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A small macro econometric model of the US economy

Statistics Norway/Research Department

Abstract

A small macro econometric model of the US economy is developed to work with FRISBEE, a model of the international oil market. Macro models for other countries are developed or under development. The aim is to facilitate simulation of interaction between the international oil market and the surrounding macro environment. The purpose of this report is to document the US model. A simulation where the oil price is kept at the 1998 level of 12.7 per barrel throughout 2006, illustrates central model properties. Interaction with other macro models and FRISBEE is left for later research.

1. Introduction[1]

The macro econometric model of the US economy described in this report is part of a project in Statistics Norway, developing macro economic models of the major countries and regions in FRISBEE, a model of the international oil market (Aune et al 2005). The aim of the project is to facilitate simulation of interaction between the oil market and the international economy, both for forecasting purposes and to enable comparison of historical (counterfactual) as well as future scenarios. Macro models of the euro area (Korvald 2006), China (Glomsrød 2007) and Saudi Arabia (Johansen and Magnussen 1996) are developed or under development and available for the same purpose. There are also plans for development of a model of the Russian economy, starting in 2008. The oil market is of importance for macro economic developments and vice versa, and a unified model framework should therefore be a useful contribution to understand relationships between the different markets and regions.

The US economy is heavily dependent on imported oil, as most OECD countries, and the oil price is of importance for the economic development. To analyse effects of the oil price on the US economy, a macro econometric model of the US economy is developed, containing 9 estimated equations – covering major national account variables, prices and the labour market – and a number of identities.

The development of the model is done with an eye to the FRISBEE model. FRISBEE is a recursively dynamic partial equilibrium model of the global oil market. The world is divided into 13 regions. Oil companies produce oil in each region and sell it on the global market. There are three different end users in each region consuming oil products, bought at regional prices linked to the international market. It is assumed that the global oil market clears in all periods, implying an oil price that equals total supply and total demand in all regions (Aune et al 2005).

There exists a variety of macro econometric models for the global economy and individual countries. See Granger (2007) for an overview and evaluation of several global models. The justification of the model of the US economy presented in the following is first and foremost that it should be compatible with FRISBEE. The present report is limited to a presentation of the US model. Interaction with FRISBEE and the other macro models is left for later work.

The outline of the report is as follows: There is a brief description of some vital aspects of the oil market and its importance to the US economy in section 2. In section 3 there is a general introduction to the model, followed by a discussion of the econometric equations and central identities in section 4

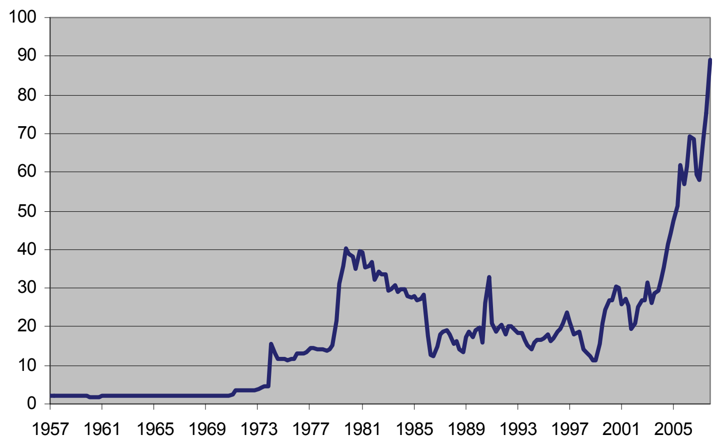
[1] Thanks to Torbjørn Eika, Håvard Hungnes and Roger Hammersland for comments and suggestions.

and 5 respectively. Section 4 also presents data sources, explains estimation procedures and presents results of the empirical investigations. In section 6 there is an evaluation of overall model performance, while section 7 reports the effects of a change in the oil price. Section 8 contains a discussion of possible extensions and modifications of the model. The final section sums up and concludes.

2. The oil market and the US economy

The oil price is volatile, as Figure 1 illustrates. Several of the major oil price shocks have been initiated by political conflicts in the Middle East. 40 per cent of global oil production originates from the Organisation of Petroleum Exporting Countries (OPEC), and 2/3 of the known reserves.[2] OPEC operates as a cartel with price control as an explicit goal. The member countries meet biannually, to negotiate production quotas. With high market shares, a coordinated OPEC could have a significant influence on the oil price, as for instance in 1999, when reduced supply caused the oil price to rice markedly. As a cartel, OPEC faces coordination problems as individual countries have incentives to produce more than allowed by their quotas. The decline in oil prices in 1986 is an example of a brake down in the cartel, as several member countries exceeded their quotas. Since 2000, the oil price has sky rocketed, with increasing tensions in the Middle East and increasing demand growth for oil from high growth developing countries as China and India.

Figure 1. Brent Blend USD per barrel



Globally, oil consumption as a share of total energy consumption fell from 46.2 per cent in 1973 to 35 per cent in 2005, see Figure 2. Natural gas and nuclear power have increased their market shares substantially. Figure 3 shows that OPECs share of global oil production shrunk by 5.9 percentage points in the same period, to 31.1 per cent. Asia increased its share by almost 80 per cent and Africa by 20 per cent, to 9.2 and 12.1 per cent respectively.

The US is the world's third largest oil producer, behind Saudi Arabia and Russia respectively. It is also by far the greatest consumer and net importer of oil, see Table 1. According to Energy Information Administration (IEA), net imports were 12.22 million barrels per day in 2006, just short of 60 per cent of total consumption. It follows that the US is heavily dependant on foreign oil. Fluctuations in the oil price may thus have a significant impact on the economy.

US imports of oil have increased continuously since World War 2, with one exception. Oil imports declined from 1979 to 1985, partly due to high oil prices – as a result of the oil crisis that occurred in the wake of the Iranian revolution in 1979 and the war between Iran and Iraq starting in 1980 – and policy measures in the US (and most other OECD countries) to increase energy efficiency and domestic energy production, see Figure 4. Since 1985, oil imports have increased threefold.

Oil intensity in the US economy, measured as oil consumption (million barrels per day) relative to real GDP, has fallen since the early 1970s, see Figure 5. Oil intensity has fallen globally, especially in industrialized countries, after the two oil price shocks in the 1970s. In the US, oil intensity is more than halved since 1973. This reflects a shift from oil intensive production to increased production of services, and a general increase in energy efficiency in the industry. It follows that the direct effect the oil price on the trade balance is reduced.

Oil price increases are particularly challenging for monetary policy in oil importing countries. It can cause high inflation and low economic growth simultaneously, so called stagflation. High inflation calls for high interest rates, which is bad for growth. Thus, monetary policy response is of great importance for the effect of oil price hikes on the real economy. Bernanke, Gertler and Watson (1997) argue that the American central bank strangled the economy with higher interest rates after the oil price shocks in 1973 and 1979.

[2] In late 2007, OPEC members were Algeria, Angola, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, Venezuela and Ecuador.

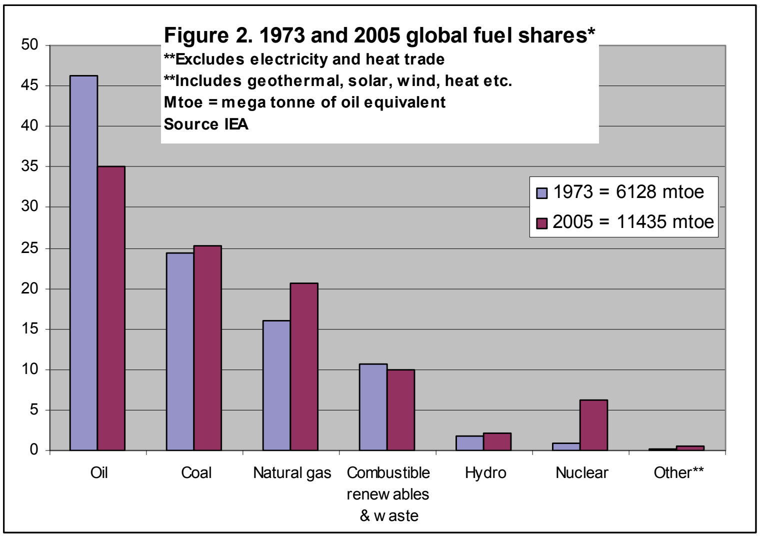


Figure 2. 1973 and 2005 global fuel shares*
**Excludes electricity and heat trade
**Includes geothermal, solar, wind, heat etc.
Mtoe = mega tonne of oil equivalent
Source IEA
1973 = 6128 mtoe
2005 = 11435 mtoe
50
45
40
35
30
25
20
15
10
5
0
Oil
Coal
Natural gas
Combustible renew ables & w aste
Hydro
Nuclear
Other**

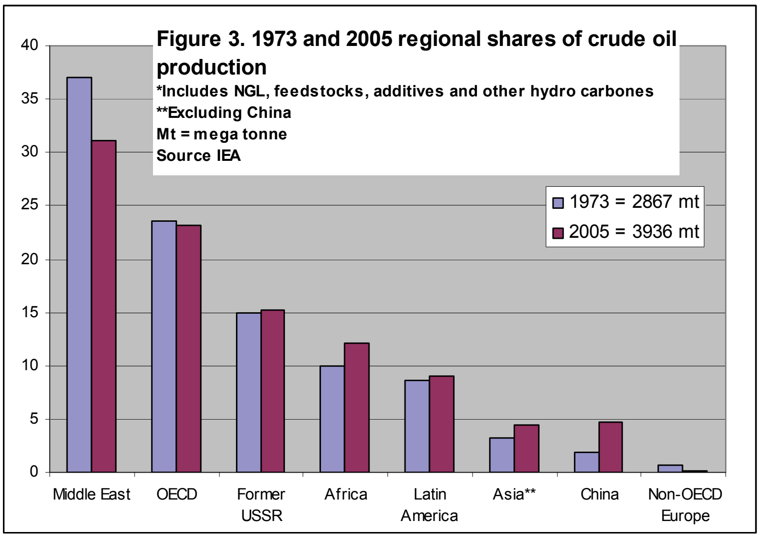


Figure 3. 1973 and 2005 regional shares of crude oil production
*Includes NGL, feedstocks, additives and other hydro carbones
**Excluding China
Mt = mega tonne
Source IEA
1973 = 2867 mt
2005 = 3936 mt
40
35
30
25
20
15
10
5
0
Middle East
OECD
Former USSR
Africa
Latin America
Asia**
China
Non-OECD Europe

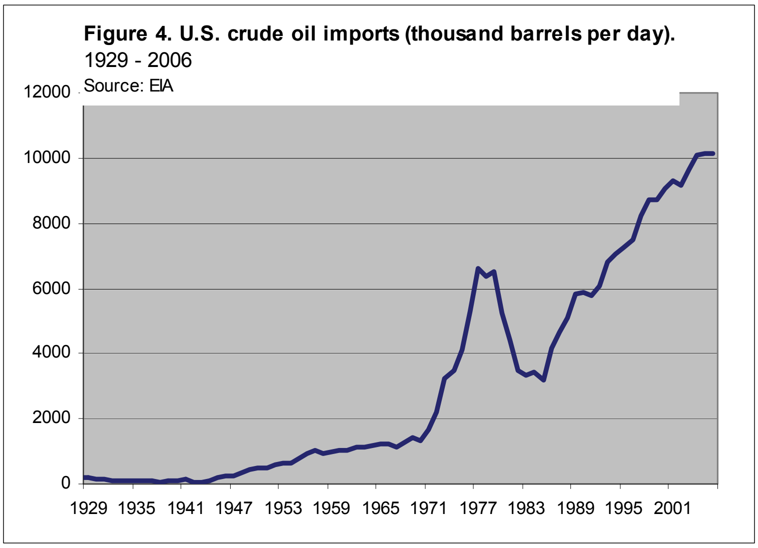


Figure 4. U.S. crude oil imports (thousand barrels per day).
1929 - 2006
Source: EIA
12000
10000
8000
6000
4000
2000
0
1929
1935
1941
1947
1953
1959
1965
1971
1977
1983
1989
1995
2001

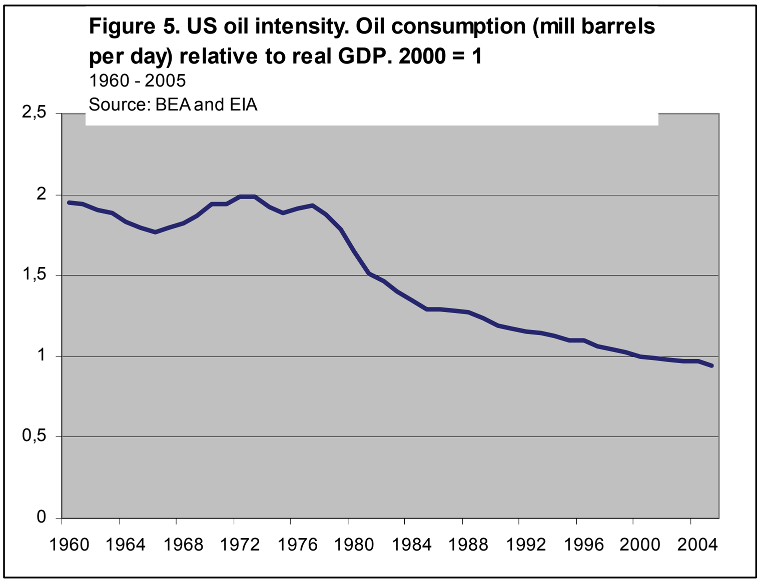


Table 1
Top world oil producers and consumers*
Thousand barrels per day

Rank	Country	Production
Top World Oil Producers, 2006		
Rank	**Country**	**Production**
1	Saudi Arabia	10719
2	Russia	9668
3	United States	8367
4	Iran	4146
5	China	3836
Top World Oil Consumers, 2006		
Rank	**Country**	**Consumption**
1	United States	20588
2	China	7274
3	Japan	5222
4	Russia	3103
5	Germany	2630
Top World Oil Net Importers, 2006		
Rank	**Country**	**Net Imports**
1	United States	12220
2	Japan	5097
3	China	3438
4	Germany	2483
5	KoreaSouth	2150
Top World Oil Net Exporters, 2006		
Rank	**Country**	**Net Exports**
1	Saudi Arabia	8651
2	Russia	6565
3	Norway	2542
4	Iran	2519
5	United Arab E	2515

*Oil production includes crude oil, lease condensates, natural gas liquids, other liquids, and refinery gain.
Source: EIA: International Energy Annual (2000-2004), International Petroleum Monthly (2005-2006).

3. Model description

The model of the US economy, hereby referred to as the US model, is a macro econometric model. The model is simple compared to large scale macro econometric models like for instance National Institute of Economic and Social Research's NIGEM model (Barrel et al 2001)[3], Ray C. Fair's US model (Fair 2004) and Statistics Norway's MODAG (Baug et al 2004), and more in line with the small scale country models in Fair's global model (Fair 2004) and the Norwegian Aggregate Model (NAM) (cf. Nymoen 2008).

The US model contains 9 estimated equations, and a number of identities. Household consumption, private domestic investment, exports and imports are modelled econometrically. Government expenditure is determined outside the model. Real GDP follows as the sum of domestic demand and net exports. Furthermore, there are estimated equations for consumer prices and the GDP deflator, and three equations describing the labour market. The model facilitates analyses of, among other things, effects on the economy of changes in interest rates, government expenditure, international demand and prices – including the oil price.

4. Data and estimation

The model is estimated on annual data, to serve FRISBEE. National accounts data are from Bureau of economic Analyses. Labour market data and data for interest rates, household wealth and household income are from the Fair model data base. The oil price and data for the G7 countries are from OECD Economic Outlook and OECD Main Economic Indicators. Se Appendix A for details.

The software EViews6 is used for all estimation and simulation procedures. The estimation periods were chosen based on data availability. The shortest time series (the GDP deflator for the G7 countries) begins in 1970. Because of dynamics, simulation of the full model can start in 1973.

The modeling strategy is the general to specific approach (cf. Davidson et al (1978)), using ordinary least squares to estimate equilibrium correction models. Restrictions based on economic theory are applied when statistical support is found. Other parameter restrictions are implemented if contributing to simplify the model without reducing the fit. It is also emphasized that the final estimated equations should pass standard statistical tests for serial correlation, heteroscedasticity and normality in the residuals. Parameter stability is tested through recursive estimation. Statistical outliers are removed by impulse dummies if explainable and/or if substantial improvement in residual properties are achieved.

[3] See also http://www.niesr.ac.uk/research/research.php#1

D is a difference operator when appearing in front of a variable name ($DX_t = X_t - X_{t-1}$). Dyy_t represents an impulse dummy variable for year yy. U_i is the error term in Equation i = 1,2,…,9.

In all estimated equations the coefficient relating to the equilibrium correction term is significant with the right sign, indicating a cointegrating relationship between the variables in the long run.

The assumption of *normal distribution* of the residuals is tested. The null hypothesis of normal distribution is not rejected for any of the equations at the five per cent level. A histogram and the Jarque-Bera statistic are reported in appendix B.

The ARCH test for *heteroskedasticity* in the residual regresses the squared residuals on lagged squared residuals and a constant. In the presence of heteroskedasticity, ordinary least squares estimates are still consistent, but the conventional computed standard errors are no longer valid. Heteroscedasticity does not appear to pose a problem in any of the equations, with the possible exception of the equation for employment (E), where the null hypothesis of no heteroskedasticity is rejected on the five per cent level, but not on the 1 per cent level, see appendix C.

If the error term is *serially correlated*, the estimated OLS standard errors are invalid and the estimated coefficients will be biased and inconsistent due to the presence of a lagged dependent variable on the right-hand side. The Durbin-Watson statistic is not appropriate as a test for serial correlation when there is a lagged dependent variable on the right-hand side of the equation. The Breusch-Godfrey LM-test does not reject the null hypothesis of no serial correlation up to order four for any of the equations at the five per cent level, see appendix D.

Appendix E displays *recursive coeffisient estimates*. They enable you to trace the evolution of estimates for a coefficient as an increasing number of observations are used in the estimation. Two standard error bands around the estimated coefficients are also shown. If the coefficient displays significant variation as more data is added, it is a strong indication of instability. In both trade equations there are indications of a structural break in the second half of the 1990's. Impulse- and step dummy variables did not do the trick on either occasion, although an impulse dummy in the export equation reduced the problem. However, recursive estimation of the residuals does not indicate instability (see below). As for the other equations, recursive coefficient estimates reveal no major cause for concern.

Appendix F displays plots of *recursive residuals* for each equation. Plus/minus two standard errors are shown at each point. Residuals outside the standard error bands would suggest instability in the equation parameters. At the 5 per cent level, 5 observations out of 100 outside the error band are acceptable. This test does not give strong indications of instability for any of the equations.

Estimation results for the nine equations are discussed below. Regression output and test statistics reported with each equation are briefly explained in Box 1. Appendix G displays actual and fitted values of the dependent variable and the residuals from the regression for each equation.

Box1. Regression output and test statistics

The **R-squared** (R^2) statistic measures the success of the regression in predicting the values of the dependent variable within the sample. The statistic will equal one if the regression fits perfectly, and zero if it fits no better than the simple mean of the dependent variable. The **adjusted R^2** penalizes the R^2 for the addition of regressors which do not contribute to the explanatory power of the model.

The standard error **(S.E.) of the regression** is a summary measure based on the estimated variance of the residuals.

The **Durbin-Watson** (DW) is a test for first order serial correlation in the residuals. As a rule of thumb, if the DW is less than 2, there is evidence of positive serial correlation. if there are lagged dependent variables on the right-hand side of the regression, the DW test is no longer valid. Additional testing of serial correlation is reported in appendix D.

The **Akaike-**, **Schwarz-** and **Hannan-Quinn information criteria** provide measures of information that strikes a balance goodness of fit and parsimonious specification of the model, and are used as a guides in model selection.

The ***F*-statistic** reported in the regression output is from a test of the hypothesis that *all* of the slope coefficients (excluding the constant, or intercept) in a regression are zero.

The **Prob(F-statistic)** shows the probability of drawing a *t*-statistic (or a *z*-statistic) as extreme as the one actually observed, under the assumption that the errors are normally distributed, or that the estimated coefficients are asymptotically normally distributed.

The Table also shows the **mean** and the **standard deviation** of the endogenous (dependent) variable.

Equation 1, CONS = household consumption expenditure

Dependent Variable: D(LOG(CONS))
Method: Least Squares
Sample: 1955 2006
Included observations: 52

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.299773	0.302629	4.294932	0.0001
D(LOG(CONS(-1)))	0.144095	0.077106	1.868788	0.0679
D(LOG(YD)-LOG(PCONS))	0.623112	0.079766	7.811766	0.0000
D(LOG(AA))-D(LOG(AA(-2)))	0.101161	0.021837	4.632584	0.0000
CIC(-1)*	-0.426326	0.099820	-4.270940	0.0001

R-squared	0.771139	Mean dependent var	0.035177
Adjusted R-squared	0.751661	S.D. dependent var	0.016641
S.E. of regression	0.008293	Akaike info criterion	-6.655631
Sum squared resid	0.003232	Schwarz criterion	-6.468011
Log likelihood	178.0464	Hannan-Quinn criter.	-6.583702
F-statistic	39.59114	Durbin-Watson stat	1.942561
Prob(F-statistic)	0.000000		

*CIC = LOG(CONS) -0.247226 * LOG(AA) +0.00129085 * RSS -0.752774 * (LOG(YD)-LOG(PCONS)) -0.00128515 * TREND

Household consumption expenditure (CONS) is modelled in Equation 1. In the long run, a one per cent increase in real disposable income (YD/PCONS) and wealth (AA) will, all else equal, lead to a 1 per cent increase in household consumption of 1 per cent – consumption is homogenous of degree one in real disposable income and wealth. There is also a negative long run effect of the real interest rate (RSS) on consumption. Thus, monetary policy has a direct effect on consumption through the interest rate. There are positive short run effects of real disposable income and (accelerating) wealth.[4]

[4] Equation 1 was derived using the multivariate cointegration procedure proposed by Johansen (1988), and estimated in Pc Give (cf. Hendry and Doornik 2001).

