[5]}\text{-non-constancy}}+\overbrace{\sum\nolimits_{j=2}^{m}\gamma_{2j}\widehat{y}_{ot}^j}^{\overline{[3]}\text{-heteroskedasticity}}+\overbrace{\sum\nolimits_{\ell=1}^{p}\alpha_{2\ell}\widehat{u}_{t-\ell}^2}^{\overline{[3]}-\overline{[4]}\text{-non-independence}}+\varepsilon_{2t}, \tag{17}$$

$$H_0\text{: }\delta_{2i}{=}0,\ \gamma_{2j}{=}0,\ \alpha_{2\ell}{=}0,\ i{=}1,..,k,\ j{=}2,..,m,\ \ell{=}1,..,p$$

where for statistical purposes we use the scaled residuals:

$$\widehat{v}_t = \frac{\sqrt{n}\widehat{u}_t}{s}, \text{ where } \widehat{u}_t{=}(y_t - \widehat{\beta}_0 - \textstyle\sum_{i=1}^{p}\widehat{\beta}_i x_{it}), \;\; s^2{=}\frac{1}{n-p-1}\textstyle\sum_{t=1}^{n}\widehat{u}_t^2 \tag{18}$$

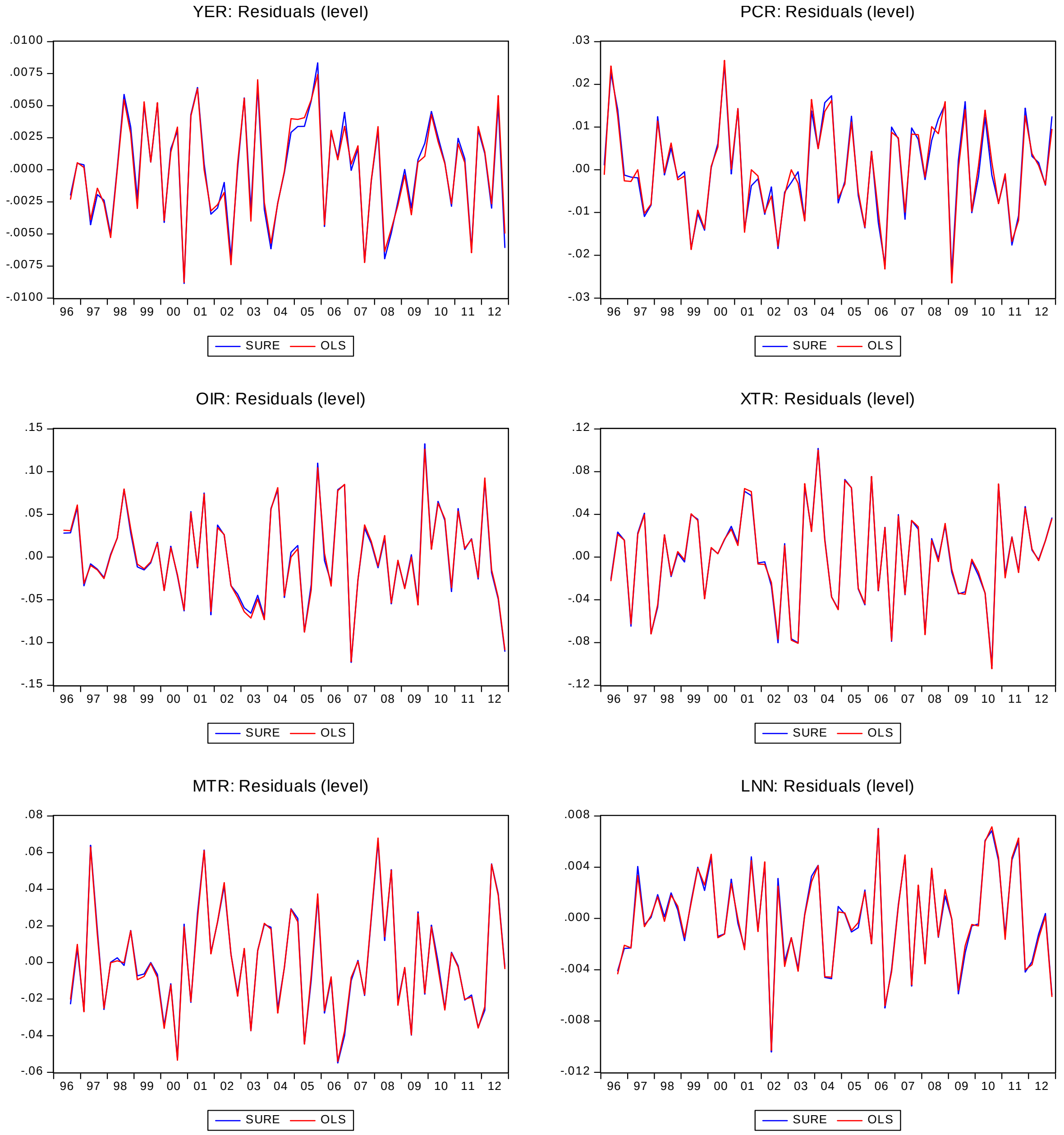
known as the studentized residuals. It is important to emphasize that the choice of (k, m, p) calls for flexibility. Joint M-S tests are particularly effective in distinguishing between different forms of departures from the model assumptions [1]-[5].

It is important to note that the specification of the Linear Regression model in table 3 is in terms of a complete and internally consistent set of probabilistic assumptions relating to the observable process $\{(y_t|\mathbf{X}_t{=}\mathbf{x}_t),\ t{\in}\mathbb{N}\}$, and not in terms of the unobservable error term $\{(u_t|\mathbf{X}_t{=}\mathbf{x}_t),\ \ t{\in}\mathbb{N}\}$. The completeness of these assumptions is particularly crucial to be able to secure statistical adequacy. In that sense, assumptions like 'no relevant variables have been omitted' has nothing to do with the statistical adequacy of the model. It's an assumption that pertains to its substantive adequacy: does the estimated model shed adequate light (describe, explain, predict) on the phenomenon of interest?

Table 4: Misspecification tests

YER	$\hat{\nu}_t$	$\hat{\nu}_t^2$
Joint Significance	F(7,56)= 1.091 [0.382]	F(6,57)= 0.519 [0.792]
Non-Constancy	F(2,56)= 0.780 [0.463]	F(2,57)= 0.179 [0.837]
Non-Linearity / Heteroskedasticity	F(2,56)= 2.956 [0.060]	F(2,57)= 0.219 [0.804]
Non-Independence	F(2,56)= 0.385 [0.682]	F(2,57)= 0.675 [0.513]
PCR		
Joint Significance	F(9,56)= 0.207 [0.992]	F(8,57)= 0.758 [0.641]
Non-Constancy	F(4,56)= 0.174 [0.951]	F(4,57)= 1.272 [0.292]
Non-Linearity / Heteroskedasticity	F(2,56)= 0.184 [0.832]	F(2,57)= 1.304 [0.279]
Non-Independence	F(2,56)= 0.245 [0.783]	F(2,57)= 0.223 [0.801]
OIR		
Joint Significance	F(9,55)= 1.262 [0.278]	F(8,56)= 1.166 [0.336]
Non-Constancy	F(4,55)= 2.154 [0.086]	F(4,56)= 2.288 [0.071]
Non-Linearity / Heteroskedasticity	F(2,55)= 1.879 [0.162]	F(2,56)= 0.616 [0.544]
Non-Independence	F(2,55)= 0.429 [0.654]	F(2,56)= 0.113 [0.893]
XTR		
Joint Significance	F(9,55)= 0.784 [0.632]	F(8,56)= 0.952 [0.482]
Non-Constancy	F(4,55)= 0.763 [0.554]	F(4,56)= 1.645 [0.176]
Non-Linearity / Heteroskedasticity	F(2,55)= 1.841 [0.168]	F(2,56)= 0.504 [0.607]
Non-Independence	F(2,55)= 0.474 [0.625]	F(2,56)= 0.478 [0.623]
MTR		
Joint Significance	F(9,54)= 0.765 [0.649]	F(8,55)= 1.108 [0.372]
Non-Constancy	F(4,54)= 0.716 [0.584]	F(4,55)= 1.626 [0.181]
Non-Linearity / Heteroskedasticity	F(2,54)= 2.708 [0.076]	F(2,55)= 2.756 [0.072]
Non-Independence	F(2,54)= 0.204 [0.816]	F(2,55)= 1.519 [0.228]
LNN		
Joint Significance	F(7,56)= 0.695 [0.676]	F(6,57)= 1.067 [0.393]
Non-Constancy	F(2,56)= 0.039 [0.962]	F(2,57)= 0.202 [0.818]
Non-Linearity / Heteroskedasticity	F(2,56)= 1.520 [0.228]	F(2,57)= 0.095 [0.910]
Non-Independence	F(2,56)= 0.665 [0.518]	F(2,57)= 1.446 [0.244]

Figure 2: t-plots of the residuals



3 Forecasting using the CBC model

It is important to emphasize at the outset that 'good forecasting' ability by a macro-econometric model is assessed by the non-systematicity of the forecast errors, not by how small they are for the specific time horizon; that latter can often arise by accident. What renders an estimated model reliable for forecasting purposes is its ability to capture the systematic changes of the endogenous variables, and this can be evaluated by the fact that its forecasts errors are white-noise. This constitutes an extension of the non-systematicity of the residuals of a statistically adequate model to the forecasting errors.

In an attempt to ensure that the model takes into account the shock induced by the March agreement between the government of Cyprus and troika, we use two types of devices. First, we ensure that as the forecasting horizon increases the trend polynomials are faced out using an AutoRegressive (AR) scheme:

$$t_o^i = \delta([t-1]_o^i),\ \delta = .97,\ i = 1, 2, 3, ...$$

This alleviates the rigidity introduced by trend polynomials for the forecasting horizon. Second, a zero-one dummy variable for the period 2013:2-2014:1 is introduced in the unemployment equation with coefficient 2.5; the magnitude of the coefficient reflects the increase in unemployment due to immediate effect of the shock. This shock affects all the other key variables via the system dynamics and feedbacks.