Equation 2, I = gross domestic investment

Dependent Variable: D(LOG(I))
Method: Least Squares
Sample: 1958 - 2006
Included observations: 49

	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.815245	0.160187	-5.089320	0.0000
LOG(I(-1))-LOG(Y(-1))	-0.278930	0.063972	-4.360166	0.0001
T	0.003122	0.000654	4.772923	0.0000
D(LOG(Y))	3.710622	0.246474	15.05481	0.0000

R-squared	0.861312	Mean dependent var	0.042288
Adjusted R-squared	0.852066	S.D. dependent var	0.089499
S.E. of regression	0.034423	Akaike info criterion	-3.822057
Sum squared resid	0.053323	Schwarz criterion	-3.667622
Log likelihood	97.64039	Hannan-Quinn criter.	-3.763464
F-statistic	93.15623	Durbin-Watson stat	1.778381
Prob(F-statistic)	0.000000		

Gross domestic investments (I) depend positively on output (Y) in the long run. Increasing output leads to increasing demand for production capacity, as well as increased depreciation of capital, both inducing higher investments. A one per cent increase in output leads to a one per cent increase in investment per restriction. This homogeneity restriction is tested and not rejected. The statistical validity of the restriction depends on the inclusion of a deterministic trend (T), taking account of the fact that investments has grown more rapidly than GDP over time.

Equation 3, EX = exports

Dependent Variable: D(LOG(EX))
Method: Least Squares
Sample (adjusted): 1971 2006
Included observations: 36 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.121487	0.294684	-3.805732	0.0007
LOG(EX(-1))	-0.208785	0.069645	-2.997846	0.0056
LOG(PY(-1))	-0.923946	0.418017	-2.210308	0.0354
LOG(PYG7(-1))	0.620219	0.314695	1.970862	0.0587
LOG(YG7(-1))	0.862354	0.244082	3.533048	0.0014
D(LOG(EX(-1)))	0.392370	0.102559	3.825794	0.0007
D(LOG(YG7))	2.168593	0.381260	5.687957	0.0000
D01	-0.100649	0.031249	-3.220834	0.0032

R-squared	0.763650	Mean dependent var	0.058038
Adjusted R-squared	0.704562	S.D. dependent var	0.053712
S.E. of regression	0.029195	Akaike info criterion	-4.036525
Sum squared resid	0.023865	Schwarz criterion	-3.684632
Log likelihood	80.65744	Hannan-Quinn criter.	-3.913704
F-statistic	12.92404	Durbin-Watson stat	2.099044
Prob(F-statistic)	0.000000		

Equation 3 explains exports (EX). International demand (Y7) and international prices (PY7) are proxied by GDP and the GDP deflator for the G7 countries respectively. The GDP deflator (PY) replaces the export price, which was not significant. In the long run exports depend positively on international demand an international prices and negatively on domestic prices. This is in line with the standard export model proposed by Armington (1969). Price homogeneity is not rejected by the standard errors. However, if this restriction is imposed explicitly, the cointegrating relationship between the variables breaks down. There are positive short run effects of international demand.

Equation 4, IM = imports

Dependent Variable: D(LOG(IM))
Method: Least Squares
Sample: 1959 - 2006
Included observations: 48

	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.980034	0.869934	-3.425584	0.0014
LOG(IM(-1))	-0.279478	0.081846	-3.414663	0.0014
LOG((CONS(-1)+G(-1)+I(-1)))	0.548627	0.158117	3.469763	0.0012
LOG(PY(-1)/PIM(-1))	0.098175	0.036744	2.671909	0.0107
D(LOG(PY(-1)/PIM(-1)))	0.324715	0.079323	4.093551	0.0002
D(YGAP)	0.021409	0.002380	8.994420	0.0000

R-squared	0.810428	Mean dependent var	0.063323
Adjusted R-squared	0.787860	S.D. dependent var	0.060360
S.E. of regression	0.027801	Akaike info criterion	-4.211022
Sum squared resid	0.032462	Schwarz criterion	-3.977122
Log likelihood	107.0645	Hannan-Quinn criter.	-4.122631
F-statistic	35.91036	Durbin-Watson stat	1.724719
Prob(F-statistic)	0.000000		

Equation 4 explains imports (IM) as a function of domestic demand and relative prices. Increased domestic demand leads to increased imports. If domestic prices increase relative to prices on imported goods and services - all else being equal - imports will increase. Domestic demand is represented by the sum of household consumption (CONS), government consumption and investment (G) and private investment (I), implying identical marginal import elasticity for all variables. This restriction is tested and not rejected. PIM is the import price. A domestic price deflator was calculated by weighing together the deflators for household consumption, private investment and government consumption and investment, but the GDP-deflator proved a better alternative due to superior statistical performance. There are also positive short run effects of relative prices and domestic economic activity. Price homogeneity was tested and not rejected, both in the long and the short run.

Equation 5, L = labour force

Dependent Variable: D(LOG(L))
Method: Least Squares
Sample: 1956 2006
Included observations: 51

	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.415533	0.236648	-1.755913	0.0861
LOG(L(-1))	-0.075518	0.020345	-3.711846	0.0006
LOG(AA(-1))	-0.032491	0.008222	-3.951682	0.0003
LOG(Y(-1))	0.088929	0.021371	4.161130	0.0001
D(UR)	-0.194092	0.054386	-3.568803	0.0009
D(LOG(POP(-3)))	1.120444	0.206223	5.433155	0.0000
LOG(WF(-1)/(PY(-1)))	-0.036181	0.018287	-1.978541	0.0541

R-squared	0.729464	Mean dependent var	0.015786
Adjusted R-squared	0.692572	S.D. dependent var	0.006450
S.E. of regression	0.003576	Akaike info criterion	-8.302045
Sum squared resid	0.000563	Schwarz criterion	-8.036893
Log likelihood	218.7022	Hannan-Quinn criter.	-8.200723
F-statistic	19.77331	Durbin-Watson stat	1.965739
Prob(F-statistic)	0.000000		

Labour supply depends negatively on net wealth (AA) and positively on output (Y) in the long run. There is also a negative effect of the real wage rate when the wage rate (WF deflated by the GDP deflator, PY). The effect of a change in the real wage rate can be separated in a substitution effect and an income effect. A higher wage increases the alternative cost of leisure time, creating a positive substitution effect towards increased labour supply. The income effect is negative, as leisure time becomes more affordable, and thereby reduces labour supply. The net effect of an increase in the real wage rate is therefore dubious, and left for data to answer. Furthermore, there is a positive lagged effect of growth in the population (POP). The unemployment rate (UR) is significant in the short run with a negative coefficient, indicating a discouraged worker effect: labour supply drops when unemployment increases.

Equation 6, E = employment

Dependent Variable: D(LOG(E))
Method: Least Squares
Sample: 1954 - 2006
Included observations: 53

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.027374	0.015290	1.790314	0.0797
LOG(E(-1))	-0.071968	0.034126	-2.108910	0.0402
LOG(Y(-1))	0.036712	0.017923	2.048311	0.0460
D(LOG(E(-1)))	0.363587	0.066400	5.475736	0.0000
D(YGAP)	0.005578	0.000441	12.65476	0.0000

R-squared	0.803073	Mean dependent var	0.015237
Adjusted R-squared	0.786663	S.D. dependent var	0.013434
S.E. of regression	0.006205	Akaike info criterion	-7.237385
Sum squared resid	0.001848	Schwarz criterion	-7.051508
Log likelihood	196.7907	Hannan-Quinn criter.	-7.165906
F-statistic	48.93643	Durbin-Watson stat	2.294657
Prob(F-statistic)	0.000000		

Employment (E) depends on output (Y), with output growing at about twice the pace of employment, implying increasing labour productivity. Real wage is statistically significant, but with the wrong sign (inconsistent with economic theory), and is left out. There are also short run effects of economic activity, represented by the output gap (YGAP). Replacing the output gap in the short run dynamics by GDP leads to rejection of cointegration.

Equation 7, WF = average wage per hour

Dependent Variable: D(LOG(WF))
Method: Least Squares
Sample: 1959 - 2006
Included observations: 48

	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.033607	1.010480	-3.002145	0.0046
LOG(WF(-1))	-0.230776	0.079572	-2.900210	0.0060
LOG(PY(-1))	0.215937	0.082322	2.623080	0.0122
LOG(Y(-1)/E(-1))	0.274614	0.079911	3.436485	0.0014
D(LOG(PY))	0.607988	0.118001	5.152402	0.0000
D(LOG(WF(-1)))	0.324156	0.131698	2.461355	0.0181
D93	-0.037425	0.012071	-3.100528	0.0035

R-squared	0.760293	Mean dependent var	0.053046
Adjusted R-squared	0.725214	S.D. dependent var	0.021541
S.E. of regression	0.011292	Akaike info criterion	-5.995449
Sum squared resid	0.005228	Schwarz criterion	-5.722566
Log likelihood	150.8908	Hannan-Quinn criter.	-5.892326
F-statistic	21.67368	Durbin-Watson stat	2.356662
Prob(F-statistic)	0.000000		

In the long run, average wage per hour (WF) is determined by the GDP-deflator (PY) and productivity. Productivity is measured by production per employed (Y/E). There are also short run effects of the GDP deflator and wage. An impulse dummy for 1993 (D93) is included in the equation, without which homoscedasticity of the residual is rejected.

Equation 8, **PCONS** = consumer prices

Dependent Variable: D(LOG(PCONS))
Method: Least Squares
Sample: 1962 2006
Included observations: 45

	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.074884	0.016789	-4.460346	0.0001
LOG(PCONS(-1))	-0.151302	0.028773	-5.258450	0.0000
LOG(ULC(-1))	0.164811	0.031496	5.232754	0.0000
D(LOG(POIL))	0.018719	0.002778	6.738613	0.0000
D(LOG(POIL(-1)))	0.009123	0.002999	3.041693	0.0044
D(LOG(ULC))	0.418550	0.041973	9.971886	0.0000
D(LOG(PCONS(-1)))	0.284395	0.065925	4.313905	0.0001
D00	-0.017807	0.004868	-3.657676	0.0008
D82	-0.022925	0.004769	-4.807110	0.0000

R-squared	0.972429	Mean dependent var	0.037740
Adjusted R-squared	0.966302	S.D. dependent var	0.023377
S.E. of regression	0.004291	Akaike info criterion	-7.887580
Sum squared resid	0.000663	Schwarz criterion	-7.526247
Log likelihood	186.4705	Hannan-Quinn criter.	-7.752878
F-statistic	158.7144	Durbin-Watson stat	2.168646
Prob(F-statistic)	0.000000		

Consumer price inflation (PCONS) depends on unit labour costs (ULC) in the long run. There are additional short run effects of the oil price (POIL) and unit labour costs.

Equation 9, PY = GDP deflator

Dependent Variable: D(LOG(PY))
Method: Least Squares
Sample: 1970 - 2006
Included observations: 37

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.145608	0.030274	4.809639	0.0000
LOG(PY(-1))	-0.059290	0.011084	-5.349296	0.0000
LOG(PIM(-1))	0.025315	0.007344	3.447155	0.0018
UR(-1)	-0.257310	0.081798	-3.145681	0.0039
LOG(POIL(-1))	0.012516	0.003417	3.662608	0.0010
D(LOG(PY(-1)))	0.165253	0.101295	1.631406	0.1140
D(LOG(PIM))	0.059895	0.018157	3.298729	0.0026
D(LOG(POIL))	0.010600	0.003854	2.750091	0.0103
D(LOG(PIM(-1)))	0.062771	0.015191	4.132214	0.0003

R-squared	0.977549	Mean dependent var	0.040392
Adjusted R-squared	0.971135	S.D. dependent var	0.023287
S.E. of regression	0.003956	Akaike info criterion	-8.019227
Sum squared resid	0.000438	Schwarz criterion	-7.627382
Log likelihood	157.3557	Hannan-Quinn criter.	-7.881083
F-statistic	152.3964	Durbin-Watson stat	1.706298
Prob(F-statistic)	0.000000		

In the long run, the GDP deflator (PY) is determined by import prices (PIM), oil prices (POIL) and the unemployment rate (UR). There are also short run effects of the GDP deflator, the import price and the oil price. No significant effect of the wage rate was found.

An overview of the estimated equations is listed below:

(1) CONS = c(YD/*PCONS, AA, RSS, U_1)

(2) I = i(Y, POIL, U_2)

(3) EX = exp[PYG7, PY, YG7, U_3]

(4) IM = im[PY/PIM, (CONS+I+G), YGAP, U_4]

(5) L = l(AA, WF/PY, UR, Y, POP, U_5)

(6) E = e(Y, YGAP, U_6)

(7) WF = wf(PY, Y/E, U_7)

(8) PCONS = pc(POIL, ULC, U_8)

(9) PY = py(UR, PIM, UR, POIL, U_9)

5. Identities

In this section, we take a closer look at important identities.

(12) Y = CONS + G + I + EX - IM + STAT

(13) YGAP = 100*(Y-YHP)/YHP

(14) UR = (L-E) /(L-JM)

(15) ULC = WF/(Y/H)

(16) RSS=RS-((PCONS/PCONS(-1))-1)*100

(17) YD = X + WF * JF * (HN + 1.5 * HO)

As shown in Equation 12, GDP (Y) equals the sum of household consumption, public consumption and investments, private sector investments, net exports and a term covering statistical discrepancies (STAT).

The GDP/output gap follows from Equation 13. The GDP trend (YHP) is calculated by a Hodrick Prescott filter (Hodrick and Prescott (1997). Lambda is set to 100, widely believed to produce a credible description of the cyclical developments of the US economy, cf. Kydland and Prescott (1990) and Ravn and Uhlig (2001).

The civilian unemployment rate is determined in Equation 14. JM is the number of military jobs - included in the definitions of employment and labour supply, E and L respectively - and is therefore subtracted in the denominator to derive the civilian unemployment rate. There are certain problems associated with determining the unemployment rate as a fraction. A fraction close to zero will be sensitive to small changes in the numerator and denominator, and may therefore be volatile. These problems can be addressed by modelling the unemployment rate directly, as a function of the explanatory variables in the labour supply and demand equations (5 and 6 respectively). Such efforts did not provide convincing however. The practical implications of the preferred approach are elaborated further in section 6.

Unit labour costs are calculated in Equation 15 by dividing average wage per hour (WF) by productivity, represented by real output (Y) per hour (H). Thus, increases in productivity lower unit labour costs while increases in hourly compensation raise them. If both series move equally, unit labour costs will remain unchanged.

Equation 16 defines the short real interest rate (RSS) as the difference between the three month money market rate (RS) and consumer price (PCONS) inflation.

Equation 17 endogenizes household disposable income (YD). YD is defined as the sum of wage income in the private sector (WF * JF * (HN + 1.5 * HO)) and other household income (X), where X follows residually.

6. Fit

Model evaluation is often based on forecasting properties and ability to reproduce history. When comparing predicted future values of endogenous variables with actual outcome, prediction errors are not only caused by the model, but also by exogenous variables. Furthermore, one has to wait for the future to become history, making data available, to enable comparison of predicted and realized values of endogenous variables. These problems can be avoided by making forecasts for a historical period. Then the "correct" exogenous variables are available, and only the model is to blame for forecast errors, not erroneous assumptions about the future paths of exogenous variables. A stringent evaluation is to test the model "out of sample". In this case the model is tested for a historical period, but after the estimation period. If the test is performed "in sample" the estimated coefficients reflects information from the forecast period and the test is not valid. However, testing the model out of sample another problem occurs: the model can not be estimated using the full sample. Giving up the last observations in the data set for evaluation purposes implies a loss to estimation. As the present model is estimated on yearly data, the number of observations is small. All available information is therefore utilized in estimation of the US model, and we are left with an in sample evaluation as the best alternative available in practice. When simulated data is compared to historical data within the estimation period, it is rather a description of how the model tracks/fits historical data than a test of forecasting properties. However, it is hard to imagine a model having good forecasting properties if it is not able to reproduce history in a realistic manner.

To assess the model, we start out by examining the ability of the model to provide one period ahead forecasts of the endogenous variables. Model predictions are compared with historical data, using actual values for both the exogenous and lagged endogenous variables of the model. Stochastic Monte Carlo simulation is used to provide a measure of uncertainty in the results, by adding error bounds of plus/minus two standard deviations to the predictions.

Figures 6 a-l in appendix I show that as a one-step ahead predictor, the model performs quite well for all variables, although the ability of the model to predict investment and the unemployment rate seems to be somewhat poorer than for the other variables. Error bounds around the predicted values of investment and unemployment are relatively wide, reflecting greater uncertainty. Remember that Y is not modeled directly, but is determined as the sum of four endogenous variables (CONS, EX, IM and I) and two exogenous variables (G and STAT), and seems to fit history quite well.

An alternative way of evaluating the model is to examine how the model performs when used to forecast many periods into "the future". In this case, forecasts from previous periods - and not actual historical data – are used when assigning values to the lagged endogenous terms in the model. The results now illustrate model performance if we in 1970 had used the model to forecast the next 36 years, assuming we had known the correct paths for the exogenous variables. Not surprisingly, the results displayed in Figures 7 a-l in appendix J now show more substantial deviations from actual outcomes and error bounds are wider. Fit still seems good for most variables.

The model performs well for household consumption (CONS). Investment (I) and imports (IM) seem to lose track somewhat in the late 1980s and early 1990s, and both are outside error bounds for a short period, but are back on track the last ten years of the estimation period. For exports (EX) however, fit to deteriorate from the late 1990s. The deflators for GDP and consumption shows relatively good fit, although PY is slightly underestimated for most of the 1980s and 1990s. Modelling of the labour market provides relatively good fit for labour supply (L). Fit for wage (WF) and particularly employment (E) is less good. Error bounds for the unemployment rate (UR) are wide and include 0 towards the end of the period, implying a possibility greater than zero for the nonsense outcome of a negative unemployment rate.

7. Changing the oil price

An efficient way to describe important properties of the model is by simulating the model with different assumptions for exogenous variables. This section illustrates the isolated effect of a change in the oil price (POIL) on the US economy. Isolated, because we keep all other exogenous variables – as interest rates, international demand and world prices – unchanged, some of which normally could have been expected to respond to a change in the oil price.

When the model is simulated using historical residuals, it reproduces the actual historical development of the data. Thus, when the residuals are set to their historical values in the alternative scenario with a higher oil price, it ensures that the difference between the actual and the alternative scenario reflects only the effect of the change in the oil price, and not model errors.

A 100 per cent sustained increase in the nominal oil price is simulated in the model; see Table 2 below and Figures 8 a-n. Inflation picks up immediately, and after eight years consumer prices are 7.1 per cent higher and the GDP deflator 4.5 per cent higher than in the reference scenario. Household consumption is down by 3.3 per cent and GDP is 4.2 percentage points lower. Exports and imports fall significantly more: this follows from high income elasticities, which is in line with what is commonly found in studies of trade elasticities (see for instance Marquez 2002). Employment is reduced by 3.0 per cent, while the labour force only falls by 1.3 percent. The unemployment rate thus increases, by 1.7 percentage points.

The effects of a change in the oil price is thus substantial in the model. This is in line with other studies, finding significant effects of the oil price on growth in developed economies; see for instance IEA (2004): "… a sustained $10 per barrel increase in oil prices from $25 to $35 would result in the OECD as a whole losing 0.4% of GDP in the first and second years of higher prices. Inflation would rise by half a percentage point and unemployment would also increase."