In addition, for certain exogenous variables we adopt troika's forecasts that incorporate the shock in question.

3.1 Macroeconomic framework for forecasting purposes

The exogenous variables of the model are projected forward following different approaches as shown in table 5. The first column indicates the variables whose forecasts (figure 3) are based on estimated restricted/modified AR models in (4). The final form of these models is chosen on statistical adequacy grounds; see table A8 in the appendix which reports the extensive misspecification testing results for these models. The first panel of table 6 shows the year-on-year (y-o-y) growth rates, which is the growth rate of the current quarterly value of the variable vis-a-vis its quarterly value four quarters before, i.e. $(\frac{y_t - y_{t-4}}{y_{t-4}})100$.

The second column of table 5 indicates the exogenous variables which are projected forward based on the latest Troika year-on-year (y-o-y) growth rates as shown in the second panel of table 6. The resulting quarterly series are shown in figure 4.

The third column of table 5 shows the exogenous variables which are part of the June 2013 ECB's Broad Macroeconomic Projection Exercise assumptions which provide three-year ahead forecasts. Thereafter the series are projected forward based on assuming constant growth rates. The forecasts for the variables CMD, CXD, EENM, LTI, POIL and WDR are not reported due to confidentiality restrictions.

The last column of table 5 refers to the euro-area real GDP incorporating the latest WEO IMF forecasts until 2018. Thereafter the projections are based on AR models.

Table 5: Macroeconomic framework: Forecasting the exogenous variables

Statistical 2013-2020	Troika 2013-2020	ECB 2013-2015 Statistical 2016-2020	WEO 2013-2018 Statistical 2019-2020
CR	GCR	CMD	YEA
GCR	GIR	CXD	
GIR	MTD	EENM	
LFN	PCD	LTI	
PDN	RPPI	POIL	
PYR	XTD	WDR	
RPPI			
SCR			
TRN			
WIN			
WUN			
PYR=(WIN+TRN-PDN)/PCD,	WUN=WIN/LNN		

The year-on-year (y-o-y) growth rates are shown in table 6.

Table 6: Projections (y-o-y) for Exogenous variables

Variable	2013	2014	2015	2016	2017	2018	2019	2020
Statistical 2013-2020								
CR	-0.28	-2.75	-5.40	-6.24	-5.33	-3.32	-1.11	0.74
GCR	-7.66	-8.82	-8.99	-6.62	-3.82	-1.57	-0.27	0.25
GIR	-15.38	-30.21	-27.58	-16.39	-7.20	4.04	11.73	14.03
LFN	-0.52	-1.07	-1.95	-2.66	-2.80	-2.62	-2.35	-2.08
PDN	-3.25	-6.35	-6.73	-4.83	-3.02	-1.29	0.39	2.04
PYR	-3.51	-6.14	-7.15	-5.95	-4.32	-2.68	-0.91	0.91
RPPI	-6.69	-7.54	-5.76	-2.23	1.54	5.83	10.25	12.50
SCR	37.87	-16.59	-27.43	-25.44	-21.42	-17.62	-14.36	-11.55
TRN	0.62	-2.53	-2.38	-0.05	2.21	4.40	6.55	8.68
WIN	-3.54	-5.93	-7.07	-5.79	-4.28	-2.79	-1.30	0.21
WUN	1.02	-0.01	-1.91	-3.84	-3.56	-2.24	-0.74	0.73
Troika 2013-2020								
GCR	-8.65	-3.69	-1.82	-1.30	-0.60	-0.10	0.90	1.50
GIR	-14.64	-4.65	4.14	3.50	5.50	4.30	4.20	4.00
MTD	1.47	1.30	1.70	1.80	1.90	2.00	2.00	2.00
PCD	1.16	1.40	1.50	1.80	1.90	2.00	2.00	2.00
RPPI	-14.00	-10.00	-1.50	0.50	1.50	3.00	2.50	2.50
XTD	1.12	1.30	1.70	1.80	1.90	2.00	2.00	2.00
WEO 2013-2018, Statistical 2019-2020								
YEA	-2.65	0.71	1.31	1.55	1.62	1.62	1.62	1.64
Notes:	SCR is in levels							

Figure 3: CBC forecasts for exogenous variables

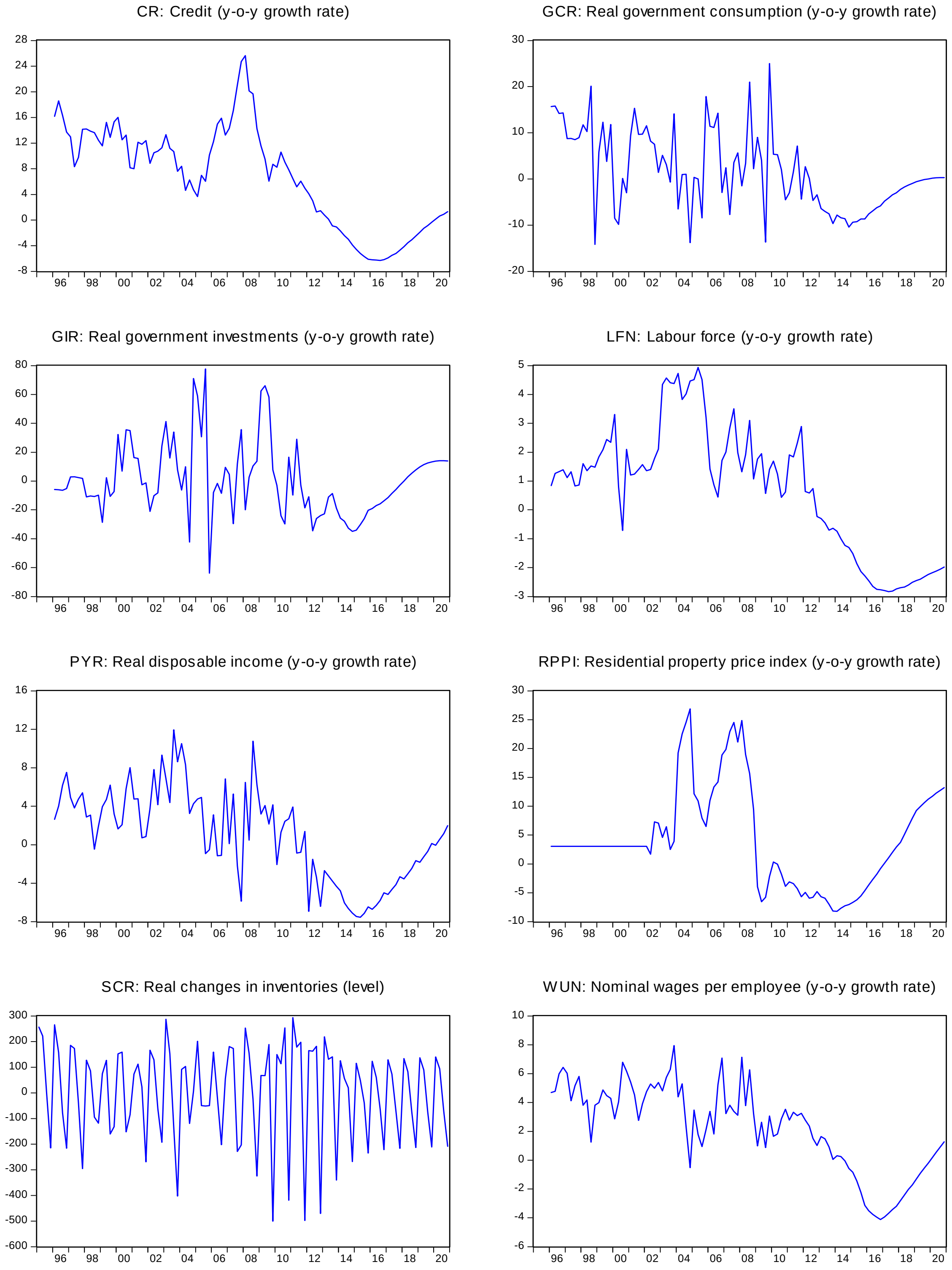
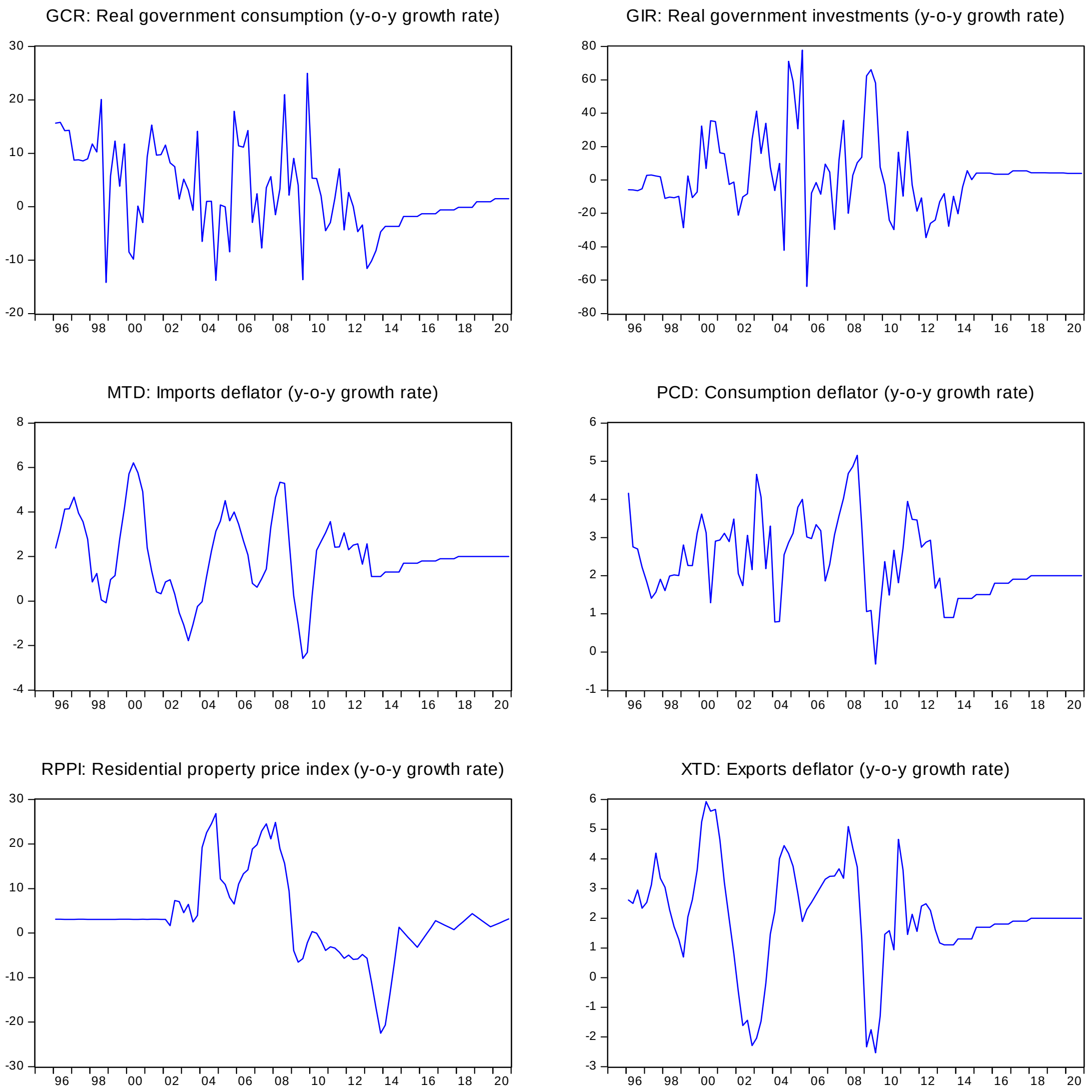


Figure 4: Troika projections for exogenous variables



3.2 Troika projections vs. the CBC model forecasts

3.2.1 Troika projections

Table 7 reports the forecasts published by troika for the 8 key variables of the CBC model; see IMF (2013).

Table 7: Troika y-o-y projections for the period 2013:1-2020:4

Variable (in real terms)	2013	2014	2015	2016	2017	2018	2019	2020
YER - GDP	**-8.7**	**-3.9**	1.1	1.9	2.3	2.2	1.9	1.8
PCR - Private consumption	-11.5	-5.1	0.8	1.9	2.5	2.6	2.2	2.2
OIR - Private investments	-29.5	-12.0	2.3	3.5	5.5	4.3	4.2	4.0
XTR - Exports	-5.0	-2.5	1.7	2.7	3.3	3.3	3.3	3.3
MTR - Imports	-16.0	-6.5	1.7	3.3	4.5	4.6	4.7	4.7
LNN - Employment	-8.4	-3.8	1.0	1.7	2.3	2.1	1.7	1.7
URX - Unemployment rate	17.5	20.0	19.2	18.0	16.4	14.8	13.5	12.3
PRO - Productivity	-0.3	-0.1	0.1	0.2	0.0	0.1	0.2	0.1

3.2.2 Scenario 1

The forecasts in table 8 are based on the estimated SURE system with forecasts for the exogenous variables based troika given projections except those for GCR, GIR and RPPI which are based on estimated CBC models (see figure 5).

Table 8: Scenario 1 y-o-y forecasts (SURE system)

Variable (in real terms)	2013	2014	2015	2016	2017	2018	2019	2020
YER - GDP	**-5.00**	**-5.57**	**-4.10**	**-1.49**	0.57	1.57	1.96	2.12
PCR - Private consumption	-5.60	-6.87	-6.12	0.25	1.16	1.34	1.87	2.59
OIR - Private investments	-27.35	-25.32	-19.27	-7.56	2.68	9.30	12.03	10.60
XTR - Exports	-5.94	-4.82	1.35	3.78	3.46	3.69	3.66	3.57
MTR - Imports	-16.13	-13.93	-12.90	-3.88	-1.73	0.44	1.90	2.32
LNN - Employment	-4.50	-5.55	-5.18	-2.21	-0.54	0.42	0.90	1.09
URX - Unemployment rate	17.52	20.09	22.13	21.77	19.95	17.46	14.71	11.94
PRO - Productivity	-0.53	-0.01	1.13	0.73	1.11	1.14	1.05	1.02

The comparison between the troika forecasts (table 7) and those based on the CBC model in table 8 reveals two important differences (see also figure 5):

(a) The time profiles of the recession differ significantly. The CBC model forecasts indicate that the recession will be less severe (-5.0) in 2013 than projected by troika (-8.7), but it will take longer to turn around. Positive rates of GDP growth will not materialize in 2015 as projected by troika, but at 2017Q2; see table 12 reporting the quarterly y-o-y forecasts.

(b) The overall negative growth rates of the GDP differ somewhat. The CBC model forecasts indicate that the overall GDP negative growth will be -16.16 as opposed to troika's forecast of -12.6.

3.2.3 Scenario 2

The forecasts in table 9 differ from those in table 8 in so far as we use the SURE model in conjunction with the forecasts proposed by troika for *all* exogenous variables.

Table 9: Scenario 2 forecasts (SURE with troika exogenous projections)

Variable (in real terms)	2013	2014	2015	2016	2017	2018	2019	2020
YER - GDP	**-5.10**	**-6.07**	**-2.95**	**-0.86**	0.97	1.50	1.73	1.82
PCR - Private consumption	-5.60	-6.87	-6.12	0.25	1.16	1.34	1.87	2.59
OIR - Private investments	-28.94	-28.82	-12.83	-6.57	2.40	7.43	8.68	6.98
XTR - Exports	-5.94	-4.82	1.35	3.78	3.46	3.69	3.66	3.57
MTR - Imports	-15.99	-13.24	-13.19	-4.07	-1.94	0.18	1.78	2.30
LNN - Employment	-4.50	-5.55	-5.18	-2.21	-0.54	0.42	0.90	1.09
URX - Unemployment rate	17.52	20.09	22.13	21.77	19.95	17.46	14.71	11.94
PRO - Productivity	-0.63	-0.54	2.35	1.37	1.52	1.07	0.82	0.72

The overall GDP negative growth is -14.98, which not very different from that of scenario 1, but there is a small shortening of the recession in the sense the first positive GDP growth rate will occur at 2016Q4 (see table 13), in contrast to troika's projection for that occurring during 2015 and scenario 1 that occurring at 2017Q2. These results suggest that the differences in the time profile of the recession between troika's projections and those in scenario 2 are likely to due to the fact that the former ignore the dynamics of the Cyprus economy as modeled by the CBC model.

3.2.4 Scenario 3

The forecasts in table 10 differ from those in table 8 in so far as we use the SURE model in conjunction with the system dynamics to account for the various feedbacks among the key endogenous variables (see figure 5). The forecasts based on the system dynamics indicate that the overall reduction in GDP growth (-12.8) is close to that projected by troika, but the time profile of the recession is still different from the troika projections in table 7. However, the results in table 10 indicate a shortening of the recession when compared with the forecasts in tables 8-9; the first positive GDP growth rate will occur at 2016Q2 (see table 14 which reports quarterly forecasts). These results confirm the above argument that the troika projections in table 7 do not take into account the dynamics of the Cyprus economy.

Table 10: Scenario 3 forecasts (SURE with system dynamics)

Variable (in real terms)	2013	2014	2015	2016	2017	2018	2019	2020
YER - GDP	**-4.93**	**-5.01**	**-2.77**	**-0.09**	1.39	1.88	2.32	2.70
PCR - Private consumption	-5.95	-6.45	-3.93	1.96	2.02	2.50	3.45	4.21
OIR - Private investments	-27.24	-22.50	-12.51	0.59	8.01	11.93	14.08	13.57
XTR - Exports	-6.43	-2.91	2.42	3.36	3.23	3.43	3.62	3.61
MTR - Imports	-15.85	-10.02	-4.28	3.33	3.37	4.70	5.70	5.74
LNN - Employment	-4.62	-5.84	-5.14	-2.27	-0.69	0.27	0.79	1.07
URX - Unemployment rate	17.63	20.44	22.44	22.13	20.44	18.08	15.45	12.72
PRO - Productivity	-0.32	0.89	2.50	2.23	2.10	1.61	1.52	1.61

3.2.5 Scenario 4

The forecasts in table 11 differ from those in table 10 in so far as we fully account for the system dynamics of the SURE model and uses all of troika's projections for the exogenous variables.