Table 1

100 per cent sustained increase in the oil price. Percentage deviation from reference scenario. *Deviation level

	1999	2000	2001	2002	2003	2004	2005	2006
CONS	-1,2	-1,8	-2,0	-2,2	-2,4	-2,6	-2,9	-3,3
E	-0,7	-1,3	-1,5	-1,7	-1,9	-2,3	-2,6	-3,0
EX	0,0	-0,7	-2,2	-4,3	-6,7	-9,1	-11,3	-13,3
I	-4,4	-5,5	-5,0	-5,2	-5,8	-6,8	-7,7	-8,6
IM	-2,6	-3,6	-3,6	-3,9	-4,3	-5,1	-5,8	-6,6
L	-0,1	-0,3	-0,4	-0,5	-0,7	-0,9	-1,1	-1,3
PCONS	2,0	3,6	4,4	4,8	5,3	5,9	6,5	7,1
PY	0,7	1,5	2,2	2,8	3,4	3,8	4,2	4,5
WF	0,4	1,0	1,5	2,1	2,6	2,9	3,2	3,3
Y	-1,2	-1,8	-1,9	-2,2	-2,6	-3,1	-3,7	-4,2
YD	0,3	0,7	1,1	1,5	1,8	2,1	2,3	2,4
UR*	0,6	1,0	1,0	1,1	1,2	1,3	1,5	1,7
RSS*	-2,0	-1,7	-0,7	-0,5	-0,5	-0,5	-0,6	-0,6
POIL	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

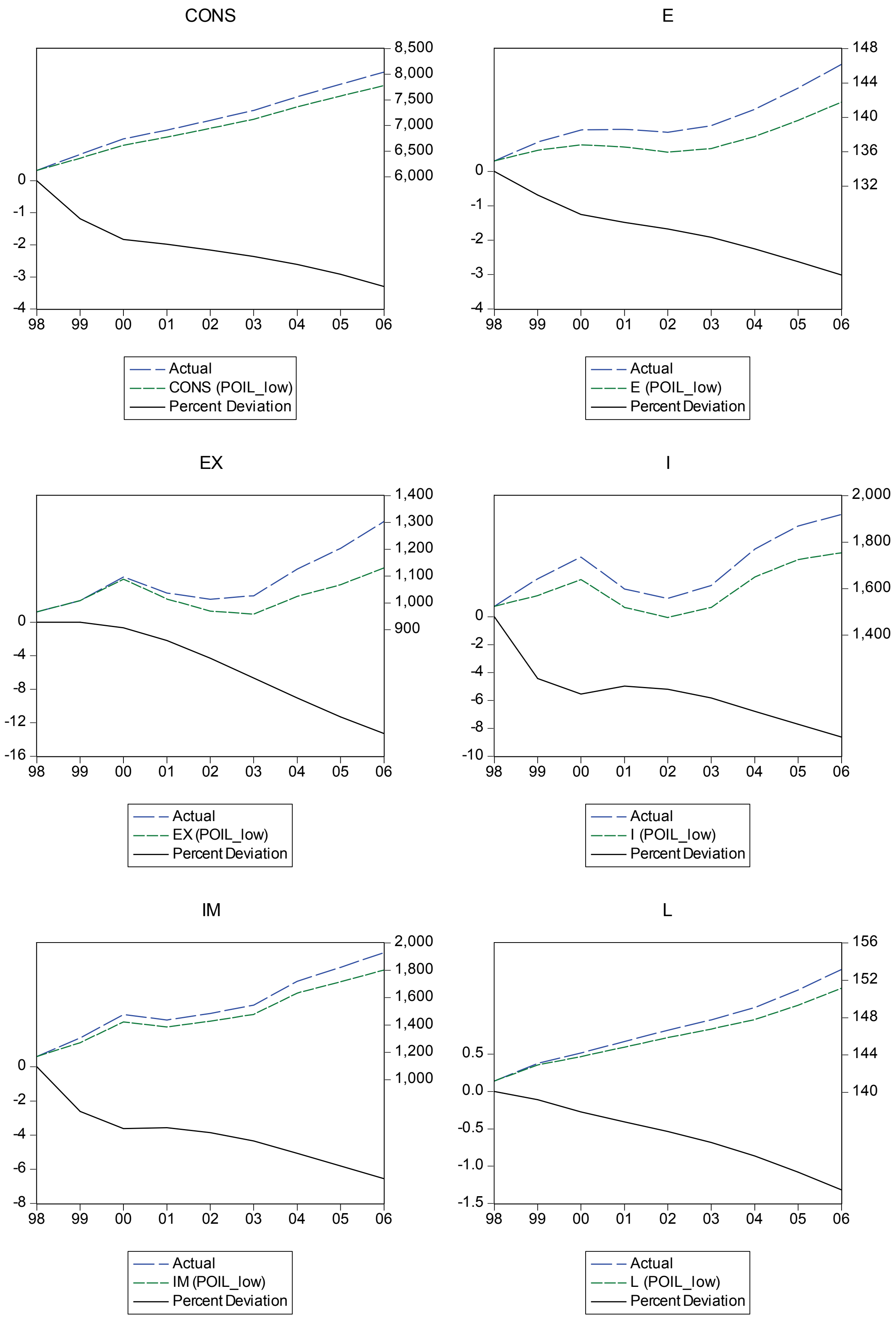
The oil price is included directly in the equations for the consumer and GDP deflators, and affects other variables indirectly through several channels in the model. A higher oil price yields higher consumer prices (PCONS), which weigh down on household consumption (CONS). GDP (Y) falls correspondingly, as well as the output gap (YGAP).[5] Lower economic activity leads to lower investment (I). Employment (E) falls more than labour supply (L), increasing the unemployment rate (UR). A smaller output gap (YGAP) points to lower wages (WF), but this is counteracted by higher prices (PY). The net effect is a somewhat higher nominal wage level, but the real wage is lower. Higher unemployment dampens the increase in the GDP deflator. Lower household consumption also reduces imports (IM), even though higher domestic prices (PY) pull in the opposite direction. Exports (EX) fall as a result of higher domestic export prices (proxied by PY), as international demand and

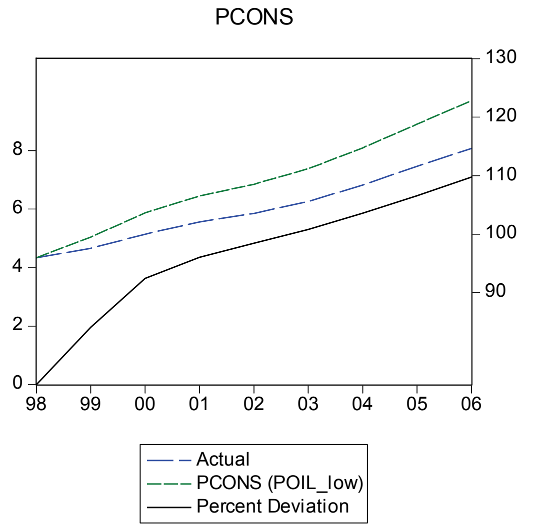
[5] Using the HP filter, the trend varies over time, causing the trend of Y to increase with an increase in Y itself. The calculated trend is based on the actual series of Y, and is exogenous in the model. In other words is the estimated GDP trend

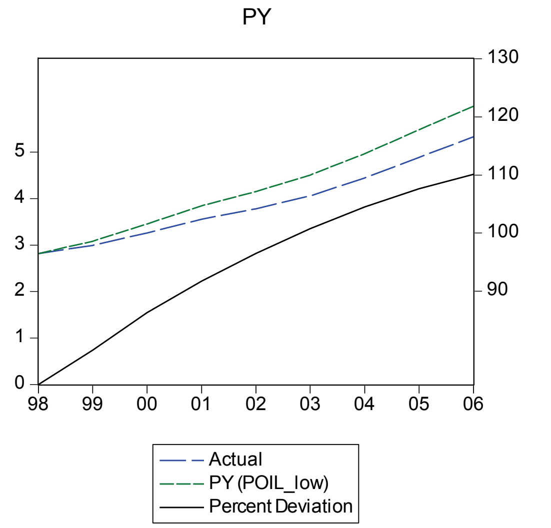
international prices keep their historical values in the alternative scenario. Exports falls more than imports and the trade balance deficit is 7.5 per cent higher after eight years. Outside the model, a higher oil price could be expected to produce lower international prices and lower international demand. These effects pull in opposite directions on US exports, leaving the net effect for empirical investigation. Furthermore, higher international prices could also be expected to reduce imports. See appendix H for other alternative scenarios, including exogenous shifts in the interest rate (RS), public spending and investment (G), foreign demand (YG7) and foreign prices (PG7).

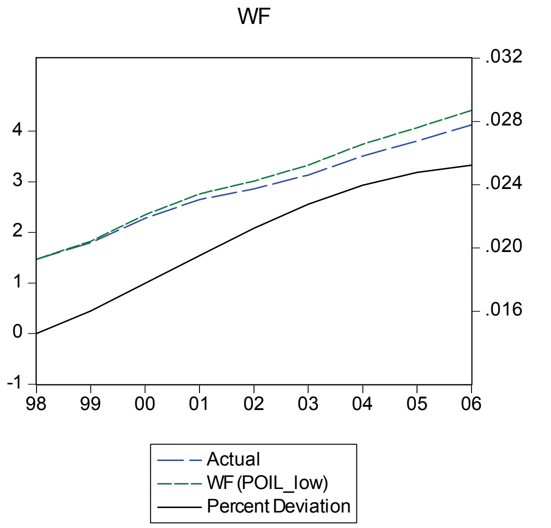
unaffected by the new GDP trajectory in the alternative scenario, and lower GDP thereby produces a smaller output gap (YGAP).

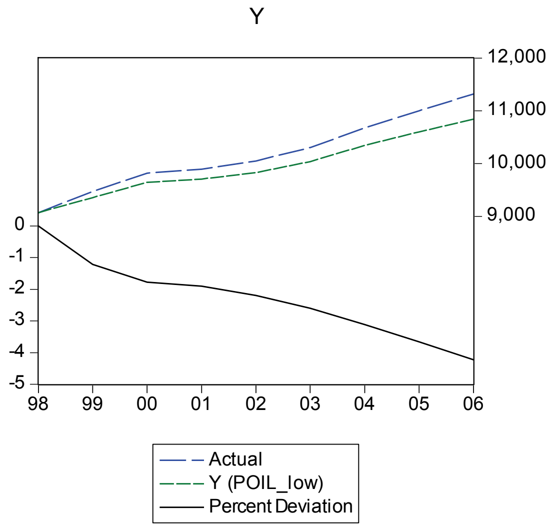
Figure 8, a-l. 100 per cent sustained increase in the oil price

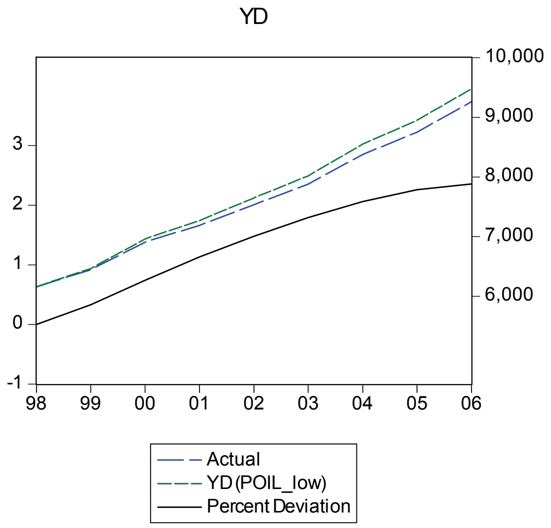


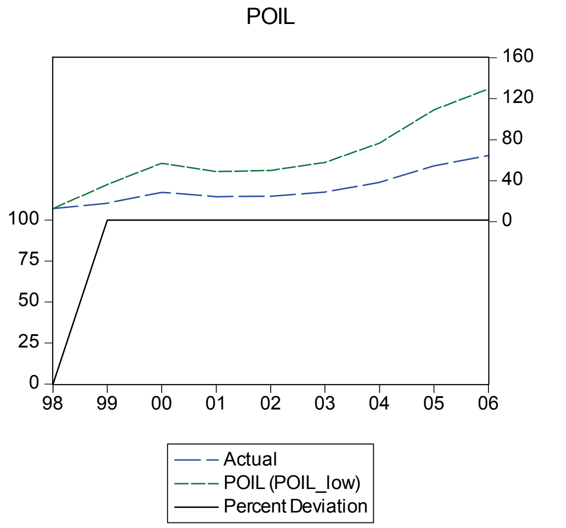

PCONS
130
120
110
100
90
8
6
4
2
0
98 99 00 01 02 03 04 05 06
Actual
PCONS (POIL_low)
Percent Deviation

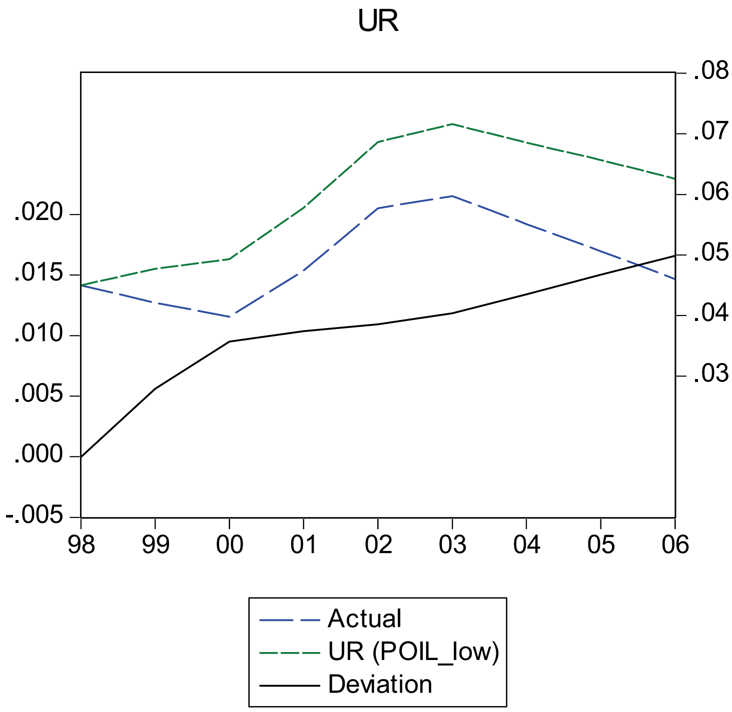

PY
130
120
110
100
90
5
4
3
2
1
0
98 99 00 01 02 03 04 05 06
Actual
PY (POIL_low)
Percent Deviation

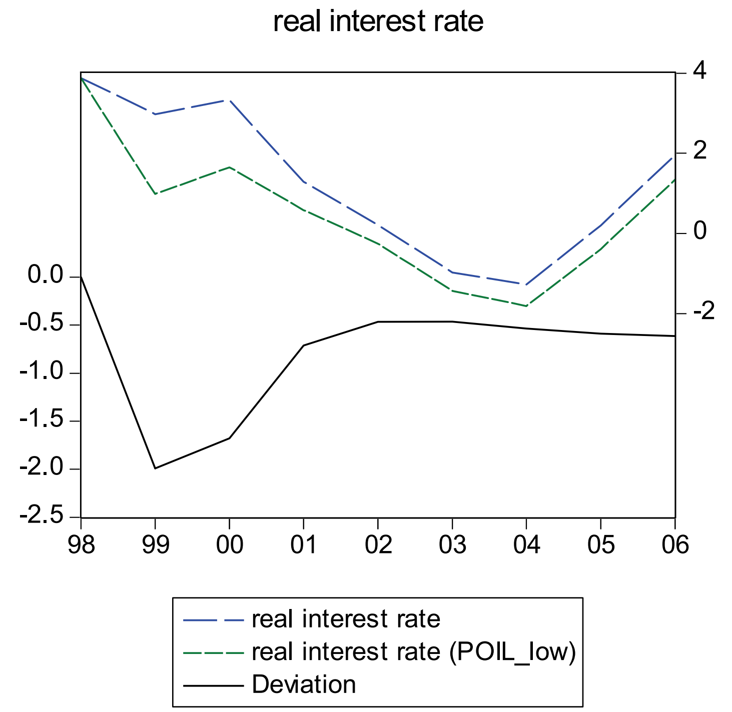

WF
.032
.028
.024
.020
.016
4
3
2
1
0
-1
98 99 00 01 02 03 04 05 06
Actual
WF (POIL_low)
Percent Deviation


Y
12,000
11,000
10,000
9,000
0
-1
-2
-3
-4
-5
98 99 00 01 02 03 04 05 06
Actual
Y (POIL_low)
Percent Deviation


YD
10,000
9,000
8,000
7,000
6,000
3
2
1
0
-1
98 99 00 01 02 03 04 05 06
Actual
YD (POIL_low)
Percent Deviation


POIL
160
120
80
40
0
100
75
50
25
0
98 99 00 01 02 03 04 05 06
Actual
POIL (POIL_low)
Percent Deviation


UR
.08
.07
.06
.05
.04
.03
.020
.015
.010
.005
.000
-.005
98
99
00
01
02
03
04
05
06
Actual
UR (POIL_low)
Deviation


real interest rate
4
2
0
-2
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
98
99
00
01
02
03
04
05
06
real interest rate
real interest rate (POIL_low)
Deviation

8. Extentions and modifications

The three month money market interest rate (RS) is exogenous in the model, but can easily be endogenized. Fair (2004) suggests a reaction function for the interest rate, where the American central bank is assumed to lean against the wind: the interest rate increases as a response to increasing inflation, and decreases as a response to an increasing unemployment rate.

(15) RS = rs(D(PC), UR)

In a global models, relations between countries and regions are typically taken care of by a trade matrix, see for instance Fair (2004). In the case of the FRISBEE macro models, modelling of trade flows are left for a later stage, when it is clear which countries and regions are included in the model system.

The same goes for exchange rates (ER). They are often modelled as a function of international interest rate- and inflation differentials and a vector of other relevant variables (Z). "*" indicates "abroad".

(16) ER = e(RS, RS*, PC, PC* ,Z)

It is also planned to include a detailed input-output matrix, to describe the production side of the economy – and in particular the link between the energy markets internally and to the rest of the economy. This would also be the link to FRISBEE. In a transitional period, one could also utilize input-output data to calculate weights for distribution of GDP on the various production sectors.

9. Summary and conclusion

The model of the US economy is made with the intention to operate it with FRISBEE, a model of the international oil market. The aim is to facilitate simulation of interaction between the international oil market and the surrounding macro environment – where the US model is supposed to be one among several models covering the major regions of the world economy - both for forecasting purposes and to be able to compare different historical (counterfactual) and future scenarios. Other macro models are developed or under development for the same purpose. The oil market is of importance for macro economic developments and vice versa, and a unified model framework should therefore be a useful contribution to understand relationships between the different markets and regions.

Independent of FRISBEE, the US model makes possible analyses of, among other things, effects of changes in interest rates, government expenditure, international demand and prices – including the oil price – on the US economy. The model can also be used for forecasting purposes. The estimated equations satisfy standard statistical tests of residual properties and parameter stability. The model is evaluated by simulating the model and comparing with historical data. Most variables are explained fairly well by the model. However, exports and the unemployment rate fit historical data relatively poorly, and therefore cause some concern.

An alternative scenario shows that a change in the oil price has significant effects in the model. The oil price is increased by 10 per cent on a permanent basis. This leads to markedly higher inflation, lower household consumption and GDP, and higher unemployment.

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Appendix A

Data definitions and sources

National accounts data are from Bureau of economic Analyses (BEA).[6] Labour market data and data for interest rates, household wealth and household income are from Bureau of Labor Statistics (BLS) and the Fair model data base (Fair).[7] The oil price and data for the G7 countries are from OECD Economic Outlook and OECD Main Economic Indicators.[8]

Variable	**Explanation**	**Source**
AA	Total net wealth of the household sector, real	Fair
CONS	Household consumption expenditure	BEA
Dt	Impulse dummy variable for year t	
E	Employment, non farm total (ew:usa09216)	BLS
EX	Exports	BEA
G	Government consumption expenditures and gross investment	BEA
H	Hours of labour input	Fair
I	Gross private domestic investment	BEA
IM	Imports	BEA
JF	Number of jobs, f, millions	Fair
JM	Number of military jobs, millions.	BLS
L	Labour force	BLS
PCONS	Consumer prices	BEA
PEX	Export prices	BEA
PIM	Import prices	BEA
POIL	Oil price	OECD Economic Outlook
POP	Non institutional population 16 and over, millions (ew:usa50025)	BLS
PY	GDP deflator	BEA
PYG7	GDP deflator G7	OECD Economic Outlook
RB	Bond Rate	Fair
RS	Short interest rate	Fair
STAT	Statistical discrepancy	BEA
T	Trend	

[6] http://www.bea.gov/national/nipaweb/SelectTable.asp?Popular=Y , table 1.1.6

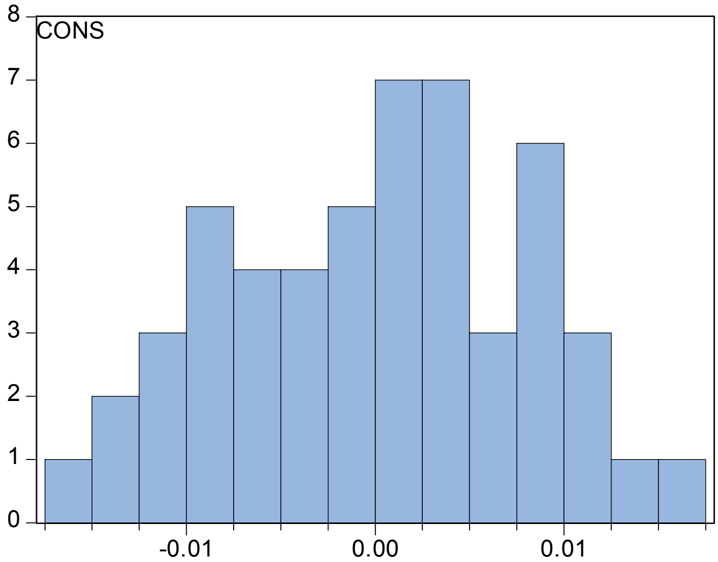
[7] http://fairmodel.econ.yale.edu/usdown.htm . Download "The US model in EViews", the database is included. Labour market data can also be downloaded directly from the primary source, Bureau of Labor Statistics: http://www.bls.gov

[8] G7GDP (MEI) = G7M.CMPGDP.VIXOBSA.A
G7GDP-deflator (Economic Outlook)=Y.BIG7.PGDP