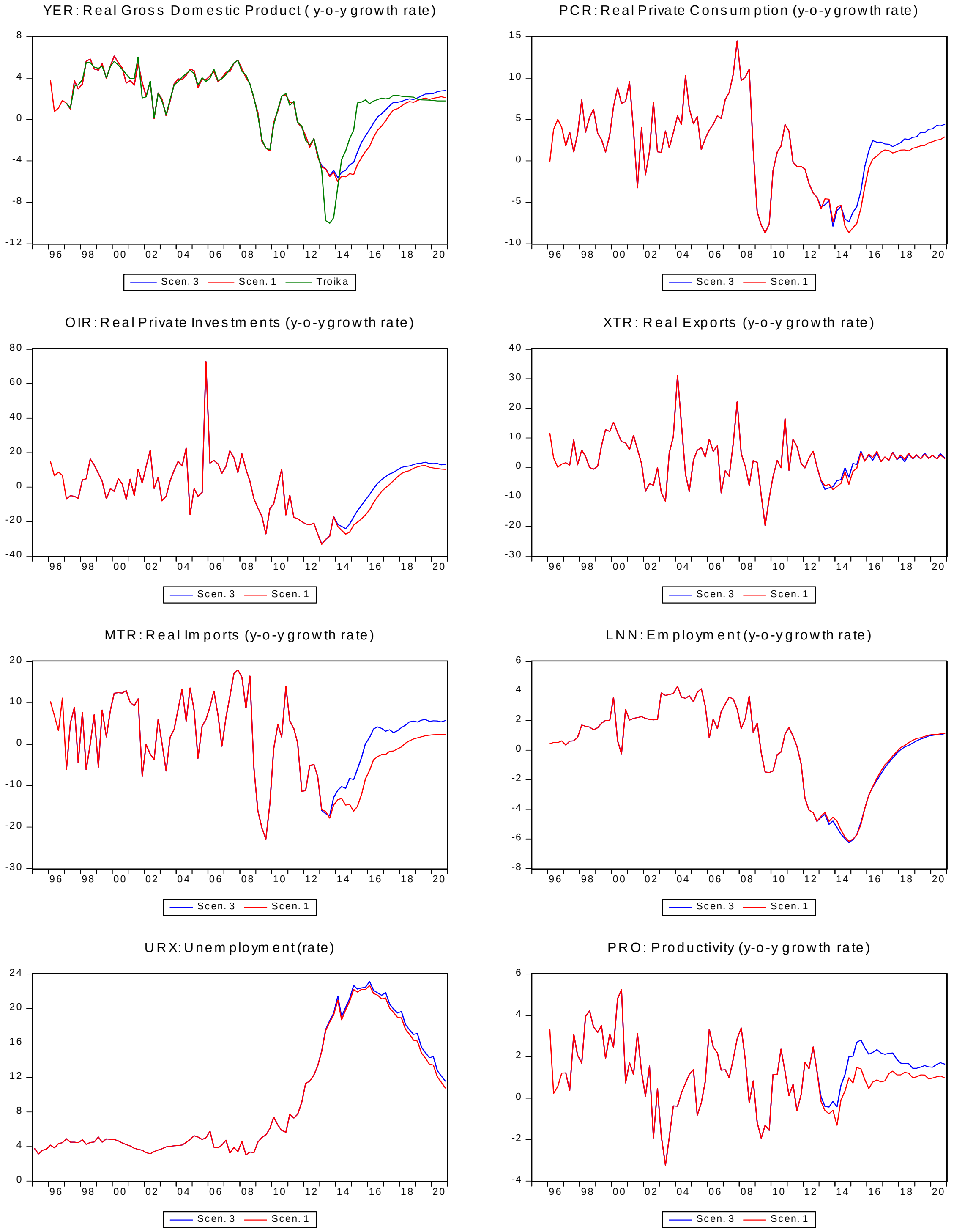
Table 11: Scenario 4 forecasts (system dynamics with troika projections)

Variable (in real terms)	2013	2014	2015	2016	2017	2018	2019	2020
YER - GDP	**-5.04**	**-5.76**	**-1.25**	0.96	1.84	1.48	1.78	2.25
PCR - Private consumption	-5.86	-6.67	-3.61	2.35	1.77	2.16	3.23	4.19
OIR - Private investments	-28.66	-27.46	-3.06	2.79	8.79	8.87	9.46	8.72
XTR - Exports	-6.61	-3.11	3.89	3.24	2.55	2.67	3.55	3.98
MTR - Imports	-16.00	-11.53	-1.01	4.32	3.41	3.38	4.40	4.30
LNN - Employment	-4.62	-5.93	-5.05	-2.11	-0.67	0.17	0.72	0.99
URX - Unemployment rate	17.63	20.51	22.43	22.00	20.29	18.01	15.43	12.77
PRO - Productivity	-0.44	0.19	4.00	3.13	2.54	1.30	1.05	1.25

What is important to note about the results in table 11 is that overall GDP negative growth (-12.05) is close to troika's projections in table 7, but the time profile of the recession is still different despite its shortening; the first positive growth rate occurs at 2016Q1 (see table 15). These comparisons can be seen more clearly in tables 12-15 (figure 5) reporting the quarterly forecasts for all the endogenous variables.

Looking more closely at the t-plot of real GDP shown in the left hand top corner of figure 5, it becomes clear that if the forecasts of the CBC model are reliable enough the Cyprus economy will experience a lost decade; real GDP will return to the 2010 level in 2020. If the troika projections are to be believed, the recession will be much deeper, but the recovery will be much faster; let's hope they are correct about the short recovery period!

Figure 5: Forecasts (y-o-y, quarterly) for different scenarios



3.3 Quarterly forecasts

An important advantage for the estimated CBC model stems from its capacity to yield quarterly forecasts for monitoring purposes. Hence, the above four scenarios are reproduced using year-on-year (y-o-y) quarterly forecasts in tables 12-15.

Table 12: Scenario 1 y-o-y quarterly forecasts (SURE system)

Quarter	YER	YER yearly	PCR	OIR	XTR	MTR	LNN	URX	PRO
2013Q1	-4.61		-5.79	-33.18	-4.38	-15.79	-4.45	15.01	-0.17
2013Q2	-4.78		-4.59	-30.31	-6.24	-16.24	-4.20	17.42	-0.60
2013Q3	-5.53		-4.63	-28.56	-5.69	-17.83	-4.82	18.43	-0.75
2013Q4	-5.09	-5.00	-7.37	-17.32	-7.47	-14.66	-4.53	19.23	-0.59
2014Q1	-6.04		-5.61	-22.86	-6.47	-13.37	-4.79	20.99	-1.31
2014Q2	-5.47		-5.35	-25.06	-5.42	-13.13	-5.39	18.69	-0.09
2014Q3	-5.54		-7.86	-27.24	-1.64	-14.73	-5.86	19.86	0.35
2014Q4	-5.22	-5.57	-8.68	-26.13	-5.75	-14.50	-6.16	20.83	0.99
2015Q1	-5.33		-8.06	-22.15	-1.33	-16.20	-6.01	22.21	0.73
2015Q2	-4.34		-7.55	-20.36	-0.38	-14.98	-5.73	21.90	1.47
2015Q3	-3.66		-5.71	-18.42	5.04	-12.08	-5.01	22.22	1.42
2015Q4	-3.09	-4.10	-3.15	-16.16	2.07	-8.34	-3.96	22.18	0.91
2016Q1	-2.60		-0.84	-13.22	4.48	-6.29	-3.05	22.69	0.47
2016Q2	-1.71		0.20	-8.99	3.27	-3.77	-2.47	21.75	0.78
2016Q3	-1.04		0.57	-5.58	5.42	-2.97	-1.90	21.54	0.88
2016Q4	-0.63	-1.49	1.06	-2.46	1.95	-2.48	-1.41	21.10	0.78
2017Q1	-0.16		1.34	-0.47	3.56	-2.50	-0.98	21.25	0.83
2017Q2	0.47		1.23	1.55	2.46	-1.70	-0.71	20.04	1.19
2017Q3	0.92		0.94	3.70	5.04	-1.62	-0.39	19.58	1.31
2017Q4	1.04	0.57	1.12	5.95	2.79	-1.10	-0.09	18.95	1.13
2018Q1	1.30		1.30	7.82	4.22	-0.64	0.17	18.92	1.13
2018Q2	1.58		1.32	8.95	2.74	0.28	0.32	17.58	1.25
2018Q3	1.72		1.22	9.50	4.80	0.84	0.51	17.01	1.21
2018Q4	1.66	1.57	1.52	10.94	3.01	1.28	0.67	16.31	0.99
2019Q1	1.84		1.64	11.73	4.29	1.55	0.79	16.23	1.04
2019Q2	1.98		1.82	12.40	2.90	1.82	0.85	14.84	1.13
2019Q3	2.07		1.86	12.49	4.48	2.05	0.94	14.24	1.12
2019Q4	1.94	1.96	2.17	11.51	2.98	2.18	1.01	13.53	0.93
2020Q1	2.04		2.32	11.07	4.13	2.27	1.06	13.46	0.97
2020Q2	2.12		2.53	10.67	2.94	2.32	1.07	12.07	1.04
2020Q3	2.20		2.60	10.43	4.22	2.34	1.11	11.47	1.08
2020Q4	2.13	2.12	2.90	10.24	3.00	2.34	1.13	10.79	0.99

Table 13: Scenario 2 y-o-y quarterly forecasts (SURE-troika exog. projections)

Quarter	YER	YER yearly	PCR	OIR	XTR	MTR	LNN	URX	PRO
2013Q1	-4.33		-5.79	-33.18	-4.38	-15.05	-4.45	15.01	0.12
2013Q2	-4.80		-4.59	-30.31	-6.24	-16.65	-4.20	17.42	-0.62
2013Q3	-5.81		-4.63	-28.56	-5.69	-19.50	-4.82	18.43	-1.05
2013Q4	-5.46	-5.10	-7.37	-23.71	-7.47	-12.75	-4.53	19.23	-0.97
2014Q1	-6.90		-5.61	-31.23	-6.47	-13.31	-4.79	20.99	-2.21
2014Q2	-6.69		-5.35	-35.19	-5.42	-11.75	-5.39	18.69	-1.38
2014Q3	-6.03		-7.86	-29.66	-1.64	-13.46	-5.86	19.86	-0.18
2014Q4	-4.66	-6.07	-8.68	-19.21	-5.75	-14.42	-6.16	20.83	1.60
2015Q1	-4.14		-8.06	-10.10	-1.33	-16.03	-6.01	22.21	1.99
2015Q2	-2.84		-7.55	-6.21	-0.38	-15.31	-5.73	21.90	3.06
2015Q3	-2.48		-5.71	-17.03	5.04	-12.50	-5.01	22.22	2.67
2015Q4	-2.33	-2.95	-3.15	-17.98	2.07	-8.92	-3.96	22.18	1.70
2016Q1	-2.01		-0.84	-16.07	4.48	-6.53	-3.05	22.69	1.07
2016Q2	-1.09		0.20	-9.95	3.27	-3.98	-2.47	21.75	1.41
2016Q3	-0.35		0.57	-1.26	5.42	-3.10	-1.90	21.54	1.57
2016Q4	0.00	-0.86	1.06	0.99	1.95	-2.68	-1.41	21.10	1.43
2017Q1	0.47		1.34	2.04	3.56	-2.58	-0.98	21.25	1.47
2017Q2	1.03		1.23	2.30	2.46	-1.94	-0.71	20.04	1.76
2017Q3	1.25		0.94	1.47	5.04	-1.87	-0.39	19.58	1.64
2017Q4	1.13	0.97	1.12	3.80	2.79	-1.37	-0.09	18.95	1.22
2018Q1	1.29		1.30	5.28	4.22	-0.99	0.17	18.92	1.11
2018Q2	1.49		1.32	6.46	2.74	0.02	0.32	17.58	1.17
2018Q3	1.65		1.22	8.75	4.80	0.61	0.51	17.01	1.13
2018Q4	1.56	1.50	1.52	9.21	3.01	1.09	0.67	16.31	0.88
2019Q1	1.69		1.64	9.92	4.29	1.37	0.79	16.23	0.89
2019Q2	1.84		1.82	10.07	2.90	1.69	0.85	14.84	0.98
2019Q3	1.79		1.86	7.71	4.48	1.95	0.94	14.24	0.85
2019Q4	1.60	1.73	2.17	7.03	2.98	2.11	1.01	13.53	0.58
2020Q1	1.67		2.32	6.25	4.13	2.21	1.06	13.46	0.60
2020Q2	1.77		2.53	6.14	2.94	2.30	1.07	12.07	0.69
2020Q3	1.91		2.60	7.74	4.22	2.34	1.11	11.47	0.79
2020Q4	1.95	1.82	2.90	7.77	3.00	2.36	1.13	10.79	0.80

Table 14: Scenario 3 y-o-y quarterly forecasts (SURE with system dynamics)

Quarter	YER	YER yearly	PCR	OIR	XTR	MTR	LNN	URX	PRO
2013Q1	-4.51		-5.60	-33.19	-4.56	-16.18	-4.51	15.07	0.00
2013Q2	-4.78		-5.34	-30.53	-7.69	-16.90	-4.29	17.50	-0.51
2013Q3	-5.47		-4.85	-28.29	-6.90	-17.26	-4.93	18.53	-0.56
2013Q4	-4.95	-4.93	-7.99	-16.96	-6.58	-13.05	-4.73	19.41	-0.22
2014Q1	-5.63		-6.09	-21.66	-4.41	-11.01	-5.22	21.40	-0.44
2014Q2	-5.11		-5.51	-22.72	-3.78	-10.15	-5.74	19.06	0.67
2014Q3	-4.89		-7.02	-23.86	-0.10	-10.67	-6.06	20.14	1.25
2014Q4	-4.40	-5.01	-7.17	-21.76	-3.35	-8.26	-6.34	21.15	2.07
2015Q1	-4.12		-6.10	-17.17	1.44	-8.35	-6.11	22.69	2.12
2015Q2	-3.15		-5.41	-14.07	0.89	-5.96	-5.72	22.24	2.72
2015Q3	-2.23		-3.49	-11.01	5.41	-3.08	-4.87	22.37	2.78
2015Q4	-1.59	-2.77	-0.74	-7.80	1.93	0.28	-3.88	22.44	2.38
2016Q1	-0.96		1.23	-4.23	4.11	1.65	-2.99	23.11	2.09
2016Q2	-0.30		2.32	-0.54	2.44	3.89	-2.46	22.09	2.21
2016Q3	0.30		2.11	2.43	4.96	4.06	-2.02	21.79	2.37
2016Q4	0.60	-0.09	2.19	4.70	1.93	3.71	-1.60	21.51	2.24
2017Q1	0.98		1.99	6.21	3.32	3.08	-1.19	21.85	2.20
2017Q2	1.33		2.14	7.23	2.27	3.46	-0.84	20.49	2.20
2017Q3	1.61		1.88	8.62	4.76	3.26	-0.53	19.96	2.16
2017Q4	1.64	1.39	2.07	9.97	2.57	3.68	-0.20	19.46	1.84
2018Q1	1.71		2.28	10.92	3.67	3.87	0.03	19.65	1.67
2018Q2	1.85		2.59	11.90	2.25	4.53	0.20	18.15	1.64
2018Q3	1.99		2.41	12.08	4.66	5.15	0.33	17.55	1.66
2018Q4	2.00	1.88	2.74	12.82	3.12	5.23	0.52	16.96	1.47
2019Q1	2.09		2.92	13.65	3.89	5.49	0.66	17.09	1.42
2019Q2	2.31		3.53	14.44	2.85	5.73	0.75	15.51	1.54
2019Q3	2.45		3.52	14.37	4.57	5.87	0.83	14.89	1.60
2019Q4	2.42	2.32	3.85	13.85	3.16	5.72	0.90	14.29	1.51
2020Q1	2.47		3.91	13.89	3.70	5.75	0.99	14.41	1.47
2020Q2	2.68		4.25	13.85	2.59	5.82	1.06	12.76	1.60
2020Q3	2.81		4.20	13.39	4.39	5.64	1.10	12.16	1.70
2020Q4	2.84	2.70	4.50	13.13	3.74	5.74	1.13	11.57	1.69

Table 15: Scenario 4 y-o-y quarterly forecasts (Troika exogenous projections)

Quarter	YER	YER yearly	PCR	OIR	XTR	MTR	LNN	URX	PRO
2013Q1	-4.21		-5.58	-33.00	-3.87	-15.15	-4.51	15.07	0.32
2013Q2	-4.79		-5.29	-30.41	-7.53	-17.18	-4.31	17.52	-0.50
2013Q3	-5.77		-4.83	-27.97	-7.45	-18.99	-4.97	18.56	-0.84
2013Q4	-5.39	-5.04	-7.73	-23.23	-7.59	-12.68	-4.67	19.35	-0.75
2014Q1	-6.68		-5.94	-30.57	-5.82	-14.01	-5.25	21.43	-1.51
2014Q2	-6.58		-5.71	-34.44	-5.32	-13.10	-5.79	19.13	-0.83
2014Q3	-5.75		-7.25	-28.47	-0.53	-11.77	-6.14	20.23	0.42
2014Q4	-4.03	-5.76	-7.79	-16.36	-0.75	-7.24	-6.52	21.25	2.67
2015Q1	-2.87		-6.89	-5.35	5.27	-5.17	-6.32	22.89	3.68
2015Q2	-1.35		-5.60	3.69	3.64	-1.13	-5.76	22.35	4.68
2015Q3	-0.56		-2.67	-5.15	5.61	0.00	-4.62	22.26	4.25
2015Q4	-0.23	-1.25	0.72	-5.45	1.05	2.26	-3.51	22.24	3.39
2016Q1	0.20		2.57	-4.79	3.29	3.23	-2.62	23.03	2.89
2016Q2	0.79		3.03	-0.55	2.83	4.74	-2.26	22.03	3.12
2016Q3	1.33		2.04	7.49	5.08	5.23	-1.96	21.62	3.35
2016Q4	1.52	0.96	1.76	9.00	1.77	4.07	-1.60	21.31	3.17
2017Q1	1.83		1.66	10.37	3.11	3.62	-1.19	21.76	3.05
2017Q2	2.03		1.82	9.73	1.93	3.92	-0.82	20.41	2.87
2017Q3	1.93		1.65	7.07	3.98	2.96	-0.50	19.76	2.45
2017Q4	1.58	1.84	1.93	7.99	1.20	3.13	-0.19	19.24	1.78
2018Q1	1.45		2.11	7.96	2.27	2.76	0.02	19.57	1.43
2018Q2	1.45		2.24	8.24	1.25	3.14	0.11	18.14	1.33
2018Q3	1.56		1.93	9.69	4.37	3.83	0.20	17.45	1.35
2018Q4	1.46	1.48	2.35	9.58	2.79	3.79	0.35	16.87	1.10
2019Q1	1.59		2.48	10.64	3.97	4.44	0.52	17.12	1.06
2019Q2	1.80		3.28	10.54	2.67	4.62	0.68	15.56	1.11
2019Q3	1.87		3.39	8.71	4.60	4.29	0.77	14.83	1.09
2019Q4	1.85	1.78	3.76	7.95	2.98	4.26	0.91	14.19	0.93
2020Q1	1.92		3.97	7.83	4.03	3.93	0.98	14.44	0.93
2020Q2	2.15		4.26	7.64	3.15	4.05	0.98	12.88	1.16
2020Q3	2.35		4.13	9.28	4.82	4.62	0.99	12.19	1.35
2020Q4	2.59	2.25	4.41	10.15	3.92	4.60	1.02	11.56	1.55

The quarterly y-o-y forecasts show more clearly the differences in the time profile of the recession and the overall negative growth between the CBC model forecasts and the troika projections.

3.4 Reflecting on the forecast results

The question that naturally arises is why troika's projections indicate such a different time profile than the forecasts based on the CBC model? Although the forecasts based on the CBC model for the period 2013:1-2020:4 do not differ significantly from those projected by troika in relation to the overall size of the recession, their time profiles are very different. As far as one can gather from troika's publications, the published projections appear to be based on (i) expert opinion based on similar episodes in other countries like Greece, Ireland and Portugal, and (ii) value judgements that make an attempt to take into account the peculiarities of the Cyprus economy. In contrast, the CBC model is based on the historical data for the period 1995:1 - 2012:4 as well as statistical techniques to model the shocks induced by the March 2013 agreement. In light of that the differences in their forecasts are likely to stem primarily from the fact that troika's projections seem to ignore the dynamics of the Cyprus economy! The latter can be particularly problematic for the implementation of the various economic measures and policies as they relate to the *timing* of the targets set by the agreement.