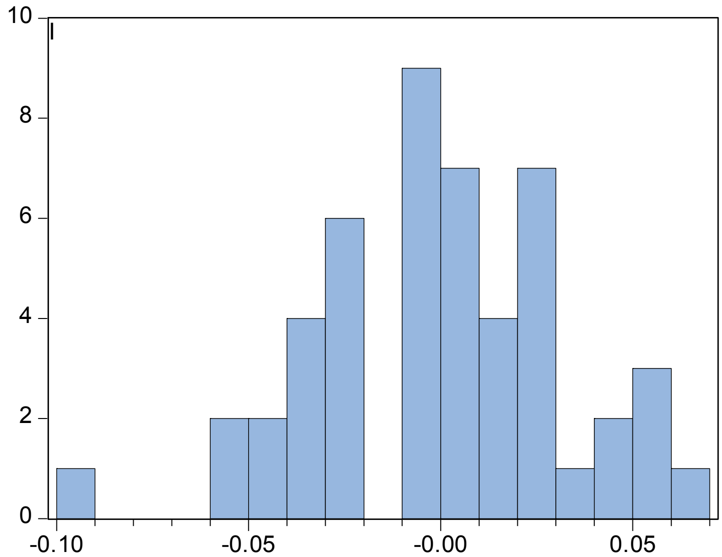
ULC	Unit labour cost	BLS
UR	Unemployment rate	BLS
WF	Average wage per hour excluding overtime, private sector	BLS
X	Household disposable income less private sector wage income	Equation 17
Y	Real GDP	BEA
YD	Disposable income of the household sector, nominal	Fair
YG7	Real GDP G7	OECD MEI
YGAP	Output gap	Benedictow
YHP	GDP trend (HP, Lambda 100)[9]	Benedictow

[9] For the purpose of HP- filtering, the GDP series was extended with forecasts to 2009 from http://fairmodel.econ.yale.edu/usdown.htm

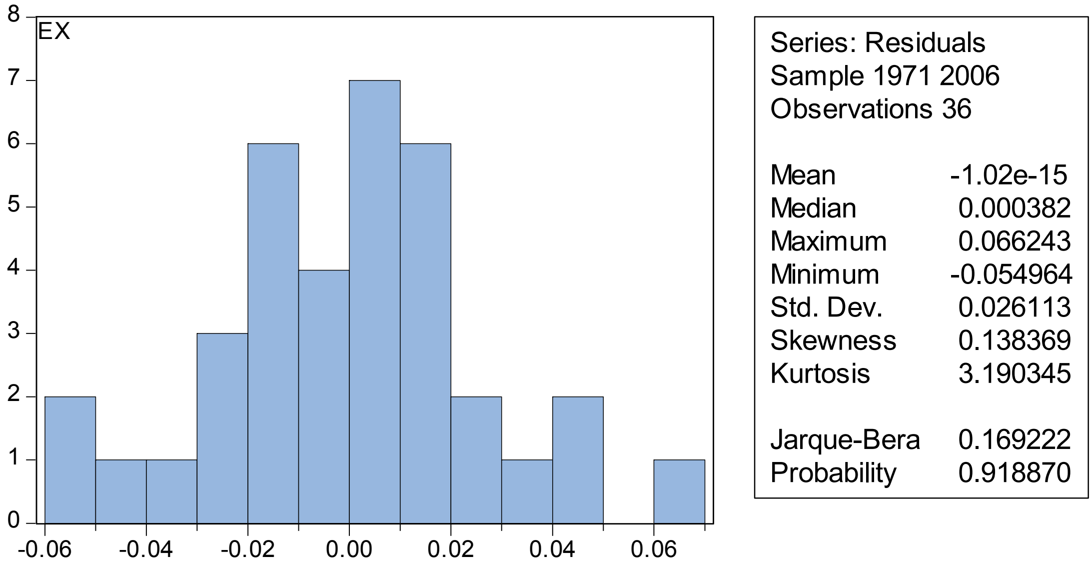
Testing normal distribution of residuals

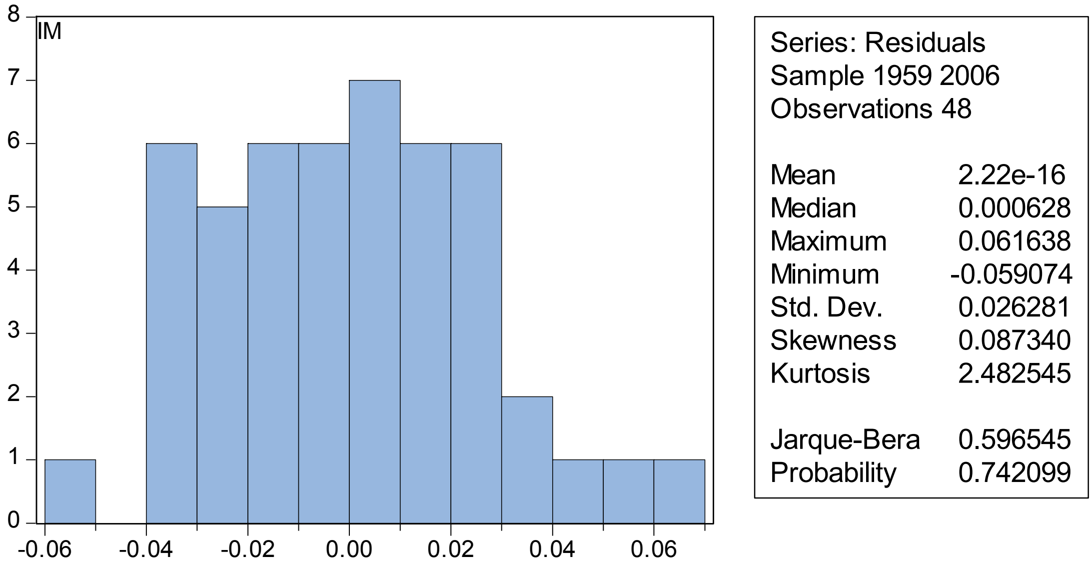


Series: Residuals	
Sample 1955 2006	
Observations 52	
Mean	-1.11e-16
Median	0.000419
Maximum	0.015514
Minimum	-0.016564
Std. Dev.	0.007961
Skewness	-0.111548
Kurtosis	2.220870
Jarque-Bera	1.423101
Probability	0.490883



Series: Residuals	
Sample 1958 2006	
Observations 49	
Mean	-7.40e-17
Median	0.004351
Maximum	0.065844
Minimum	-0.093731
Std. Dev.	0.033330
Skewness	-0.292195
Kurtosis	3.111746
Jarque-Bera	0.722745
Probability	0.696719


EX
8
7
6
5
4
3
2
1
0
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
Series: Residuals
Sample 1971 2006
Observations 36
Mean -1.02e-15
Median 0.000382
Maximum 0.066243
Minimum -0.054964
Std. Dev. 0.026113
Skewness 0.138369
Kurtosis 3.190345
Jarque-Bera 0.169222
Probability 0.918870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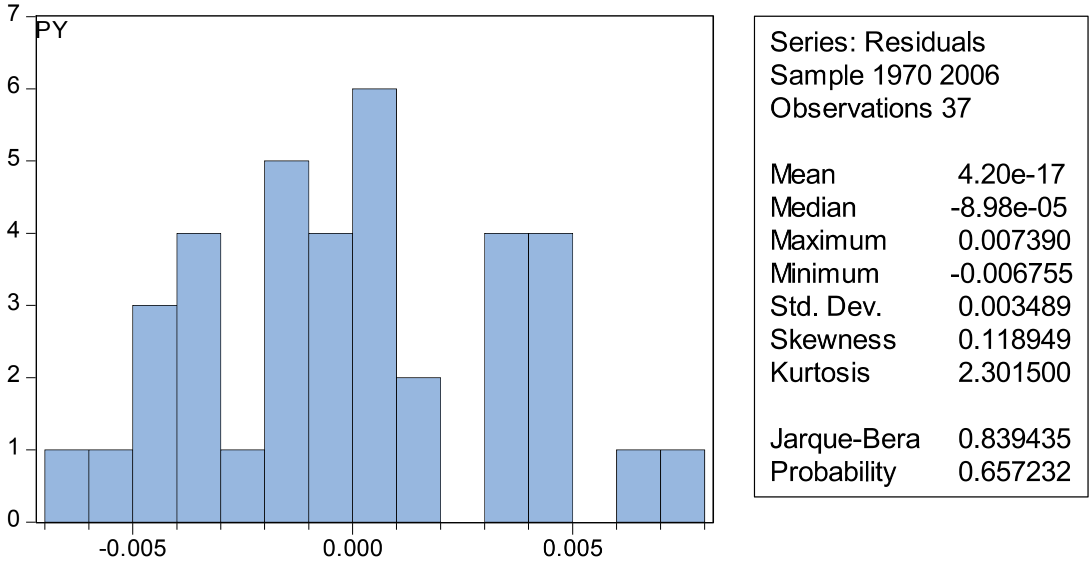
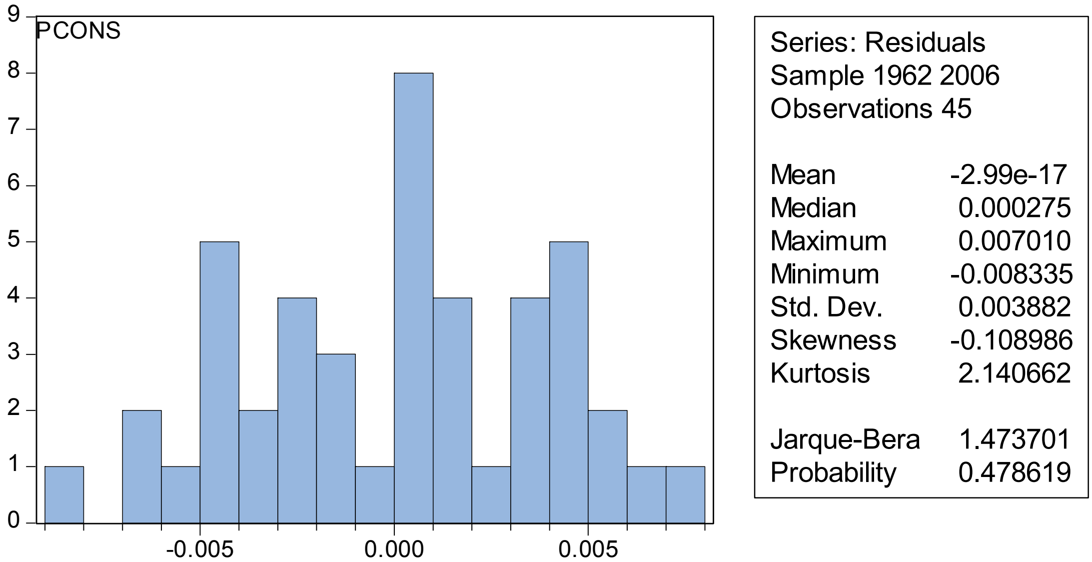
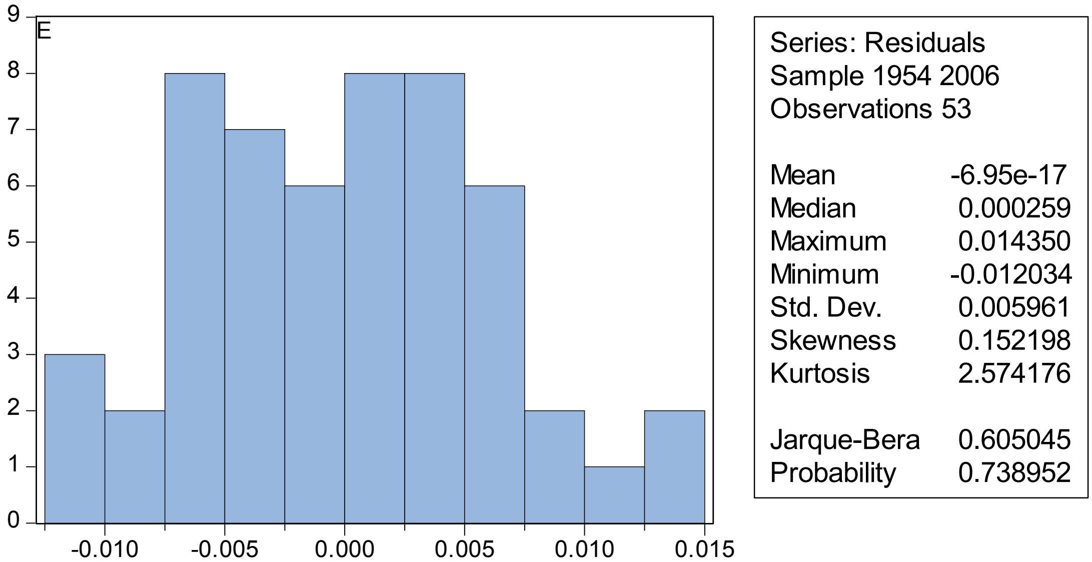
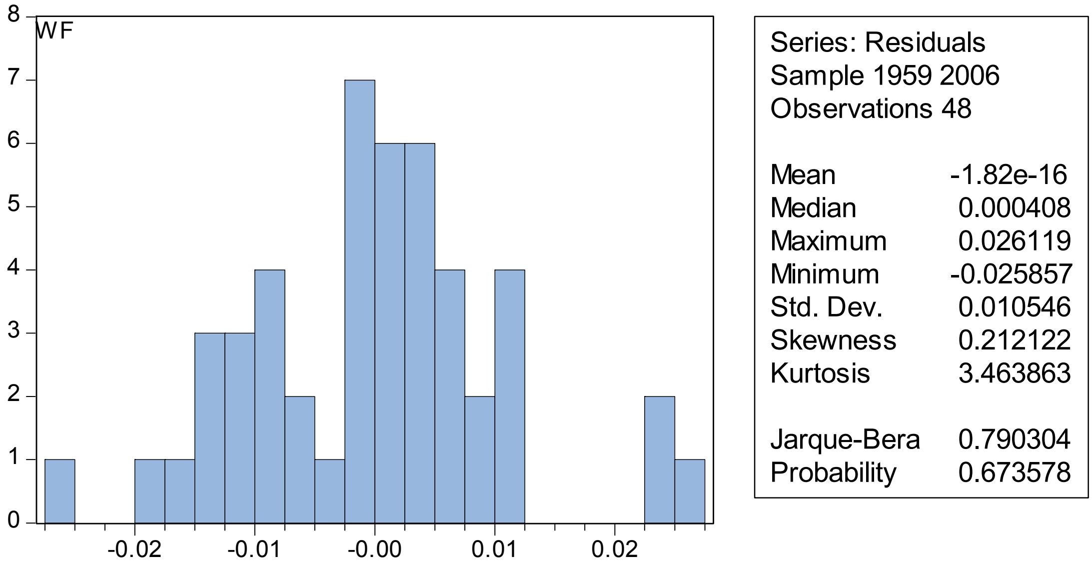
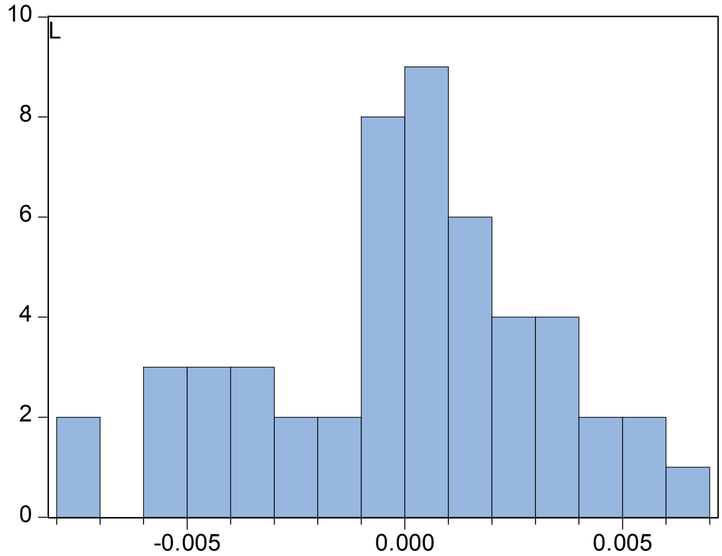
8
7
6
5
4
3
2
1
0
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
Series: Residuals
Sample 1959 2006
Observations 48
Mean 2.22e-16
Median 0.000628
Maximum 0.061638
Minimum -0.059074
Std. Dev. 0.026281
Skewness 0.087340
Kurtosis 2.482545
Jarque-Bera 0.596545
Probability 0.742099


PY
Series: Residuals
Sample 1970 2006
Observations 37
Mean 4.20e-17
Median -8.98e-05
Maximum 0.007390
Minimum -0.006755
Std. Dev. 0.003489
Skewness 0.118949
Kurtosis 2.301500
Jarque-Bera 0.839435
Probability 0.657232


PCONS
Series: Residuals
Sample 1962 2006
Observations 45
Mean -2.99e-17
Median 0.000275
Maximum 0.007010
Minimum -0.008335
Std. Dev. 0.003882
Skewness -0.108986
Kurtosis 2.140662
Jarque-Bera 1.473701
Probability 0.478619


E
Series: Residuals
Sample 1954 2006
Observations 53
Mean -6.95e-17
Median 0.000259
Maximum 0.014350
Minimum -0.012034
Std. Dev. 0.005961
Skewness 0.152198
Kurtosis 2.574176
Jarque-Bera 0.605045
Probability 0.738952


WF
Series: Residuals
Sample 1959 2006
Observations 48
Mean -1.82e-16
Median 0.000408
Maximum 0.026119
Minimum -0.025857
Std. Dev. 0.010546
Skewness 0.212122
Kurtosis 3.463863
Jarque-Bera 0.790304
Probability 0.673578



Series: Residuals	
Sample 1956 2006	
Observations 51	
Mean	-7.93e-17
Median	0.000578
Maximum	0.006621
Minimum	-0.007830
Std. Dev.	0.003355
Skewness	-0.400921
Kurtosis	2.687703
Jarque-Bera	1.573520
Probability	0.455318

Appendix C

Testing for first order heteroscedatsticity in the residuals.
The ARCH test for heteroskedasticity in the residual regresses the squared residuals on lagged squared residuals and a constant. In the presence of heteroskedasticity, ordinary least squares estimates are still consistent, but the conventional computed standard errors are no longer valid.

CONS

Heteroskedasticity Test: ARCH

F-statistic	0.005633	Prob. F(1,49)	0.9405
Obs*R-squared	0.005862	Prob. Chi-Square(1)	0.9390

I

Heteroskedasticity Test: ARCH

F-statistic	1.132815	Prob. F(1,46)	0.2927
Obs*R-squared	1.153658	Prob. Chi-Square(1)	0.2828

EX

Heteroskedasticity Test: ARCH

F-statistic	0.526678	Prob. F(1,33)	0.4731
Obs*R-squared	0.549823	Prob. Chi-Square(1)	0.4584

IM

Heteroskedasticity Test: ARCH

F-statistic	1.618846	Prob. F(1,45)	0.2098
Obs*R-squared	1.632082	Prob. Chi-Square(1)	0.2014

PY

Heteroskedasticity Test: ARCH

F-statistic	0.016734	Prob. F(1,34)	0.8978
Obs*R-squared	0.017709	Prob. Chi-Square(1)	0.8941

PCONS

Heteroskedasticity Test: ARCH

F-statistic	0.125222	Prob. F(1,42)	0.7252
Obs*R-squared	0.130795	Prob. Chi-Square(1)	0.7176

E

Heteroskedasticity Test: ARCH

F-statistic	4.608833	Prob. F(1,50)	0.0367
Obs*R-squared	4.388655	Prob. Chi-Square(1)	0.0362

WF

Heteroskedasticity Test: ARCH

F-statistic	0.056322	Prob. F(1,45)	0.8135
Obs*R-squared	0.058752	Prob. Chi-Square(1)	0.8085

L

Heteroskedasticity Test: ARCH

F-statistic	0.128277	Prob. F(1,48)	0.7218
Obs*R-squared	0.133266	Prob. Chi-Square(1)	0.7151

Appendix D

Serial correlation

CONS

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.174210	Prob. F(4,43)	0.9504
Obs*R-squared	0.829251	Prob. Chi-Square(4)	0.9345

I

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.234699	Prob. F(4,41)	0.0819
Obs*R-squared	8.770755	Prob. Chi-Square(4)	0.0671

EX

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.501890	Prob. F(4,24)	0.7346
Obs*R-squared	2.778888	Prob. Chi-Square(4)	0.5955

IM

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.992434	Prob. F(4,38)	0.1153
Obs*R-squared	8.321720	Prob. Chi-Square(4)	0.0805

PY

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.284737	Prob. F(4,24)	0.8850
Obs*R-squared	1.676324	Prob. Chi-Square(4)	0.7950

PCONS

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.515103	Prob. F(4,32)	0.2212
Obs*R-squared	7.165413	Prob. Chi-Square(4)	0.1274

E

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.955742	Prob. F(4,44)	0.4412
Obs*R-squared	4.236822	Prob. Chi-Square(4)	0.3749

WF

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.619966	Prob. F(4,40)	0.6509
Obs*R-squared	2.977245	Prob. Chi-Square(4)	0.5616