A retrospective view of troika's projections for the implementation of similar agreements with countries like Greece, Ireland and Portugal, reveals serious systematic forecasting errors which undoubtedly contributed significantly to the need to amend the original agreements several times along the way. For instance, in the case of Greece troika had to revise its projections several times as shown in table 16; see IMF (2010a-b), IMF (2011a-c), IMF (2012), IMF (2013a-b).

Table 16: Troika's Projections for Greece's GDP, evolving over time

Year	2010	2011	2012	2013	2014	2015
First review - September 2010:	-4.00	-2.60	1.10	2.10	2.10	2.70
Second review - December. 2010:	-4.00	-3.00	1.10	2.10	2.10	2.70
Third review - March 2011:	-4.20	-3.00	1.10	2.10	2.10	2.70
Fourth review - July 2011:	-4.50	-3.90	0.60	2.10	2.30	2.70
Fifth review - December 2011:	-3.50	-6.00	-3.00	0.30	2.40	2.90
Extended agreement - March 2012:	-3.50	-6.90	-4.80	0.00	2.50	3.10
Actual data:	**-4.94**	**-7.10**	**-6.38**	**-4.20(?)**	**?**	**?**

This table reveals a number of interesting features pertaining to *troika's projections*:

(i) The projections are systematically wrong, even in cases where the time horizon is just one-year-ahead.

(ii) Troika exhibits great *reluctance to correct blatantly incorrect forecasts* even in light of overwhelming evidence against the original forecasts. As late as July 2011 the growth of GDP forecasts for 2011 and 2012 were -3.90 and 0.60, respectively, when the true values were -7.10 and -6.38; an overall difference of -10.18!

(iii) The projections exhibit a clear tendency to present an overly optimistic picture of the *country's ability to rebound quickly* from a recession; none of their optimistic recession profiles for the other three countries materialized.

(iv) The last projections for 2013-2015 are likely to be badly wrong; even the crudest rule of thumb will project negative growth for 2013 and nothing as large as the positive growth rates projected by troika for 2014 and 2015.

A similar picture arises from revisiting troika's forecasts for other countries like Portugal and Ireland. Hence, one should be sceptical about troika's forecasts concerning the time profile of the recession in Cyprus. The CBC model's forecasts seems a lot more realistic about the potential path of the Cyprus economy.

It is illuminating to also revisit troika's projections for Greece's Debt/GDP ratio as it evolved over time. As shown in table 17, troika's projections for 2010 and 2011, as late as December 2010, was 133% and 152%, respectively, but they turned out to be 148% and 171%! The over-optimistic projections by troika are mainly due to their erroneous projections concerning the depth and time profile of Greece's recession.

Table 17: Troika's Projections for Greece's Debt/GDP, evolving over time

Year	2010	2011	2012	2013	2014	2015
First review - September 2010:	133	139	144	144	139	134
Second review - December. 2010:	130	152	158	158	154	150
Third review - March 2011:	141	153	159	158	154	151
Fourth review - July 2011:	143	166	172	170	160	146
Fifth review - December 2011:	145	162	151	149	141	133
Extended agreement - March 2012:	145	165	163	167	161	153
Actual data:	**148**	**171**	**157**	**187(?)**	**?**	**?**

In the next subsection we compare troika's projections pertaining to Debt/GDP ratio for Cyprus with those stemming from the CBC model forecasts.

4 Debt sustainability evaluations

The evaluations in table 18 are based on the equation:

$$\text{Government Debt:} \quad GDN_t = GDN_{t-1} - GLN_t \tag{19}$$

where GLN - government deficit. The results in table 18 indicate three things:

(i) The time profiles of Debt/GDP ratio for scenarios 1 and 2 indicate certain differences from troika's projections, which can be seen more clearly in the quarterly forecasts in table 20.

(ii) Using troika's own forecasts of Debt and GDP separately to evaluate Troika's Debt/GDP(%), one can see that the projection (105) and the evaluation (96) are significantly different, which means that the latter do not seem to be based on troika's numbers as given in their report.

(iii) Both scenario 1 and 2 forecasts are within the time profile and the magnitudes of Debt/GDP sustainability projected by troika; see figure 6.

Table 18: Debt sustainability forecasting

Year	2013	2014	2015	2016	2017	2018	2019	2020
Troika projections $\frac{\text{Deficit}}{\text{GDP}}$	-5.9	-7.7	-5.6	-2.4	-0.7	0.2	0.2	-0.2
Troika projections $\frac{\text{Debt}}{\text{GDP}}$	**109**	**123**	**126**	**122**	**116**	**112**	**108**	**105**
Troika Debt	16371	17599	18514	18921	19044	19007	18969	19009
Troika $\frac{\text{Debt}}{\text{GDP}}$ evaluated	**100**	**110**	**113**	**112**	**108**	**103**	**99**	**96**
Scenario 1 Debt	16408	17659	18545	18926	19040	19006	18971	19008
Scenario 1 $\frac{\text{Debt}}{\text{GDP}}$	96	109	117	119	117	113	108	104
Scenario 3 Debt	16409	17670	18574	18969	19087	19052	19015	19054
Scenario 3 $\frac{\text{Debt}}{\text{GDP}}$	96	108	115	116	113	108	103	99

Figure 6: Debt Sustainability evaluations

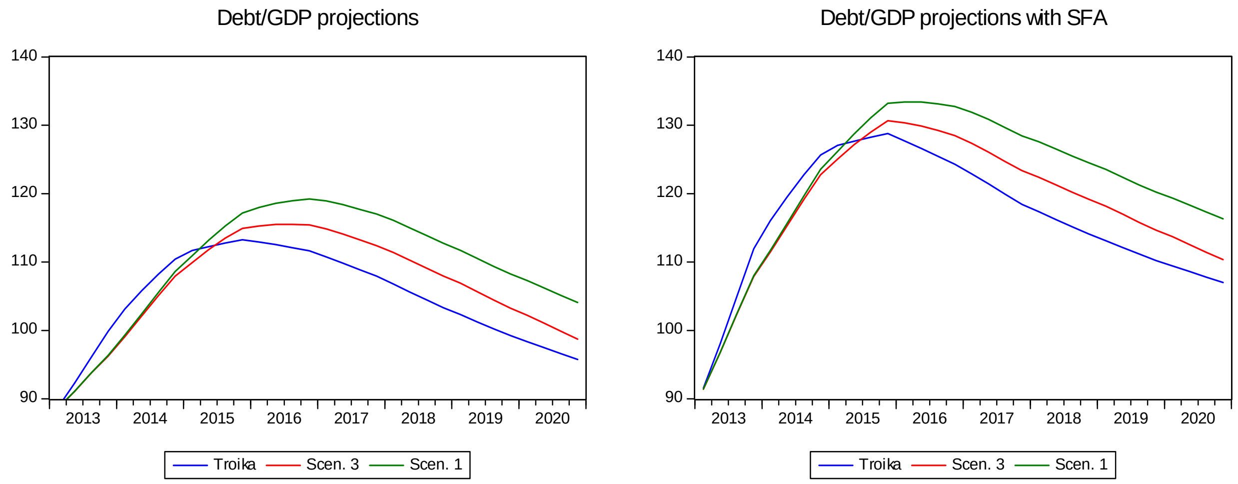


Table 19: Debt sustainability forecasting with the IMF SFA included

Year	2013	2014	2015	2016	2017	2018	2019	2020
Troika forecast $\frac{\text{Debt}}{\text{GDP}}$	**109**	**123**	**126**	**122**	**116**	**112**	**108**	**105**
Troika Debt	18352	20031	21052	21067	20903	20986	21073	21244
Troika $\frac{\text{Debt}}{\text{GDP}}$ evaluated	112	126	129	124	118	114	110	107
Scenario 1 Debt	18389	20092	21083	21072	20899	20985	21075	21243
Scenario 1 $\frac{\text{Debt}}{\text{GDP}}$	108	124	133	133	129	125	120	116
Scenario 3 Debt	18390	20103	21112	21114	20947	21030	21119	21289
Scenario 3 $\frac{\text{Debt}}{\text{GDP}}$	108	123	131	129	123	119	115	110

Table 19 indicates that, when the IMF stock-flow adjustments (SFA) are included, Troika's evaluated Debt/GDP(%) of 107 is closer to the original projection of 105; see figure 6. Hence, it looks as though the troika projections do include the IMF SFA, reported in the European Commission (2013), p. 110. However, when the additional financing needs are included in the debt sustainability evaluation, both scenarios lie just outside the profile of the troika projections; see table 20.

Table 20: Debt sustainability – quarterly

Quarter	Troika's projections				Scenario 1				Scenario 2			
	Debt	$\frac{\text{Debt}}{\text{GDP}}$	Debt_A	$\frac{\text{Debt}_A}{\text{GDP}}$	Debt	$\frac{\text{Debt}}{\text{GDP}}$	Debt_A	$\frac{\text{Debt}_A}{\text{GDP}}$	Debt	$\frac{\text{Debt}}{\text{GDP}}$	Debt_A	$\frac{\text{Debt}_A}{\text{GDP}}$
2013Q1	15648	89	16143	92	15642	89	16138	91	15643	89	16138	91
2013Q2	15890	92	16881	98	15901	91	16892	97	15901	91	16892	97
2013Q3	16133	96	17618	105	16160	94	17646	102	16161	94	17647	102
2013Q4	16371	100	18352	112	16408	96	18389	108	16409	96	18390	108
2014Q1	16672	103	18766	116	16704	99	18798	112	16708	99	18802	111
2014Q2	16980	106	19187	120	17027	102	19234	116	17032	102	19239	115
2014Q3	17290	108	19610	123	17350	106	19670	120	17357	105	19677	119
2014Q4	17598	110	20031	126	17660	109	20093	124	17670	108	20103	123
2015Q1	17818	112	20278	127	17867	111	20326	126	17882	110	20341	125
2015Q2	18049	112	20534	128	18095	113	20580	129	18113	112	20598	127
2015Q3	18282	113	20793	128	18324	115	20836	131	18348	114	20860	129
2015Q4	18513	113	21052	129	18546	117	21084	133	18575	115	21113	131
2016Q1	18611	113	21051	128	18634	118	21074	133	18666	115	21106	130
2016Q2	18713	113	21055	127	18732	119	21074	133	18767	116	21109	130
2016Q3	18817	112	21061	125	18831	119	21075	133	18870	116	21114	129
2016Q4	18920	112	21066	124	18927	119	21073	133	18970	115	21115	129
2017Q1	18950	111	21024	123	18953	119	21027	132	18997	115	21071	127
2017Q2	18981	110	20983	121	18982	118	20985	131	19027	114	21030	126
2017Q3	19012	109	20943	120	19012	118	20943	130	19058	113	20989	125
2017Q4	19044	108	20903	118	19041	117	20900	128	19088	112	20948	123
2018Q1	19035	107	20924	117	19033	116	20922	128	19080	111	20969	122
2018Q2	19026	106	20944	116	19025	115	20943	127	19071	110	20990	121
2018Q3	19016	104	20965	115	19016	114	20964	126	19062	109	21011	120
2018Q4	19007	103	20985	114	19007	113	20986	124	19053	108	21032	119
2019Q1	18998	102	21007	113	18999	112	21009	124	19045	107	21054	118
2019Q2	18988	101	21029	112	18990	111	21031	122	19035	106	21076	117
2019Q3	18978	100	21051	111	18981	109	21053	121	19026	104	21098	116
2019Q4	18969	99	21072	110	18972	108	21076	120	19016	103	21120	115
2020Q1	18978	98	21115	109	18981	107	21117	119	19025	102	21162	114
2020Q2	18988	97	21158	109	18990	106	21159	118	19035	101	21205	113
2020Q3	18998	97	21201	108	18999	105	21202	117	19045	100	21248	111
2020Q4	19008	96	21244	107	19009	104	21244	116	19055	99	21290	110

Note: Debt_A denotes Debt with the IMF SFA

5 Summary and Conclusions

A small macroeconometric model for the Cyprus economy has been constructed, taking into account the limitations imposed by the sample size and the number of variables involved. The CBC model differs from traditional macroeconometric models in two important respects. *First*, due attention has been paid to its statistical adequacy to ensure that the model accounts for the statistical information in the data. This secures the reliability of inference in the sense that the actual error probabilities are close to the nominal ones. *Second*, the estimated model is viewed as a system of adjustment equations and not as representative agents's decision functions stemming from a certain intertemporal optimization. This takes into consideration the fact that such decision functions can only refer to intentions but the observed data represent realizations at a highly aggregate level.

The macroeconometric model for the Cyprus economy is estimated for the period 1995Q1-2012Q4 and then used to provide forecasts for the period 2013Q1-2020Q4. It is well-known that the reliability of forecasts deteriorates as the forecasting horizon increases, and in the present case this is particularly problematic. However, unless major unpredictable shocks occur the forecasts in tables 8-16 should be reliable enough to guide any economic policy decisions in the near future. On the other hand, the projections given by troika in table 7 should be viewed with a healthy dosage of scepticism in light of the above discussion pertaining to their track record, as it relates to Greece.

When the forecasts of the estimated CBC model are compared with troika's projections two important difference stand out. First, the CBC forecasts pertaining to the *time profile of the recession* are in conflict with that projected by troika. The CBC model forecasts indicate that the recession will be less severe in 2013 than projected by troika, but it will take longer for the GDP to turn around. Positive rates of GDP growth will materialize closer to 2017, and not 2015 as projected by troika. This has important implications for ensuring the timely success of any fiscal consolidation measures. *Second*, the debt sustainability evaluations using the CBC model forecasts indicate potential problems that might arise because of the time profile of the recession as well as the way the deficit is reported without the IMF SFA.

In conclusion, the CBC model provides reliable enough forecasts of the year-on-years changes in the key variables on a quarterly basis that can be used as a guide for different policy measures to render the government debt sustainable in the longer run. A key advantage of forecasting as an inferential procedure is that eventually reality will confirm or disconfirm one's forecasts, and thus it will provide evidence for the reliability of the model's forecasting trustworthiness.

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A Appendix

A.1 Variable definitions

Table A1: Variable definitions		
CMD	=	Competitor's import prices
CR	=	Credit
CXD	=	Competitor's export prices
EENM	=	Nominal effective exchange rate on the import side
GCR	=	Real government consumption
GDN	=	Government net nominal debt
GIR	=	Real government investment
GLN	=	Government net nominal surplus
LFN	=	Labour force
LNN	=	Employment
LTI	=	Long-term interest rate
MTD	=	Imports deflator
MTR	=	Real imports
OIR	=	Real private investments
PCD	=	Private consumption deflator
PCR	=	Real private consumption
PDN	=	Household income tax and social security contributions
POIL	=	Price of Oil
PRO	=	Productivity
PYR	=	Real private sector disposable income
RPPI	=	Real estate property price index
SCR	=	Real changes in inventories
TRN	=	Transfers from government to households
URX	=	Unemployment rate
WDR	=	World demand
WIN	=	Nominal wages
WUN	=	Nominal wages per employee
XTD	=	Export deflator
XTR	=	Real exports
YEA	=	Euro area real GDP
YER	=	Real GDP

A.2 Estimation results for the CBC model

Table A2: YER Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.403	0.758	-0.532	0.597
D_1	-0.010	0.010	-1.033	0.307
D_2	-0.025	0.009	-2.647	0.011
D_3	-0.010	0.007	-1.459	0.152
D_{982}	0.020	0.006	3.412	0.001
D_{013}	0.018	0.006	3.153	0.003
$LYER_{t-1}$	0.505	0.063	8.064	0.000
$LYER_{t-4} - LYER_{t-5}$	0.497	0.058	8.536	0.000
$LPCR_{t-4}$	0.089	0.028	3.189	0.003
$LPCR_{t-2} - LPCR_{t-3}$	0.112	0.033	3.417	0.001
$LOIR_t$	0.053	0.007	7.765	0.000
$LXTR_t$	0.052	0.012	4.351	0.000
$LLNN_t - LLNN_{t-1}$	0.188	0.067	2.789	0.008
$LURX_t - LURX_{t-1}$	-0.011	0.007	-1.482	0.146
$LGCR_{t-3}$	0.036	0.011	3.245	0.002
$LGCR_t - LGCR_{t-1}$	-0.020	0.008	-2.455	0.018
$LGIR_t - LGIR_{t-1}$	0.015	0.003	5.372	0.000
$LWDR_t - LWDR_{t-1}$	0.184	0.037	4.951	0.000
$LYEA_{t-1}$	0.160	0.074	2.166	0.036
LCR_{t-2}	0.047	0.014	3.338	0.002
$LCR_{t-3} - LCR_{t-4}$	-0.167	0.038	-4.388	0.000
$LRPPI_{t-1} - LRPPI_{t-6}$	-0.028	0.020	-1.412	0.165
$LRPPI_{t-2} - LRPPI_{t-4}$	0.052	0.034	1.496	0.142
R-squared	0.999	Mean dependent var		8.073
Adjusted R-squared	0.999	S.D. dependent var		0.151
S.E. of regression	0.005	Akaike info criterion		-7.542
Sum squared resid	0.001	Schwarz criterion		-6.779
Log likelihood	271.880	Hannan-Quinn criter.		-7.240
F-statistic	2845.594	Durbin-Watson stat		2.061
Prob(F-statistic)	0.000			

Table A3: PCR Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.208	0.543	0.384	0.703
D_1	-0.022	0.022	-1.008	0.318
D_2	-0.175	0.015	-11.317	0.000
D_3	-0.097	0.021	-4.619	0.000
D_{972}	0.062	0.014	4.324	0.000
D_{013}	-0.056	0.014	-3.947	0.000
D_{031}	-0.057	0.015	-3.841	0.000
$LPCR_{t-1}$	0.458	0.060	7.626	0.000
$LPCR_{t-3} - LPCR_{t-4}$	0.187	0.063	2.952	0.005
$LYER_{t-3} - LYER_{t-4}$	0.406	0.155	2.609	0.012
$LXTR_{t-3}$	0.113	0.024	4.741	0.000
$LLNN_{t-1} - LLNN_{t-2}$	1.090	0.165	6.611	0.000
$LURX_t - LURX_{t-1}$	-0.036	0.018	-1.954	0.056
$LPYR_{t-4}$	0.187	0.050	3.725	0.001
$LPYR_{t-2} - LPYR_{t-3}$	0.084	0.051	1.629	0.110
LCR_t	0.185	0.048	3.842	0.000
$LCR_t - LCR_{t-3}$	0.304	0.060	5.103	0.000
$LPCD_t - LPCD_{t-1}$	1.073	0.196	5.474	0.000
t_0	-0.002	0.001	-1.753	0.086
R-squared	0.996	Mean dependent var		7.637
Adjusted R-squared	0.994	S.D. dependent var		0.188
S.E. of regression	0.014	Akaike info criterion		-5.448
Sum squared resid	0.010	Schwarz criterion		-4.860
Log likelihood	203.217	Hannan-Quinn criter.		-5.215
F-statistic	685.118	Durbin-Watson stat		1.838
Prob(F-statistic)	0.000			