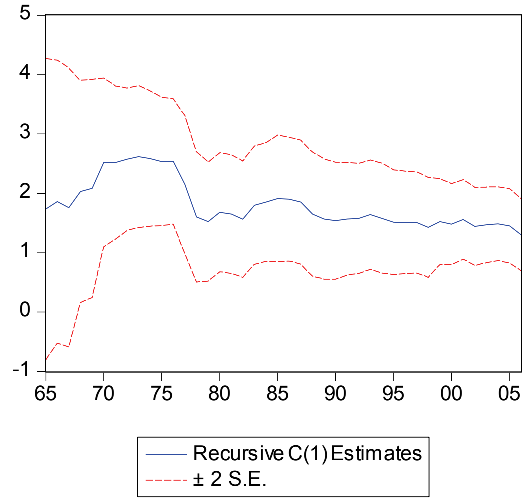
L

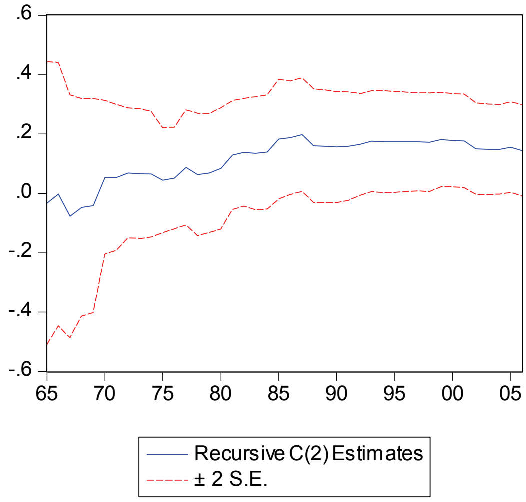
Breusch-Godfrey Serial Correlation LM Test:

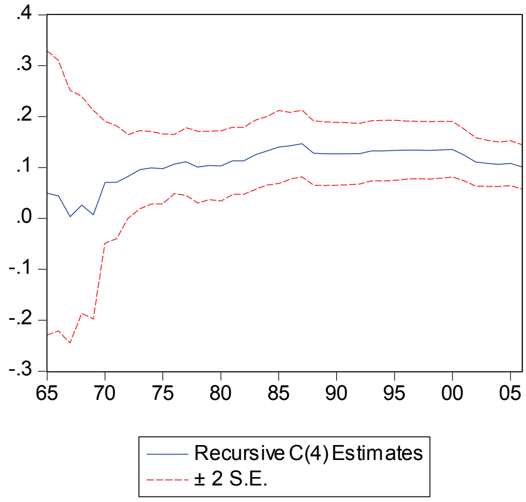
F-statistic	1.346254	Prob. F(4,43)	0.2684
Obs*R-squared	5.898641	Prob. Chi-Square(4)	0.2068

Appendix E

Recursive coefficients
CONS







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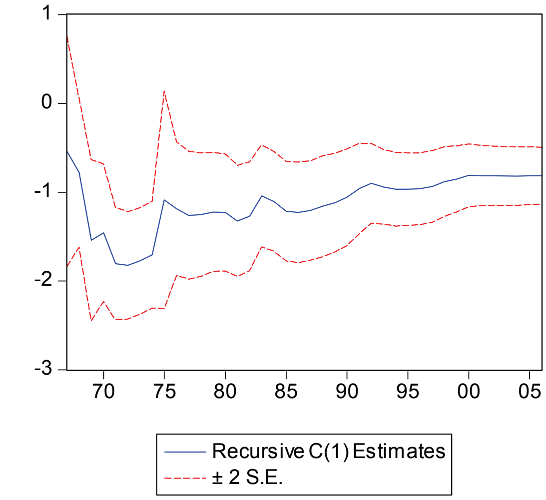
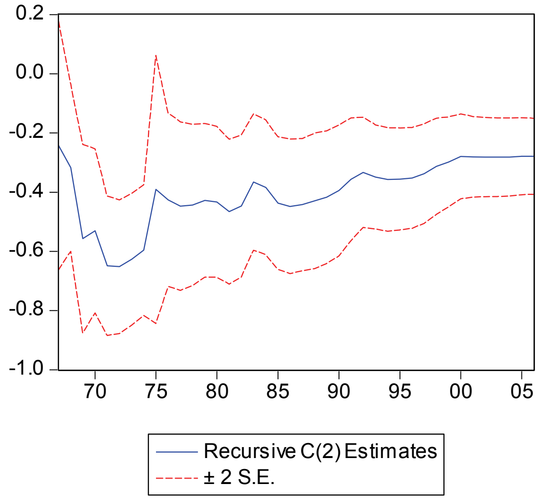
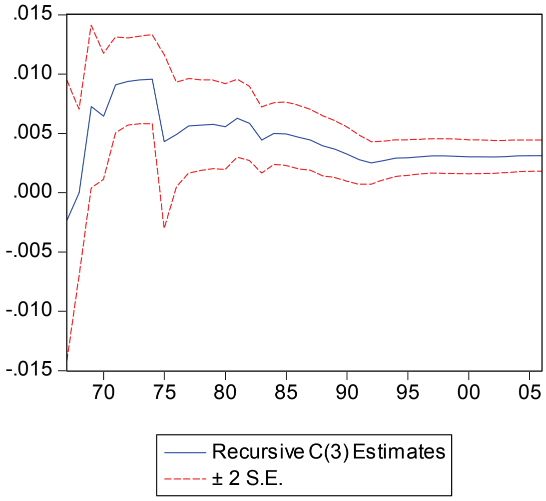
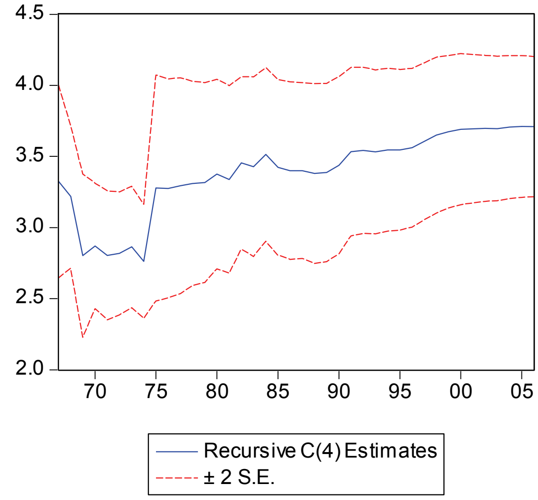
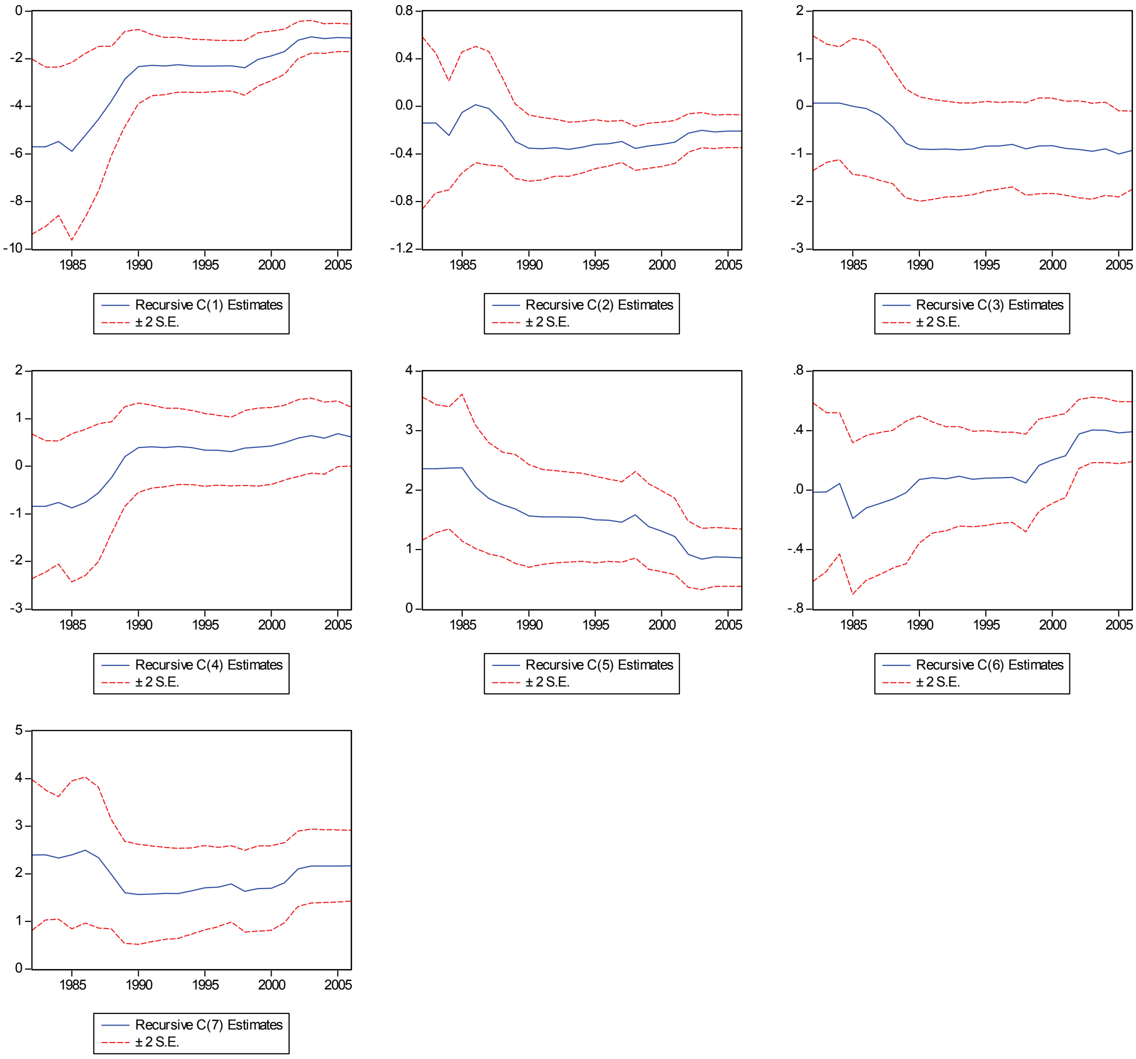

1
0
-1
-2
-3
70 75 80 85 90 95 00 05
Recursive C(1) Estimates
± 2 S.E.


0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
70 75 80 85 90 95 00 05
Recursive C(2) Estimates
± 2 S.E.

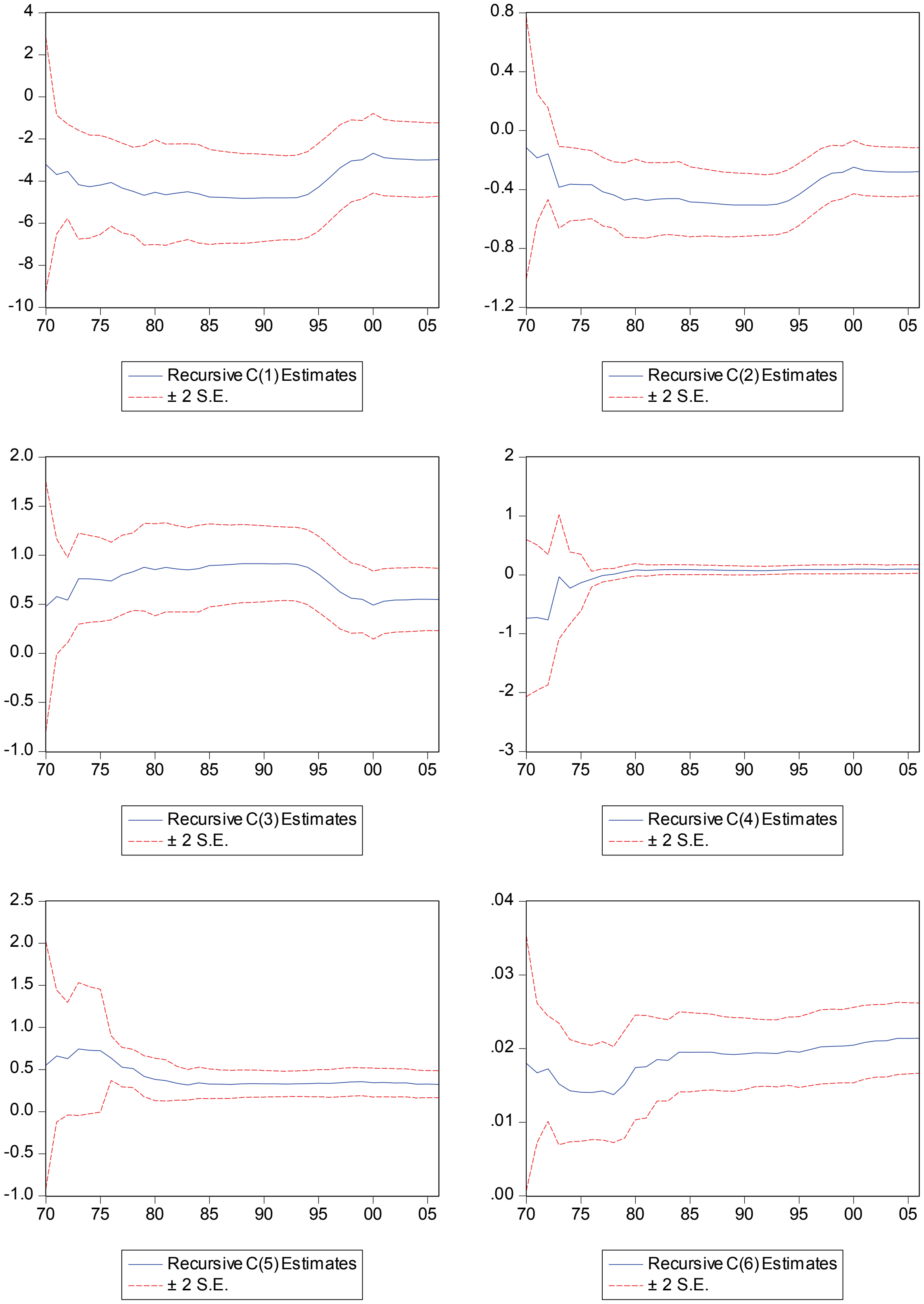

.015
.010
.005
.000
-.005
-.010
-.015
70 75 80 85 90 95 00 05
Recursive C(3) Estimates
± 2 S.E.


4.5
4.0
3.5
3.0
2.5
2.0
70 75 80 85 90 95 00 05
Recursive C(4) Estimates
± 2 S.E.

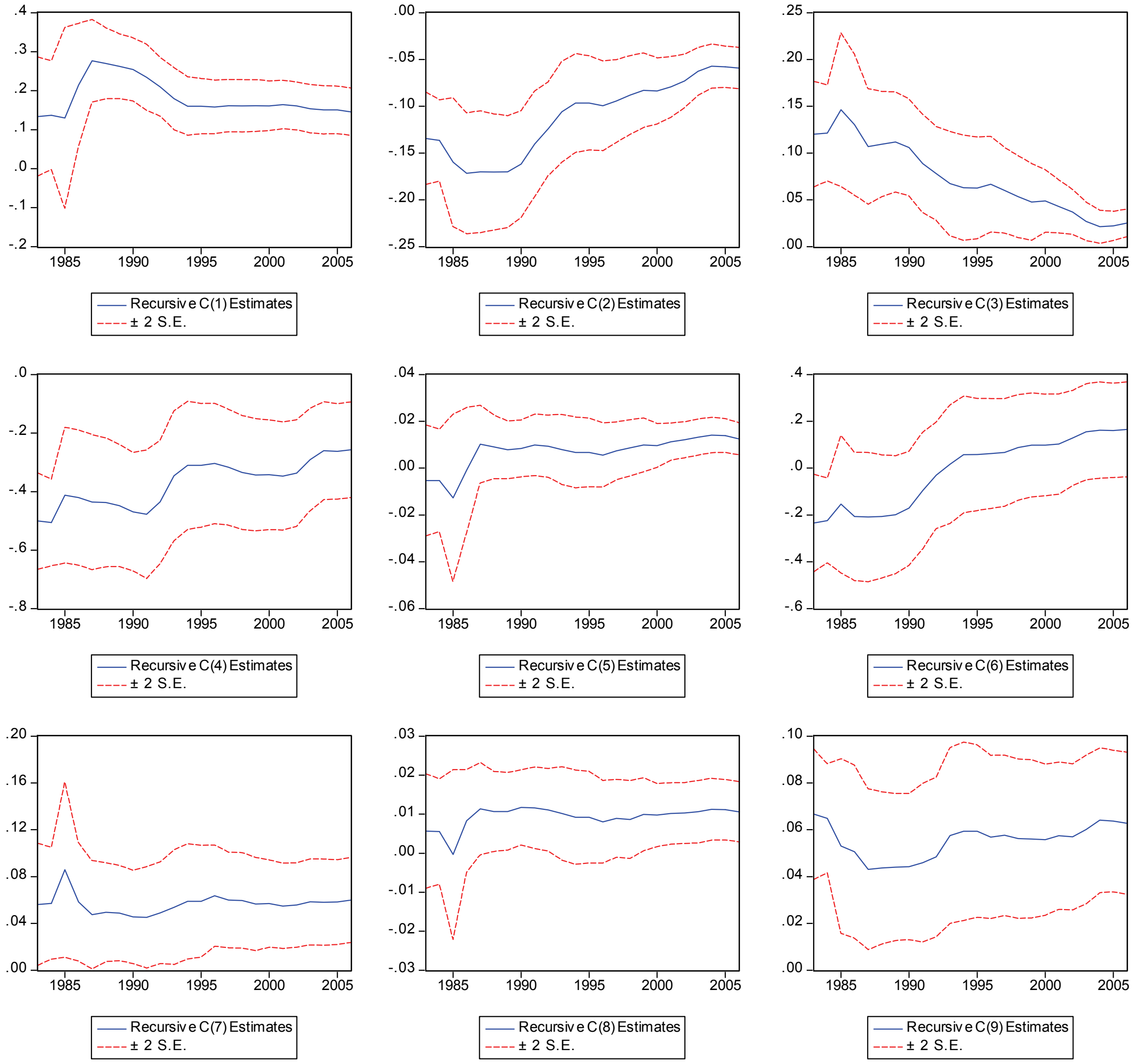
EX


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
Recursive C(7) Estimates
± 2 S.E.

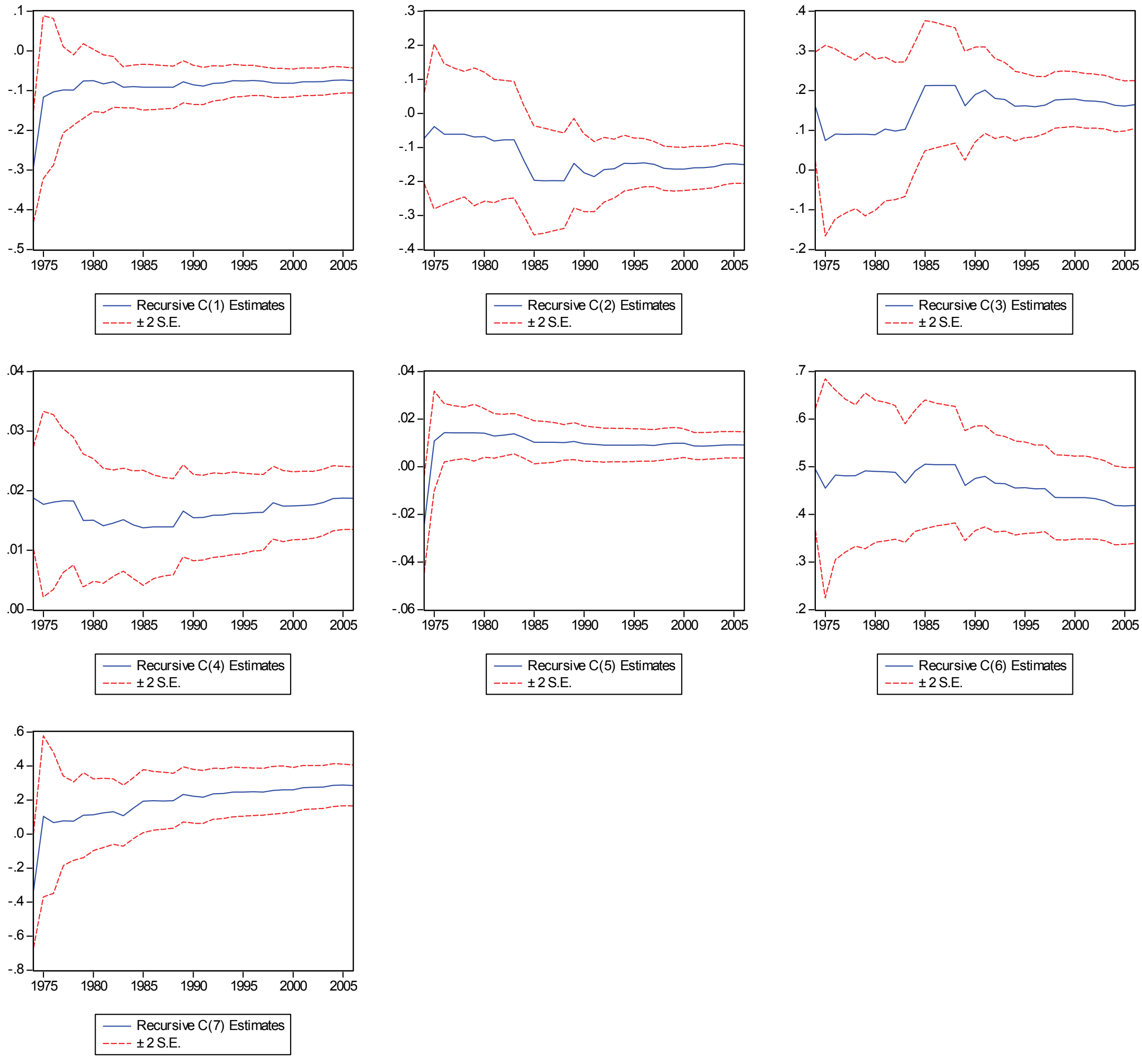
IM


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
70 75 80 85 90 95 00 05

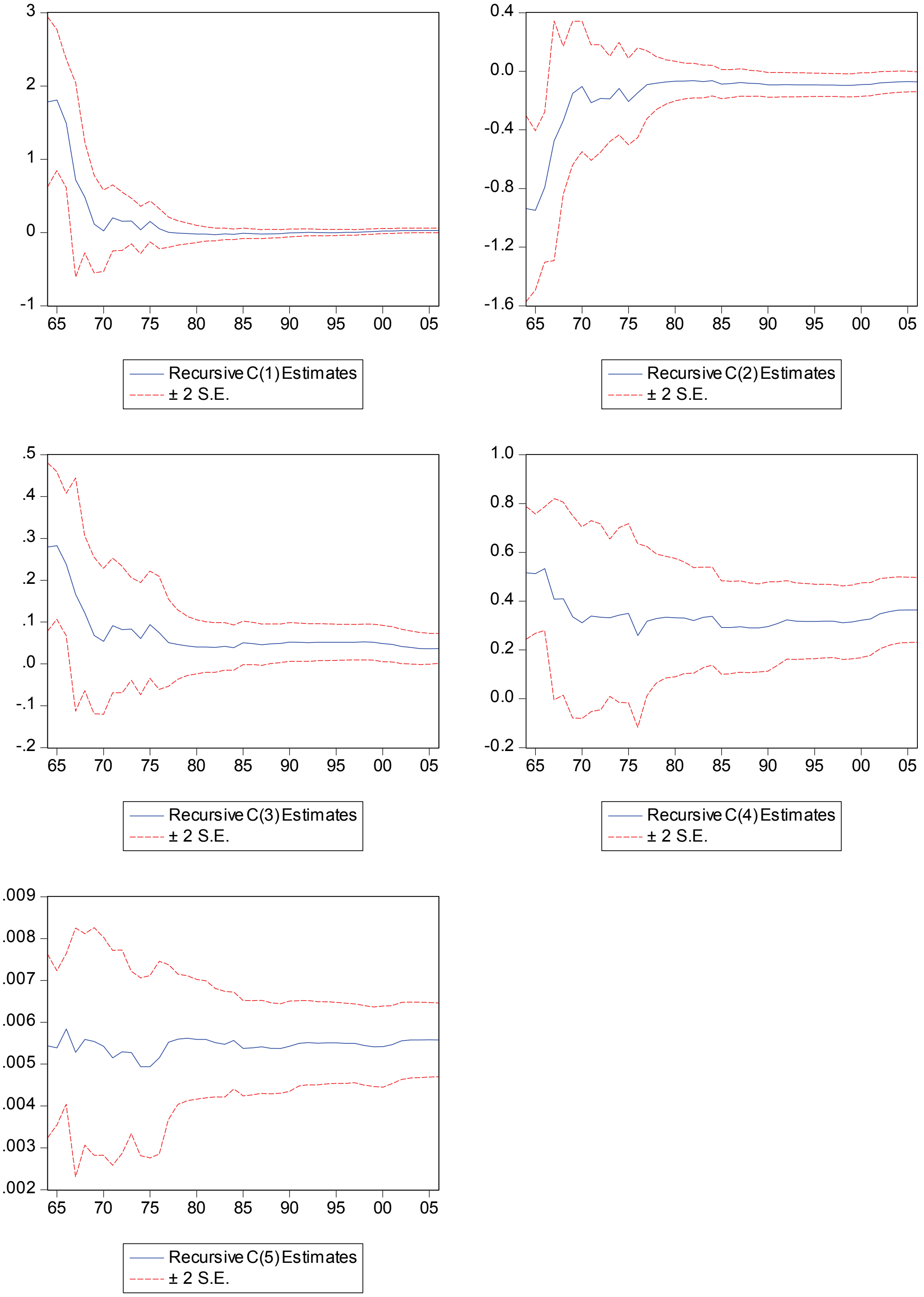
PY


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
Recursive C(7) Estimates
± 2 S.E.
Recursive C(8) Estimates
± 2 S.E.
Recursive C(9) Estimates
± 2 S.E.

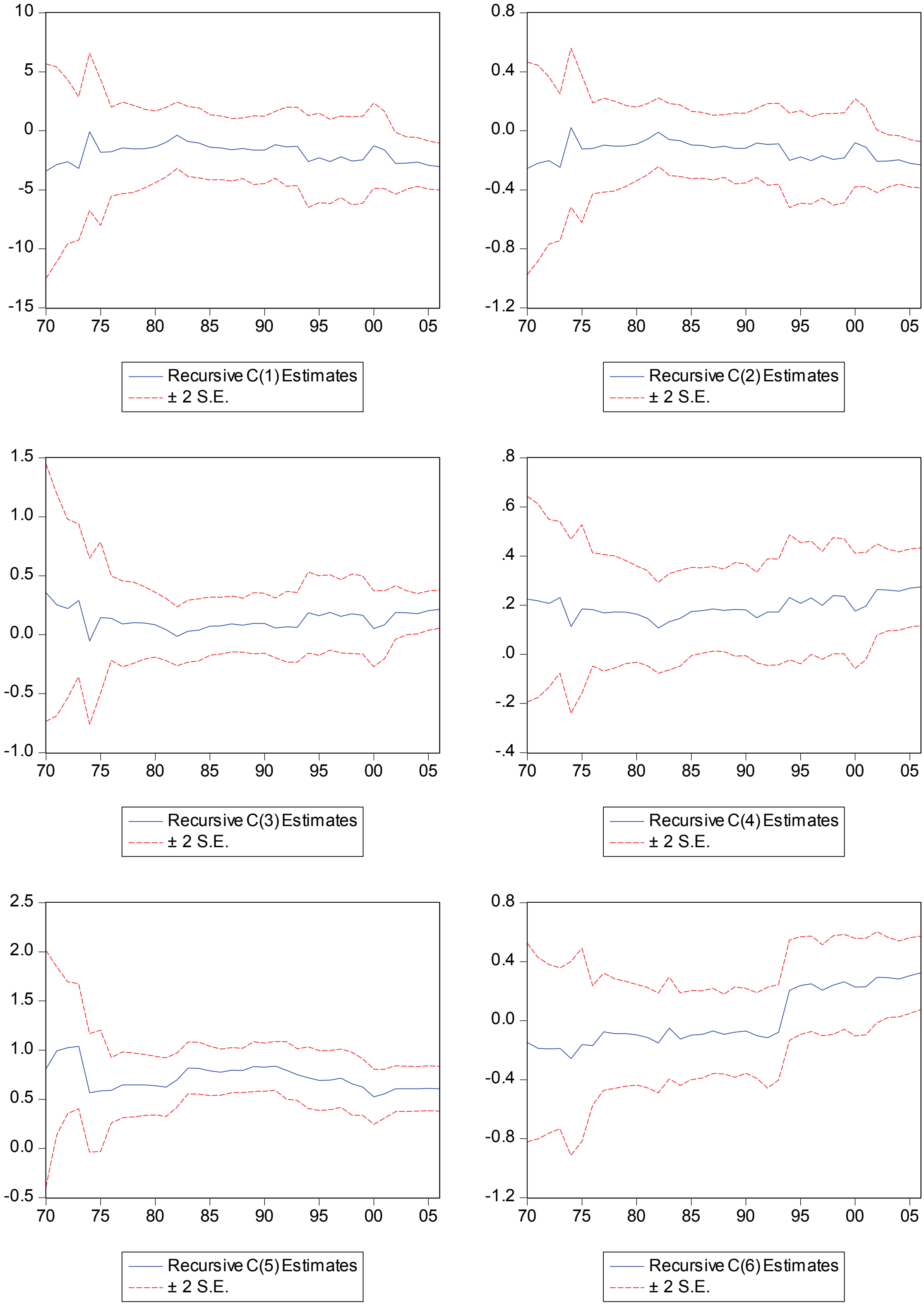
PCONS


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
Recursive C(7) Estimates
± 2 S.E.

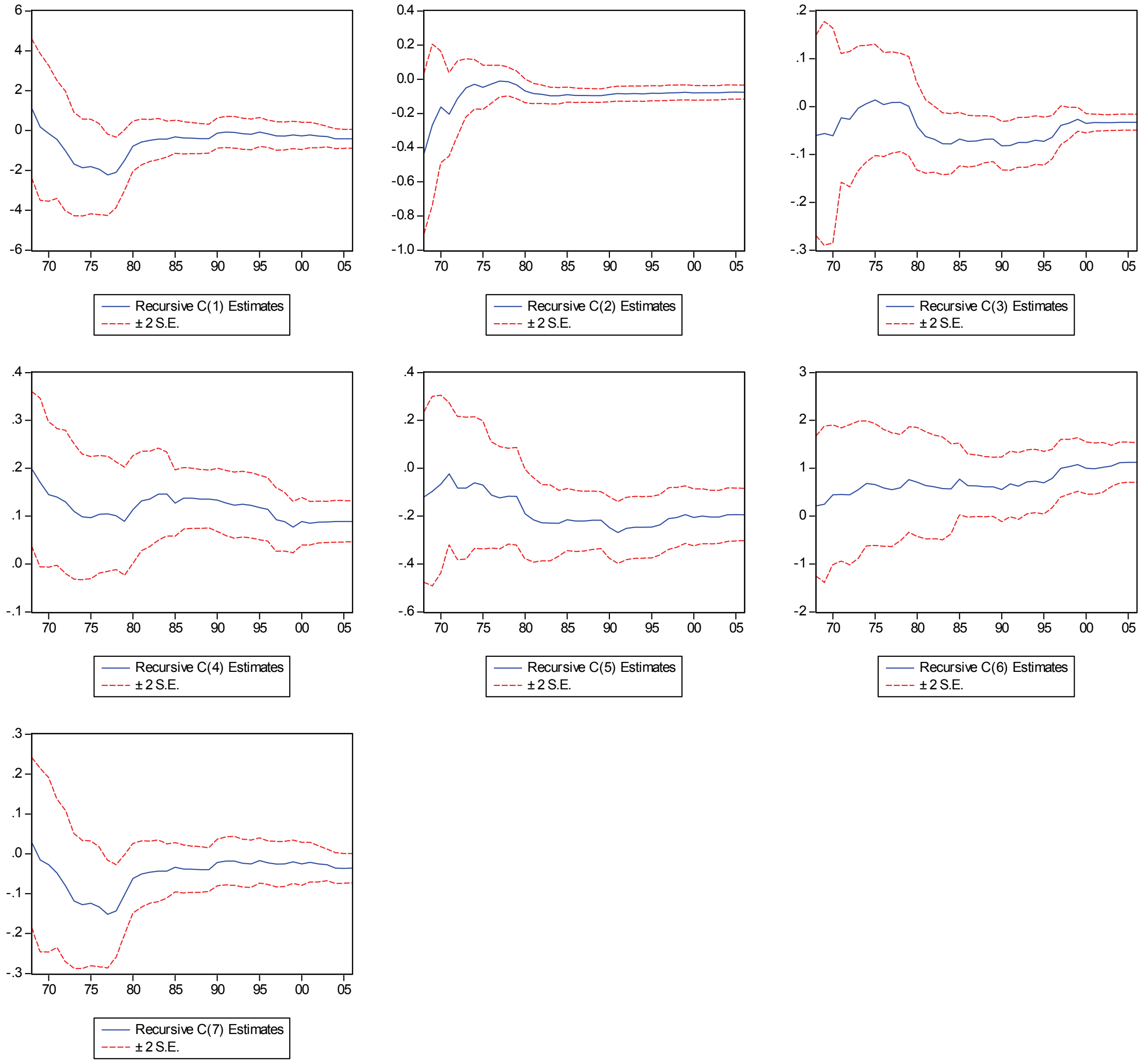
E


3
2
1
0
-1
65 70 75 80 85 90 95 00 05
Recursive C(1) Estimates
± 2 S.E.
0.4
0.0
-0.4
-0.8
-1.2
-1.6
65 70 75 80 85 90 95 00 05
Recursive C(2) Estimates
± 2 S.E.
.5
.4
.3
.2
.1
.0
-.1
-.2
65 70 75 80 85 90 95 00 05
Recursive C(3) Estimates
± 2 S.E.
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
65 70 75 80 85 90 95 00 05
Recursive C(4) Estimates
± 2 S.E.
.009
.008
.007
.006
.005
.004
.003
.002
65 70 75 80 85 90 95 00 05
Recursive C(5) Estimates
± 2 S.E.

WF


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.

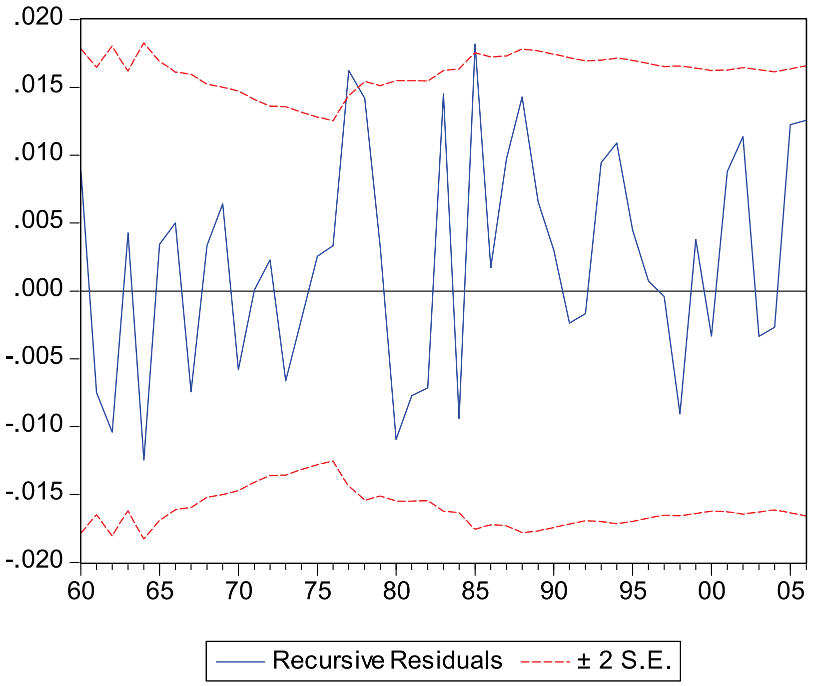
L


Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
Recursive C(7) Estimates
± 2 S.E.

Appendix F

Recursive residuals

CONS



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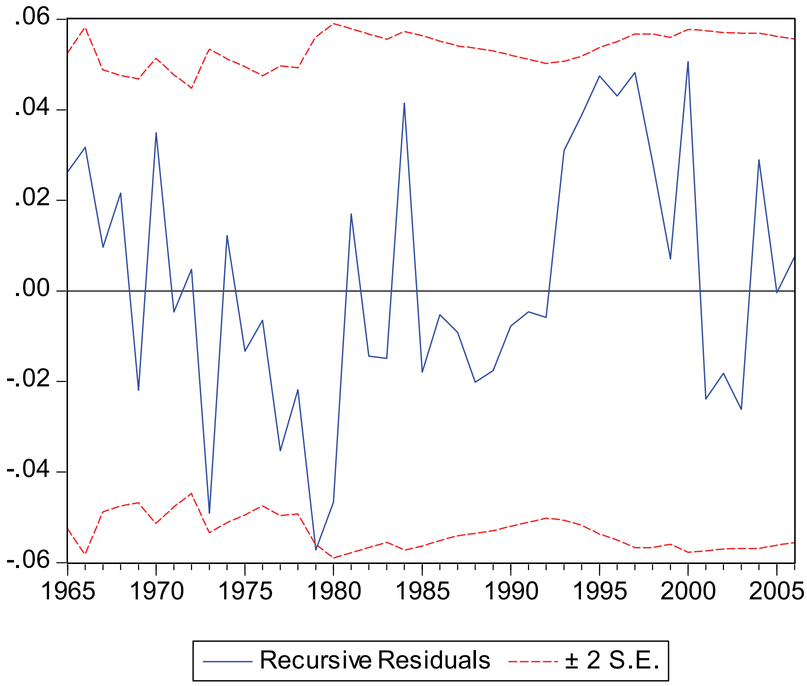
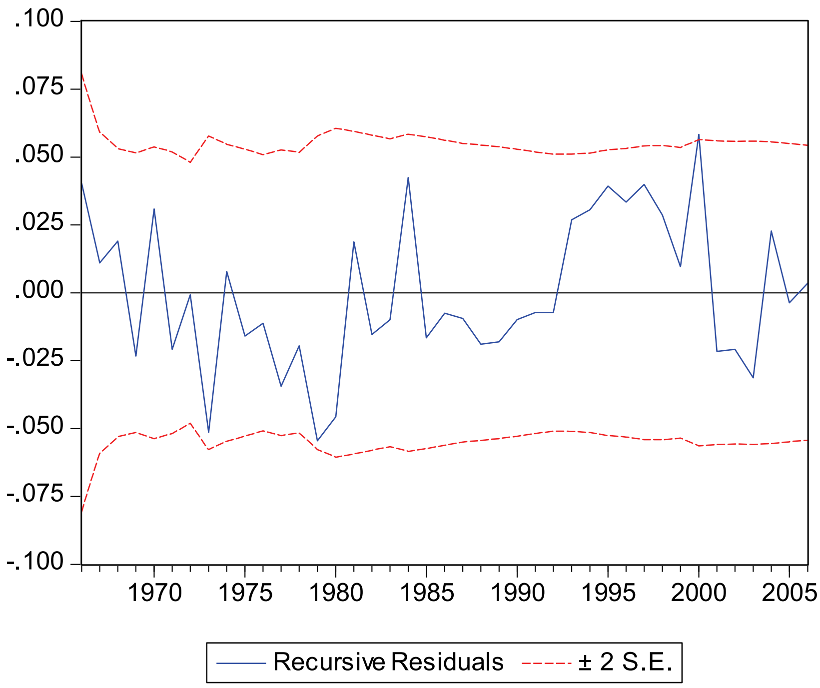


EX


.08
.06
.04
.02
.00
-.02
-.04
-.06
-.08
1980
1985
1990
1995
2000
2005
Recursive Residuals
± 2 S.E.

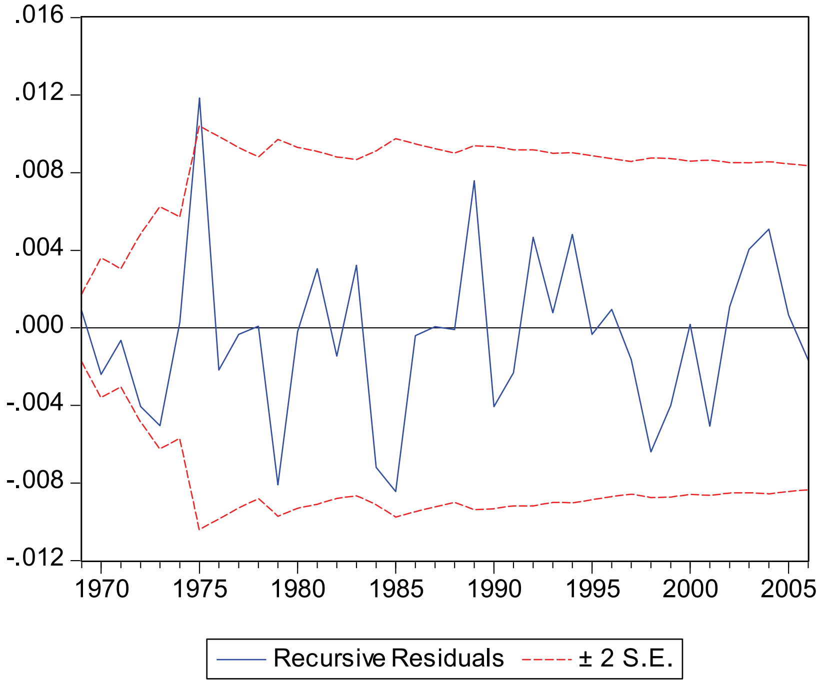
IM


.100
.075
.050
.025
.000
-.025
-.050
-.075
-.100
1970
1975
1980
1985
1990
1995
2000
2005
Recursive Residuals
± 2 S.E.

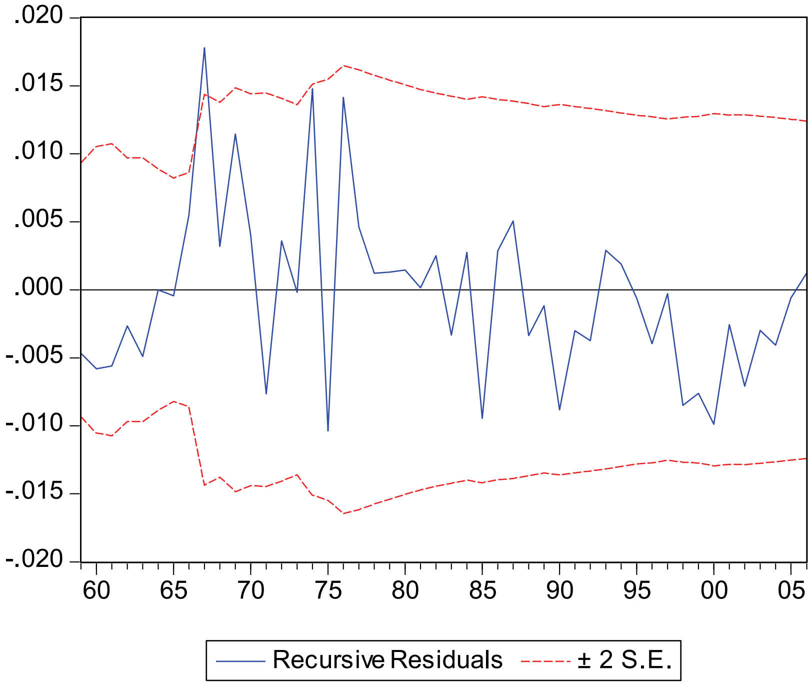
PY


.0100
.0075
.0050
.0025
.0000
-.0025
-.0050
-.0075
-.0100
1980
1985
1990
1995
2000
2005
Recursive Residuals
± 2 S.E.