Table A4: OIR Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.035	1.530	-0.023	0.982
D_1	0.123	0.035	3.491	0.001
D_2	0.138	0.029	4.690	0.000
D_3	-0.029	0.043	-0.668	0.507
D_{044}	-0.407	0.069	-5.937	0.000
$LOIR_{t-1}$	0.433	0.084	5.153	0.000
$LOIR_{t-2} - LOIR_{t-3}$	0.146	0.078	1.865	0.068
$LOIR_{t-5}$	0.273	0.090	3.028	0.004
$LYER_t$	0.298	0.202	1.475	0.146
$LYER_{t-2} - LYER_{t-5}$	0.911	0.473	1.924	0.060
$LRPPI_{t-2} - LRPPI_{t-3}$	1.441	0.354	4.068	0.000
$LLTI_t$	-0.318	0.069	-4.598	0.000
$LLTI_{t-2} - LLTI_{t-5}$	0.189	0.076	2.484	0.016
t_0^2	-0.002	0.001	-2.577	0.013
R-squared	0.939	Mean dependent var		6.180
Adjusted R-squared	0.927	S.D. dependent var		0.247
S.E. of regression	0.067	Akaike info criterion		-2.424
Sum squared resid	0.253	Schwarz criterion		-2.035
Log likelihood	95.617	Hannan-Quinn criter.		-2.270
F-statistic	79.764	Durbin-Watson stat		1.957
Prob(F-statistic)	0.000			

Table A5: XTR Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.386	3.010	-4.780	0.000
D_1	0.108	0.048	2.281	0.027
D_2	0.236	0.065	3.620	0.001
D_3	0.165	0.037	4.443	0.000
$LXTR_{t-4}$	0.521	0.098	5.290	0.000
$LXTR_{t-5}$	-0.276	0.100	-2.746	0.008
$LXTR_{t-1} - LXTR_{t-3}$	0.357	0.071	5.052	0.000
$LPRO_t - LPRO_{t-2}$	1.157	0.318	3.633	0.001
$LXTD_{t-1} - LXTD_{t-2}$	-1.939	0.837	-2.316	0.024
$LWDR_{t-1} - LWDR_{t-2}$	1.217	0.354	3.434	0.001
$LCXD_{t-2} - LCXD_{t-3}$	1.588	0.509	3.118	0.003
$LYEA_{t-4}$	1.365	0.263	5.191	0.000
t_0^3	0.000	0.000	-1.265	0.211
R-squared	0.963	Mean dependent var		7.316
Adjusted R-squared	0.954	S.D. dependent var		0.227
S.E. of regression	0.049	Akaike info criterion		-3.035
Sum squared resid	0.128	Schwarz criterion		-2.607
Log likelihood	114.679	Hannan-Quinn criter.		-2.866
F-statistic	115.548	Durbin-Watson stat		2.141
Prob(F-statistic)	0.000			

Table A6: MTR Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.131	0.716	0.183	0.856
D_1	0.008	0.028	0.276	0.784
D_2	-0.035	0.019	-1.810	0.076
D_3	0.007	0.016	0.442	0.661
$LMTR_{t-1}$	0.152	0.085	1.783	0.081
$LYER_t$	0.562	0.136	4.122	0.000
$LPCR_{t-1} - LPCR_{t-4}$	0.469	0.115	4.094	0.000
$LOIR_t$	0.209	0.036	5.786	0.000
$LGIR_t - LGIR_{t-1}$	0.074	0.016	4.529	0.000
$LPYR_{t-2} - LPYR_{t-6}$	0.269	0.126	2.139	0.037
$LMTD_t - LMTD_{t-1}$	-2.330	0.672	-3.469	0.001
$LCMD_t - LCMD_{t-1}$	1.244	0.398	3.125	0.003
$LEENM_{t-3} - LEENM_{t-4}$	0.854	0.429	1.993	0.052
$LWDR_{t-5} - LWDR_{t-6}$	0.512	0.228	2.242	0.029
$LPOIL_t$	0.080	0.024	3.396	0.001
R-squared	0.980	Mean dependent var		7.389
Adjusted R-squared	0.974	S.D. dependent var		0.196
S.E. of regression	0.032	Akaike info criterion		-3.837
Sum squared resid	0.050	Schwarz criterion		-3.273
Log likelihood	143.630	Hannan-Quinn criter.		-3.614
F-statistic	151.146	Durbin-Watson stat		1.835
Prob(F-statistic)	0.000			

Table A7: LNN Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.223	0.548	2.232	0.030
D_1	-0.022	0.004	-4.874	0.000
D_2	-0.008	0.006	-1.240	0.221
D_3	0.011	0.006	1.809	0.076
$LLNN_{t-1}$	0.715	0.067	10.694	0.000
$LLNN_{t-6}$	0.075	0.056	1.331	0.189
$LLNN_{t-2} - LLNN_{t-5}$	0.073	0.048	1.536	0.131
$LPRO_{t-3} - LPRO_{t-4}$	0.216	0.038	5.657	0.000
$LLFN_t - LLFN_{t-1}$	0.811	0.064	12.633	0.000
$LWUN_{t-2} - LWUN_{t-3}$	0.050	0.033	1.536	0.131
$LWDR_{t-1}$	0.021	0.013	1.620	0.111
t_0	-0.002	0.001	-2.113	0.039
t_0^2	0.005	0.002	2.337	0.023
t_0^3	-0.002	0.001	-2.585	0.013
R-squared	0.999	Mean dependent var		5.856
Adjusted R-squared	0.998	S.D. dependent var		0.102
S.E. of regression	0.004	Akaike info criterion		-7.983
Sum squared resid	0.001	Schwarz criterion		-7.518
Log likelihood	277.438	Hannan-Quinn criter.		-7.799
F-statistic	3142.045	Durbin-Watson stat		2.099
Prob(F-statistic)	0.000			

A.3 Misspecification tests of the exogenous variables

Table A8: Misspecification tests for the AR models for the exogenous variables

CR	$\hat{\nu}_t$	$\hat{\nu}_t^2$
Joint Significance	F(9,54)= 0.597 [0.794]	F(8,55)= 0.733 [0.662]
Non-Constancy	F(4,54)= 0.859 [0.495]	F(4,55)= 0.464 [0.762]
Non-Linearity / Heteroskedasticity	F(2,54)= 1.562 [0.219]	F(2,55)= 0.605 [0.550]
Non-Independence	F(2,54)= 0.764 [0.471]	F(2,55)= 0.017 [0.983]
GCR		
Joint Significance	F(7,58)= 1.222 [0.305]	F(6,59)= 1.253 [0.293]
Non-Constancy	F(2,58)= 1.757 [0.182]	F(2,59)= 2.180 [0.122]
Non-Linearity / Heteroskedasticity	F(2,58)= 2.742 [0.073]	F(2,59)= 1.380 [0.260]
Non-Independence	F(2,58)= 0.520 [0.597]	F(2,59)= 0.341 [0.713]
GIR		
Joint Significance	F(10,55)= 0.510 [0.876]	F(9,56)= 1.549 [0.154]
Non-Constancy	F(4,55)= 0.018 [0.999]	F(4,56)= 2.085 [0.095]
Non-Linearity / Heteroskedasticity	F(3,55)= 0.292 [0.831]	F(3,56)= 1.833 [0.152]
Non-Independence	F(2,55)= 1.941 [0.153]	F(2,56)= 0.118 [0.889]
LFN		
Joint Significance	F(7,57)= 0.398 [0.899]	F(6,58)= 0.470 [0.828]
Non-Constancy	F(2,57)= 1.004 [0.373]	F(2,58)= 0.010 [0.990]
Non-Linearity / Heteroskedasticity	F(2,57)= 1.332 [0.272]	F(2,58)= 0.130 [0.879]
Non-Independence	F(2,57)= 0.037 [0.963]	F(2,58)= 0.282 [0.755]
PDN		
Joint Significance	F(10,55)= 0.535 [0.858]	F(9,56)= 1.069 [0.400]
Non-Constancy	F(4,55)= 0.572 [0.684]	F(4,56)= 0.981 [0.425]
Non-Linearity / Heteroskedasticity	F(3,55)= 0.954 [0.421]	F(3,56)= 0.419 [0.740]
Non-Independence	F(2,55)= 0.181 [0.835]	F(2,56)= 1.099 [0.340]
RPPI		
Joint Significance	F(10,31)= 0.922 [0.526]	F(9,32)= 0.831 [0.593]
Non-Constancy	F(4,31)= 1.028 [0.408]	F(4,32)= 0.441 [0.778]
Non-Linearity / Heteroskedasticity	F(3,31)= 1.913 [0.148]	F(3,32)= 0.711 [0.553]
Non-Independence	F(2,31)= 0.383 [0.685]	F(2,32)= 1.874 [0.170]
SCR		
Joint Significance	F(10,55)= 3.684 [0.001]*	F(9,56)= 7.894 [0.000]*
Non-Constancy	F(4,55)= 0.754 [0.559]	F(4,56)= 2.428 [0.058]
Non-Linearity / Heteroskedasticity	F(3,55)= 2.801 [0.048]*	F(3,56)= 20.971 [0.000]*
Non-Independence	F(2,55)= 1.837 [0.169]	F(2,56)= 0.503 [0.608]

Table A8: Misspecification tests for the AR models for the exogenous variables (continued)

TRN	$\hat{\nu}_t$	$\hat{\nu}_t^2$
Joint Significance	F(10,55)= 0.404 [0.939]	F(9,56)= 1.221 [0.301]
Non-Constancy	F(4,55)= 0.618 [0.651]	F(4,56)= 1.608 [0.185]
Non-Linearity / Heteroskedasticity	F(3,55)= 1.046 [0.380]	F(3,56)= 0.531 [0.663]
Non-Independence	F(2,55)= 0.018 [0.982]	F(2,56)= 0.802 [0.454]
WIN		
Joint Significance	F(10,55)= 0.380 [0.940]	F(9,56)= 1.341 [0.243]
Non-Constancy	F(4,55)= 0.514 [0.726]	F(4,56)= 1.526 [0.207]
Non-Linearity / Heteroskedasticity	F(3,55)= 0.542 [0.585]	F(3,56)= 0.592 [0.556]
Non-Independence	F(2,55)= 0.433 [0.651]	F(2,56)= 0.298 [0.743]