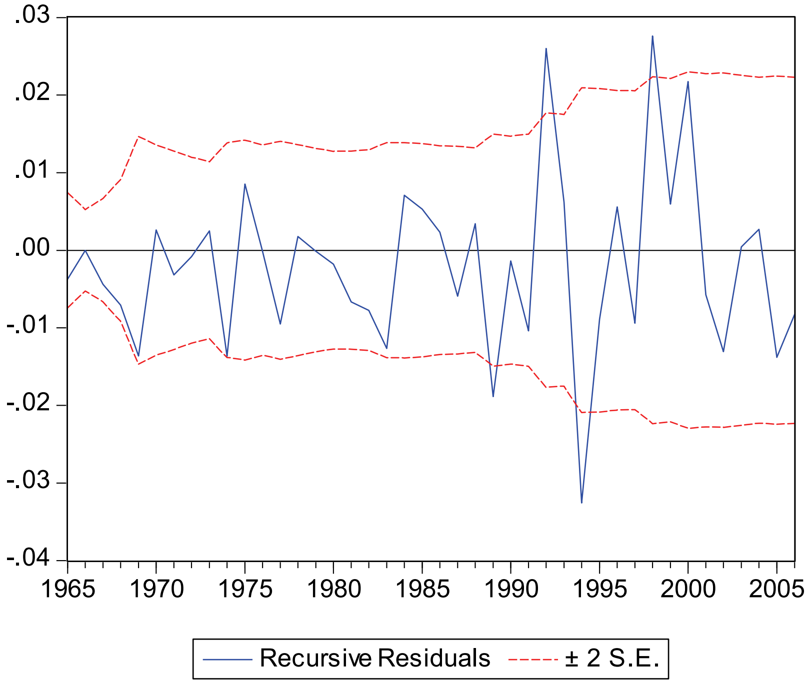
PCONS


.016
.012
.008
.004
.000
-.004
-.008
-.012
1970
1975
1980
1985
1990
1995
2000
2005
Recursive Residuals
± 2 S.E.

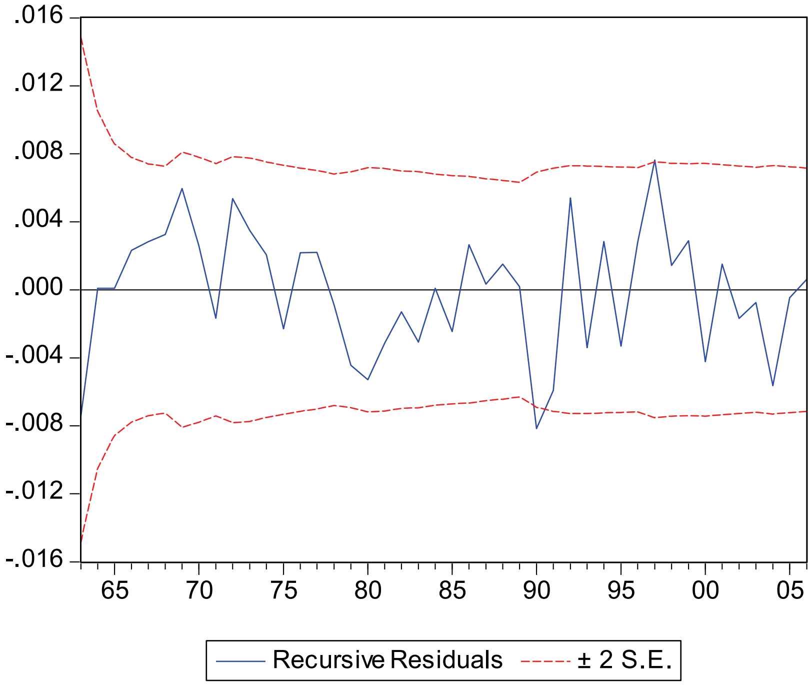
E


.020
.015
.010
.005
.000
-.005
-.010
-.015
-.020
60 65 70 75 80 85 90 95 00 05
Recursive Residuals
± 2 S.E.

WF

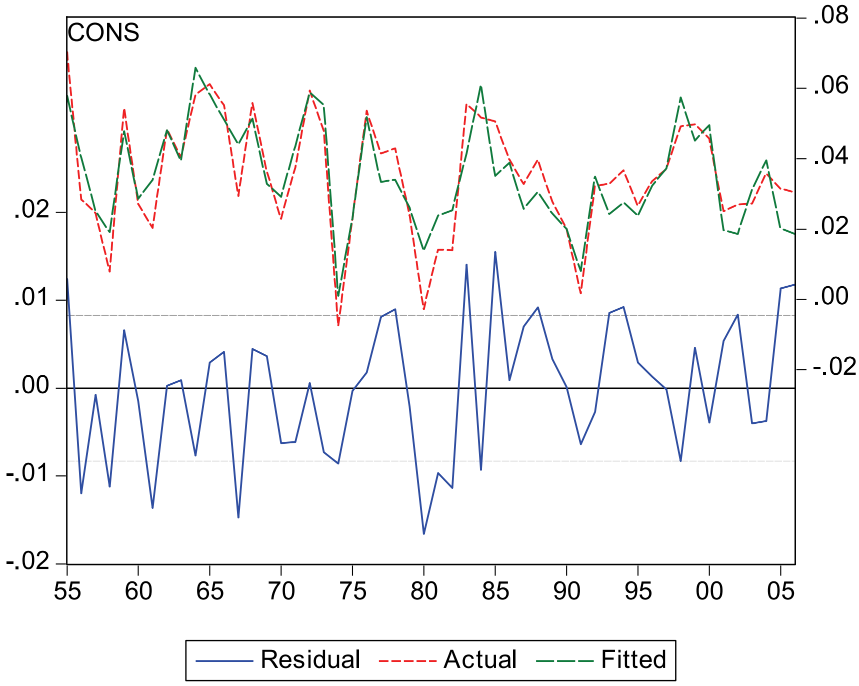

.03
.02
.01
.00
-.01
-.02
-.03
-.04
1965 1970 1975 1980 1985 1990 1995 2000 2005
Recursive Residuals
± 2 S.E.

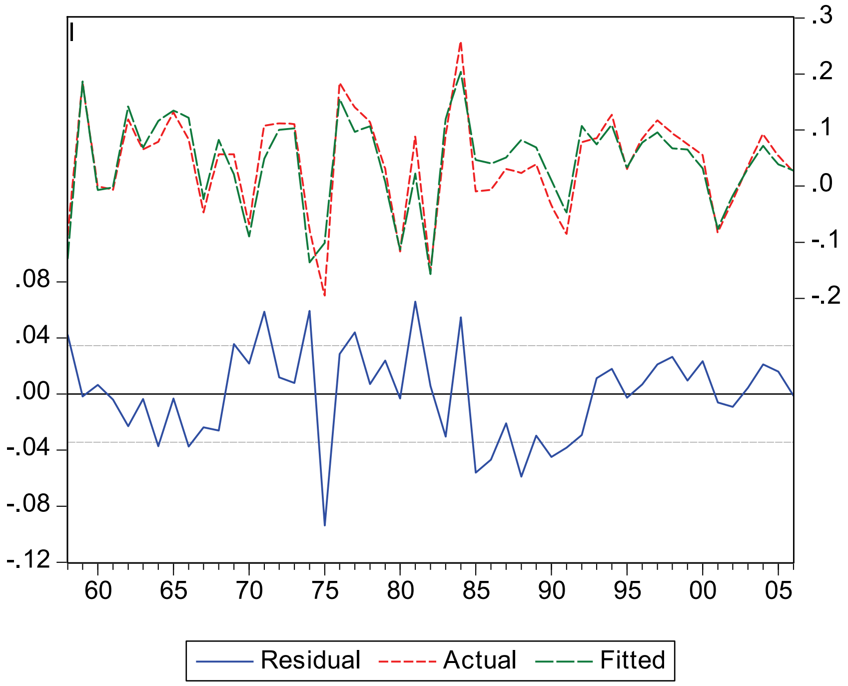
L

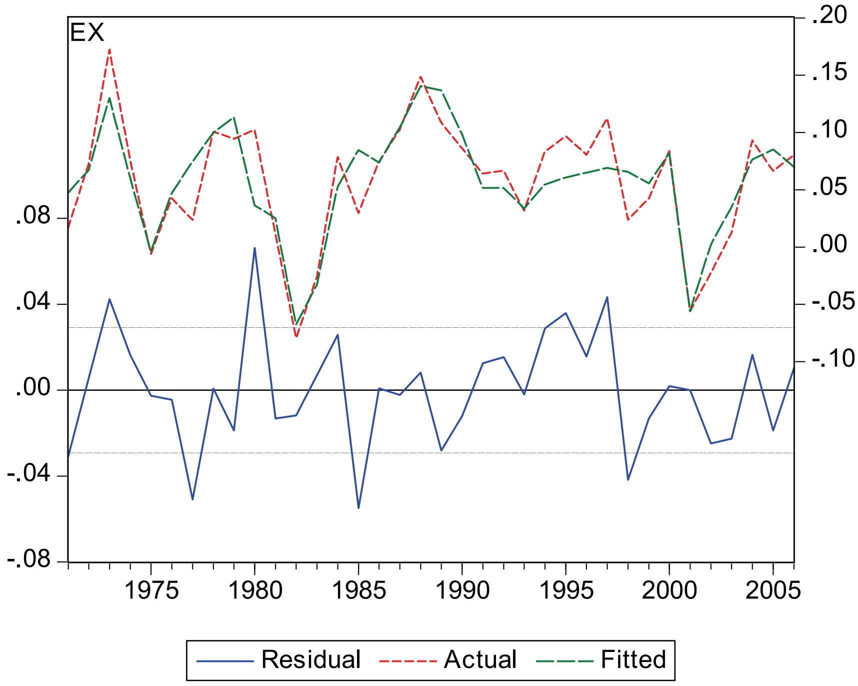

.016
.012
.008
.004
.000
-.004
-.008
-.012
-.016
65
70
75
80
85
90
95
00
05
Recursive Residuals
± 2 S.E.

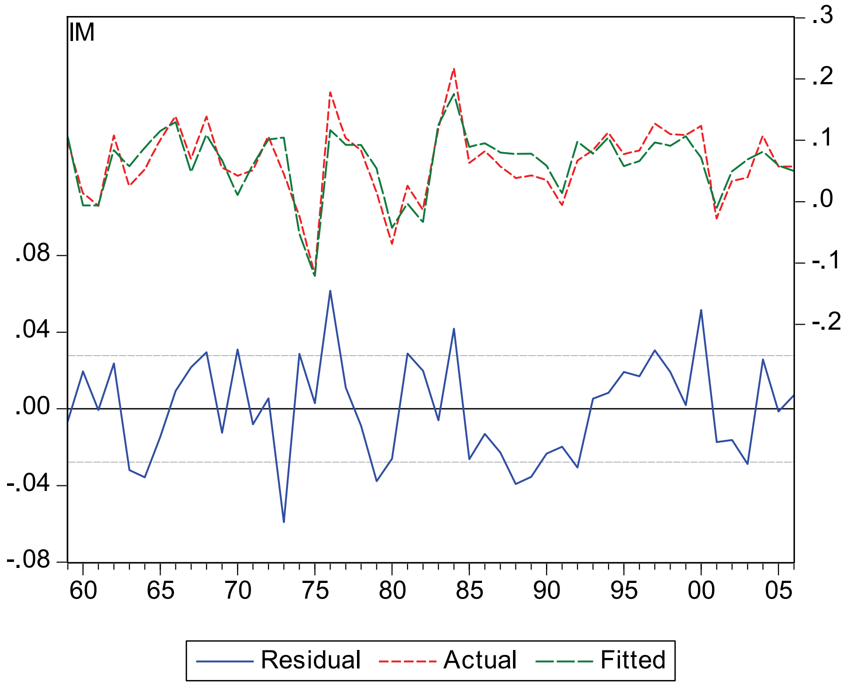
Appendix G

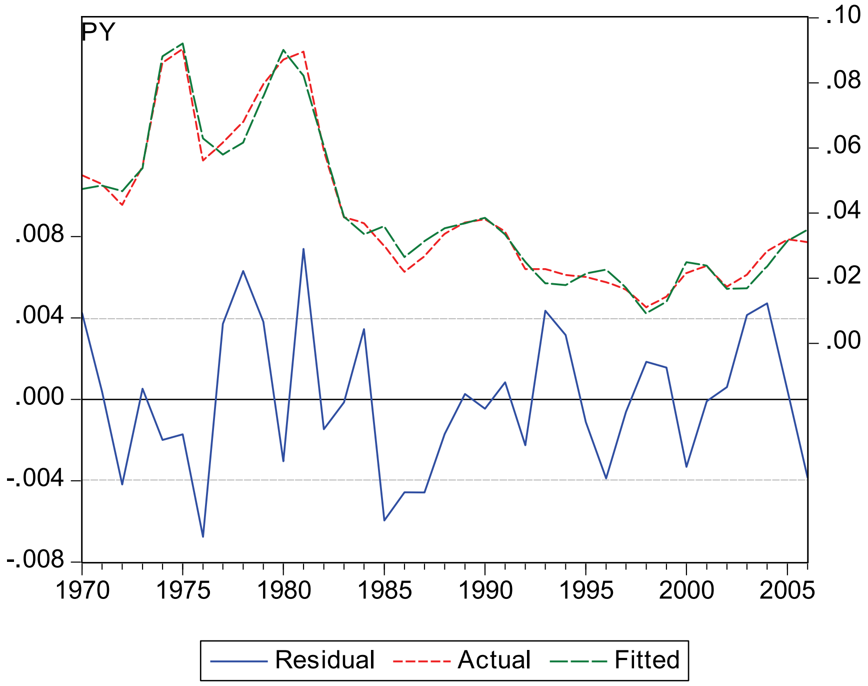
Actual and fitted values of the dependent variable and the residuals from the regression. I.e. the first graph displays actual and fitted d(log(cons/pop)), and the equation residual.

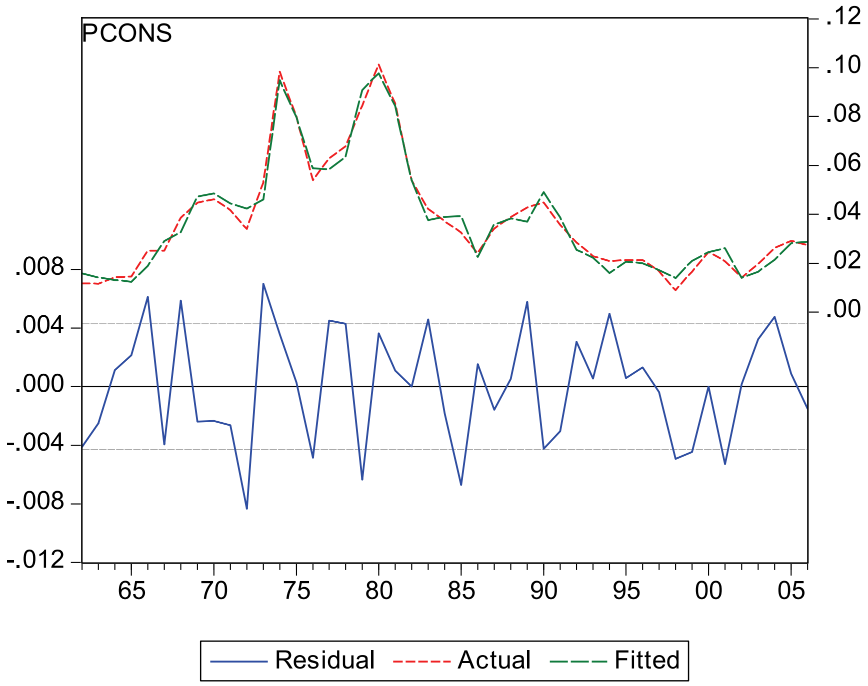


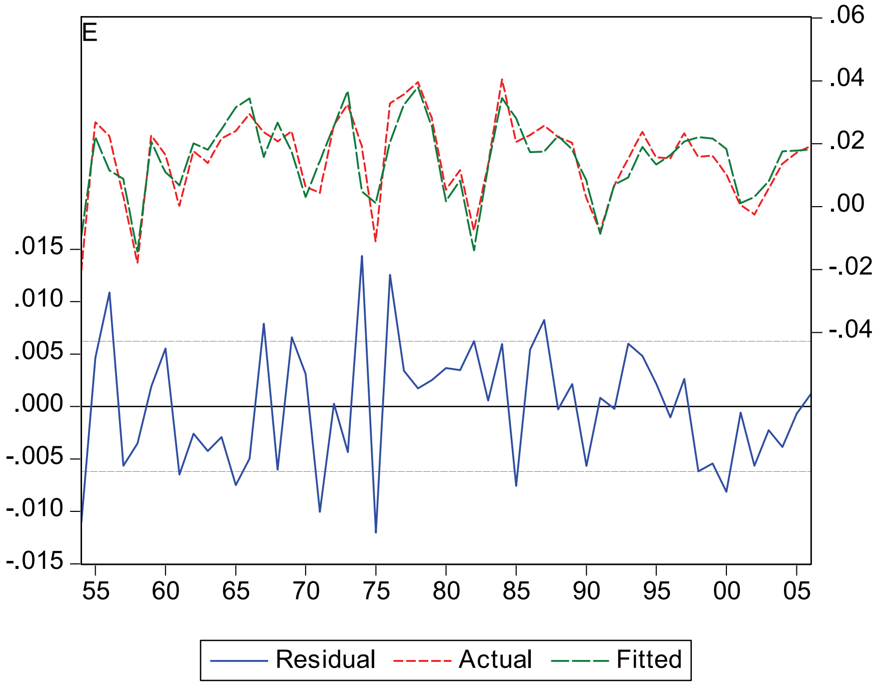


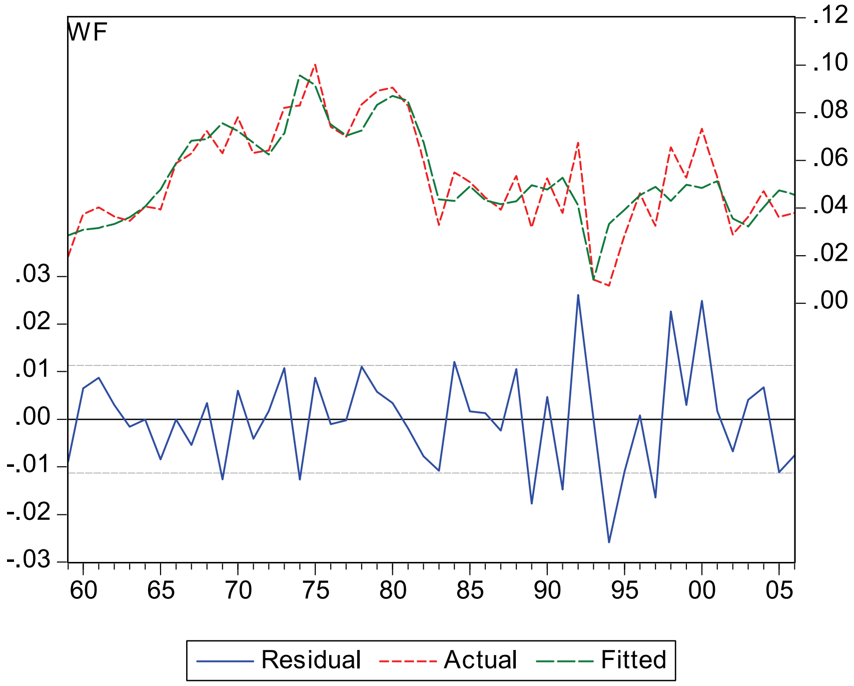

EX
.20
.15
.10
.05
.00
-.05
-.10
.08
.04
.00
-.04
-.08
1975
1980
1985
1990
1995
2000
2005
Residual
Actual
Fitted

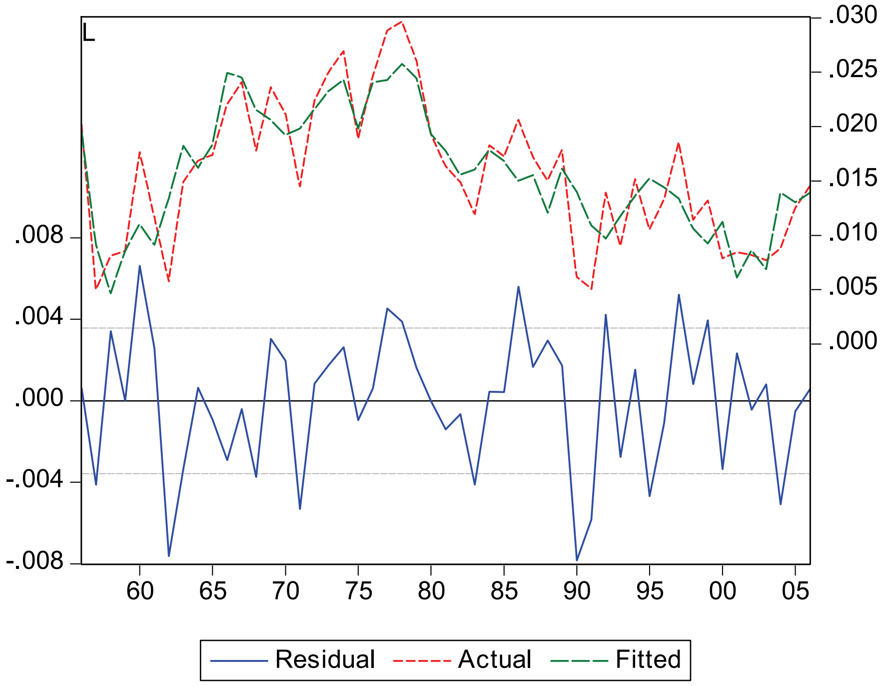

IM
.3
.2
.1
.0
-.1
-.2
.08
.04
.00
-.04
-.08
60
65
70
75
80
85
90
95
00
05
Residual
Actual
Fitted


PY
.10
.08
.06
.04
.02
.00
.008
.004
.000
-.004
-.008
1970
1975
1980
1985
1990
1995
2000
2005
Residual
Actual
Fitted


PCONS
.12
.10
.08
.06
.04
.02
.00
.008
.004
.000
-.004
-.008
-.012
65
70
75
80
85
90
95
00
05
Residual
Actual
Fitted


E
.06
.04
.02
.00
-.02
-.04
.015
.010
.005
.000
-.005
-.010
-.015
55 60 65 70 75 80 85 90 95 00 05
Residual Actual Fitted


WF
.12
.10
.08
.06
.04
.02
.00
.03
.02
.01
.00
-.01
-.02
-.03
60 65 70 75 80 85 90 95 00 05
Residual Actual Fitted


L
.030
.025
.020
.015
.010
.005
.000
.008
.004
.000
-.004
-.008
60
65
70
75
80
85
90
95
00
05
Residual
Actual
Fitted

Appendix H

Alternative scenarios

1 percentage point sustained increase in the nominal interest rate 2000 - 2006. Percentage deviation from reference scenario. *Deviation level

	2000	2001	2002	2003	2004	2005	2006
CONS	-0,2	-0,3	-0,5	-0,5	-0,6	-0,6	-0,6
E	-0,1	-0,2	-0,3	-0,3	-0,3	-0,3	-0,2
EX	0,0	0,0	0,0	0,1	0,2	0,4	0,5
I	-0,7	-1,0	-1,0	-0,9	-0,7	-0,4	-0,2
IM	-0,4	-0,7	-0,8	-0,9	-0,9	-0,9	-0,8
L	0,0	0,0	-0,1	-0,1	-0,1	-0,1	-0,1
PCONS	0,1	0,1	0,2	0,2	0,2	0,1	0,1
PY	0,0	0,0	-0,1	-0,1	-0,2	-0,2	-0,2
WF	0,0	0,0	-0,1	-0,2	-0,2	-0,3	-0,3
Y	-0,2	-0,3	-0,4	-0,4	-0,4	-0,3	-0,3
YD	0,0	0,0	-0,1	-0,1	-0,2	-0,2	-0,2
UR*	0,1	0,2	0,2	0,2	0,2	0,1	0,1
RSS*	0,9	0,9	1,0	1,0	1,0	1,0	1,1
RS	1	1	1	1	1	1	1

Sustained increase in public spending, 100 bn 1999-USD. Percentage deviation from reference scenario. *Deviation level

	1999	2000	2001	2002	2003	2004	2005	2006
CONS	0,6	0,9	1,2	1,2	1,2	1,1	0,8	0,6
E	1,3	1,7	1,6	1,4	1,2	0,8	0,5	0,2
EX	0,0	0,0	-0,3	-0,9	-1,8	-2,7	-3,6	-4,2
I	9,0	5,9	4,3	2,8	1,5	0,0	-1,0	-1,7
IM	5,2	4,8	4,6	4,3	4,0	3,3	2,8	2,2
L	0,2	0,4	0,5	0,6	0,6	0,6	0,6	0,6
PCONS	-0,8	-1,1	-1,0	-0,8	-0,5	-0,2	0,1	0,4
PY	0,0	0,3	0,6	0,9	1,1	1,2	1,2	1,1
WF	0,0	0,4	0,9	1,2	1,4	1,5	1,5	1,4
Y	2,3	2,0	1,9	1,7	1,4	1,0	0,7	0,3
YD	0,0	0,3	0,6	0,8	1,0	1,1	1,1	1,0
UR*	-1,1	-1,2	-1,0	-0,8	-0,5	-0,2	0,1	0,4
RSS*	0,9	0,2	0,0	-0,2	-0,3	-0,4	-0,3	-0,3
G	6,1	6,1	6,1	5,9	5,9	6,0	6,1	6,2

Sustained 1 per cent increase in international demand, YG7 (compared to reference scenario). Percentage deviation from reference scenario. *Deviation level

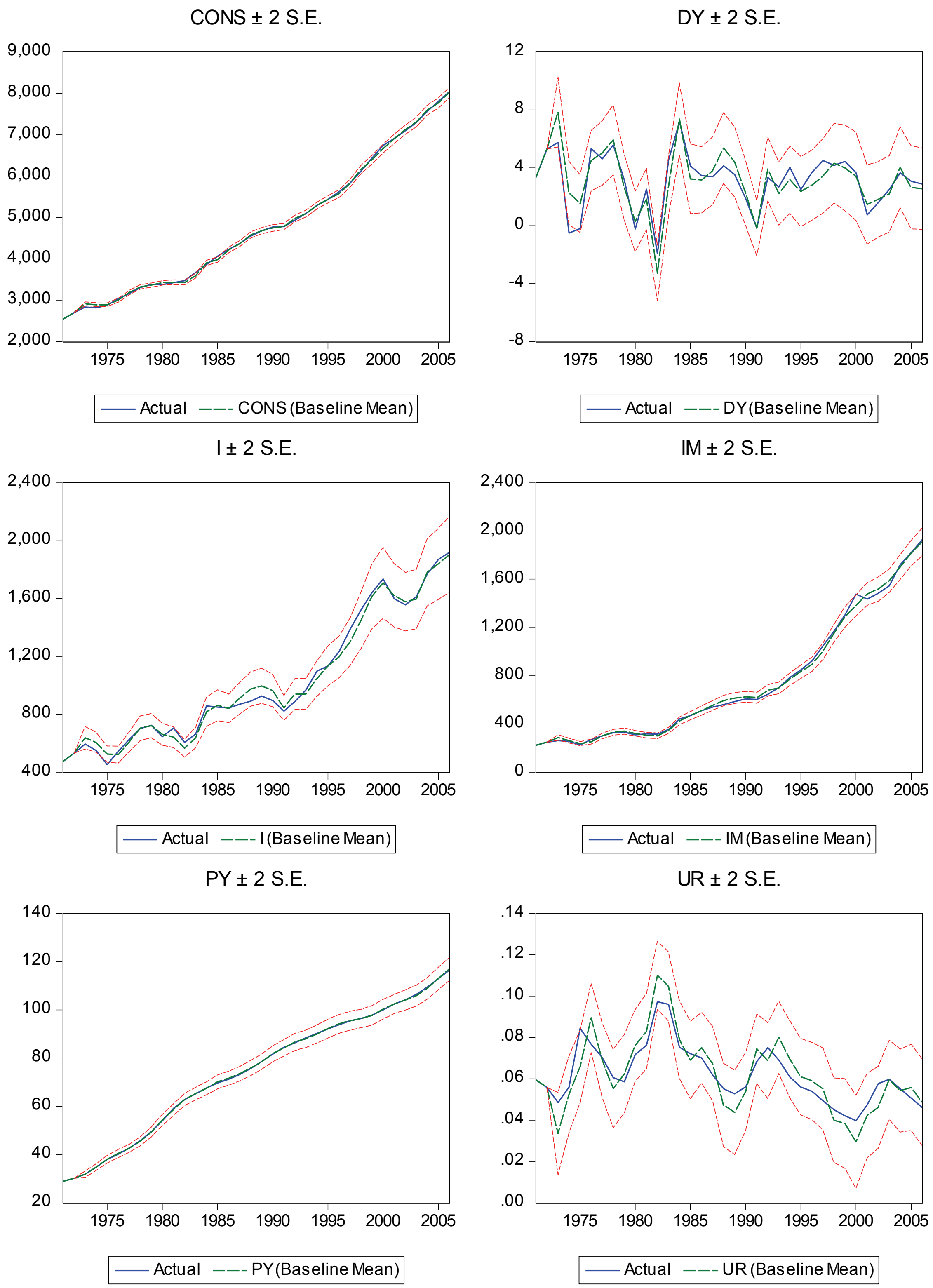
	1999	2000	2001	2002	2003	2004	2005	2006
CONS	0,1	0,3	0,5	0,6	0,6	0,6	0,6	0,5
E	0,3	0,7	0,8	0,8	0,7	0,6	0,5	0,3
EX	2,3	3,9	4,6	4,7	4,3	3,6	2,9	2,3
I	2,2	3,4	2,8	2,1	1,4	0,8	0,3	-0,1
IM	1,3	2,2	2,1	1,9	1,6	1,4	1,0	0,7
L	0,0	0,1	0,2	0,3	0,3	0,3	0,3	0,3
PCONS	-0,2	-0,4	-0,5	-0,4	-0,4	-0,2	-0,1	0,0
PY	0,0	0,1	0,2	0,4	0,5	0,6	0,6	0,6
WF	0,0	0,1	0,3	0,5	0,6	0,7	0,8	0,8
Y	0,5	0,9	1,0	0,9	0,8	0,7	0,6	0,5
YD	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,6
UR*	-0,3	-0,5	-0,5	-0,5	-0,4	-0,2	-0,1	0,0
RSS*	0,2	0,2	0,1	0,0	-0,1	-0,1	-0,1	-0,1
YG7	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

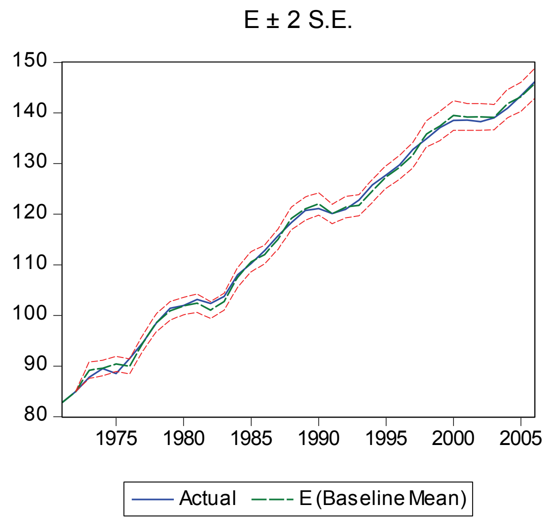
Sustained 1 per cent increase in international price level, PYG7 (compared to reference scenario). Percentage deviation from reference scenario. *Deviation level

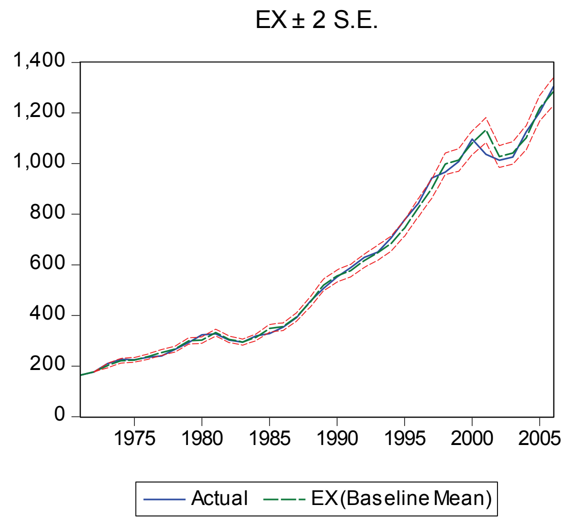
	1999	2000	2001	2002	2003	2004	2005	2006
CONS	0,0	0,1	0,2	0,3	0,3	0,4	0,4	0,4
E	0,1	0,2	0,3	0,4	0,4	0,4	0,4	0,4
EX	0,6	1,4	2,1	2,5	2,7	2,7	2,5	2,2
I	0,5	1,1	1,3	1,3	1,2	1,1	0,8	0,5
IM	0,3	0,7	0,9	1,0	1,0	1,0	1,0	0,8
L	0,0	0,0	0,1	0,1	0,1	0,2	0,2	0,2
PCONS	0,0	-0,1	-0,2	-0,2	-0,2	-0,2	-0,2	-0,1
PY	0,0	0,0	0,1	0,1	0,2	0,3	0,3	0,4
WF	0,0	0,0	0,1	0,2	0,3	0,3	0,4	0,5
Y	0,1	0,3	0,4	0,5	0,5	0,5	0,5	0,5
YD	0,0	0,0	0,1	0,1	0,2	0,2	0,3	0,3
UR*	-0,2	-0,2	-0,3	-0,2	-0,2	-0,2	-0,1	0,0
RSS*	0,1	0,1	0,1	0,0	0,0	0,0	0,0	-0,1
PYG7	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

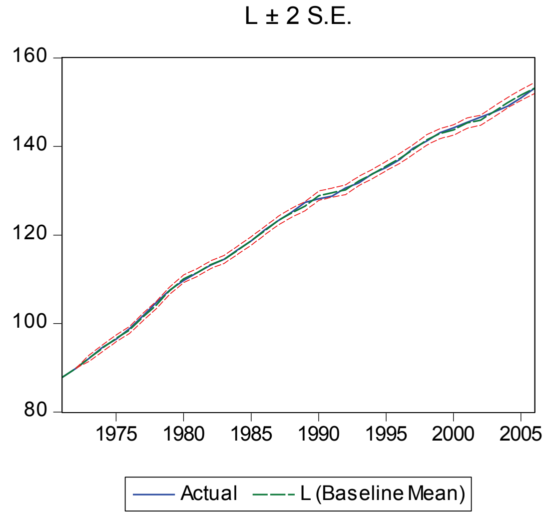
Appendix I

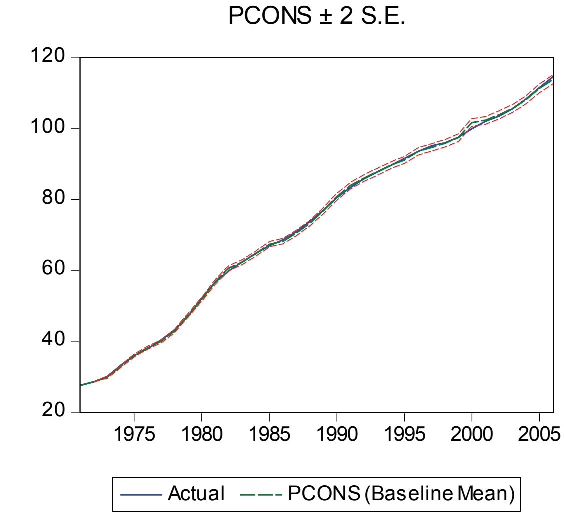
Figure 6 Static simulation. Actual and mean +/- 2 std.

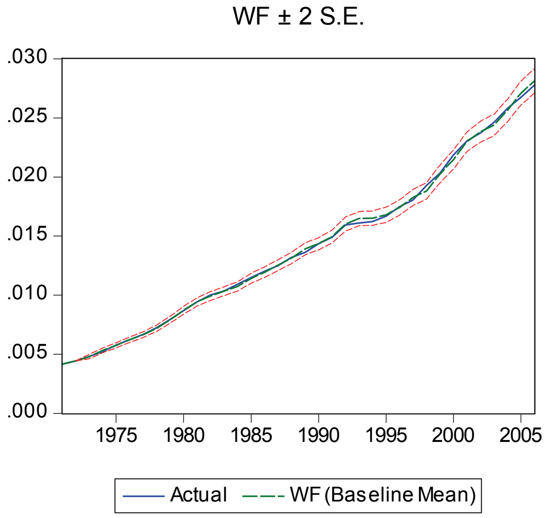


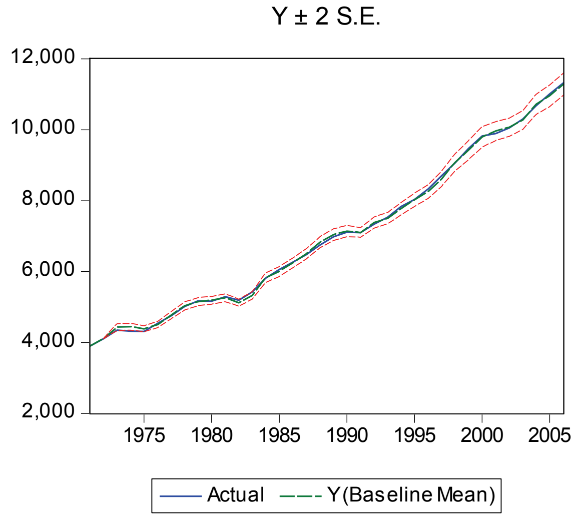

E ± 2 S.E.
150
140
130
120
110
100
90
80
1975
1980
1985
1990
1995
2000
2005
Actual
E (Baseline Mean)


EX ± 2 S.E.
1,400
1,200
1,000
800
600
400
200
0
1975
1980
1985
1990
1995
2000
2005
Actual
EX (Baseline Mean)


L ± 2 S.E.
160
140
120
100
80
1975
1980
1985
1990
1995
2000
2005
Actual
L (Baseline Mean)

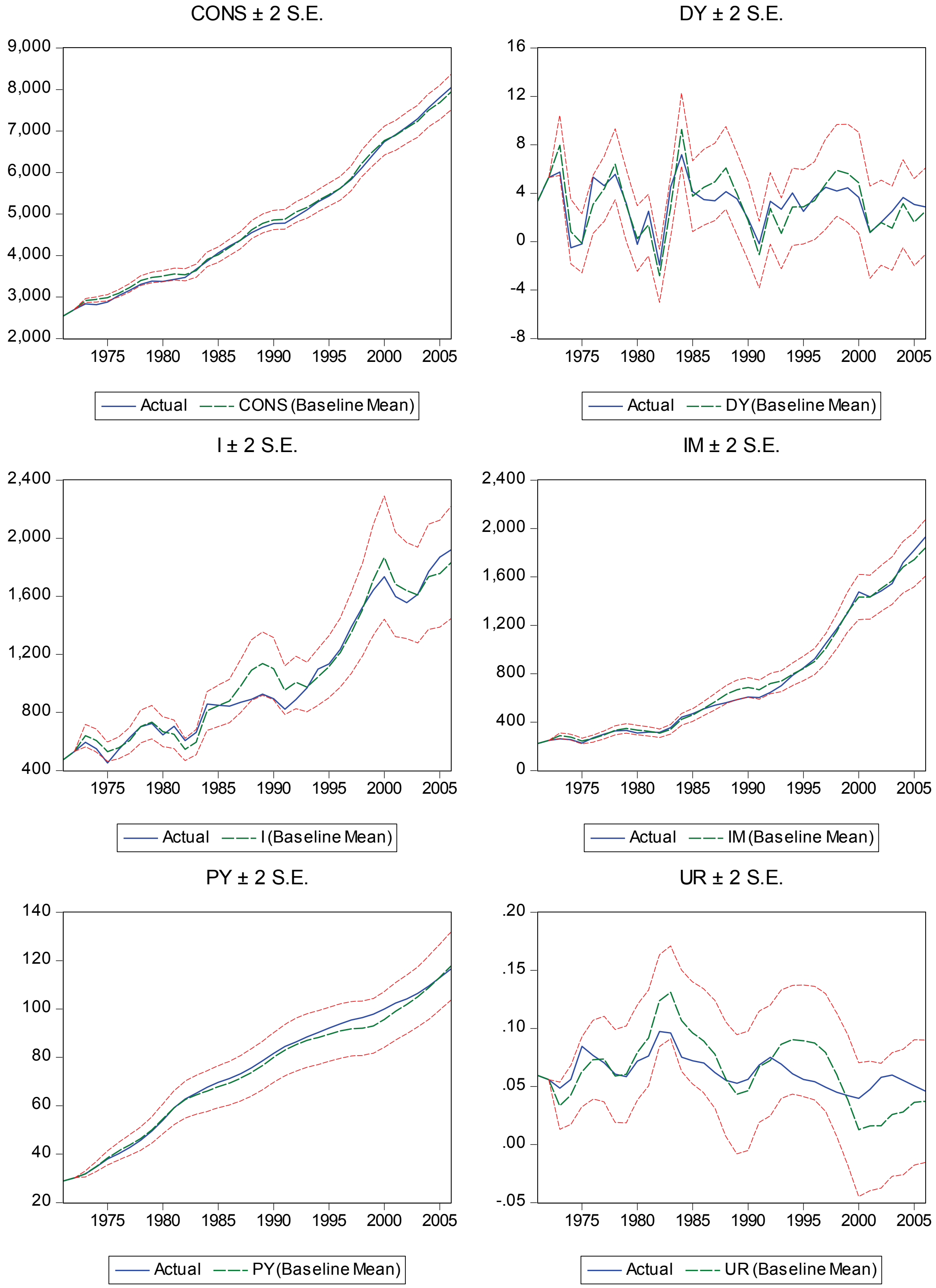

PCONS ± 2 S.E.
120
100
80
60
40
20
1975
1980
1985
1990
1995
2000
2005
Actual
PCONS (Baseline Mean)

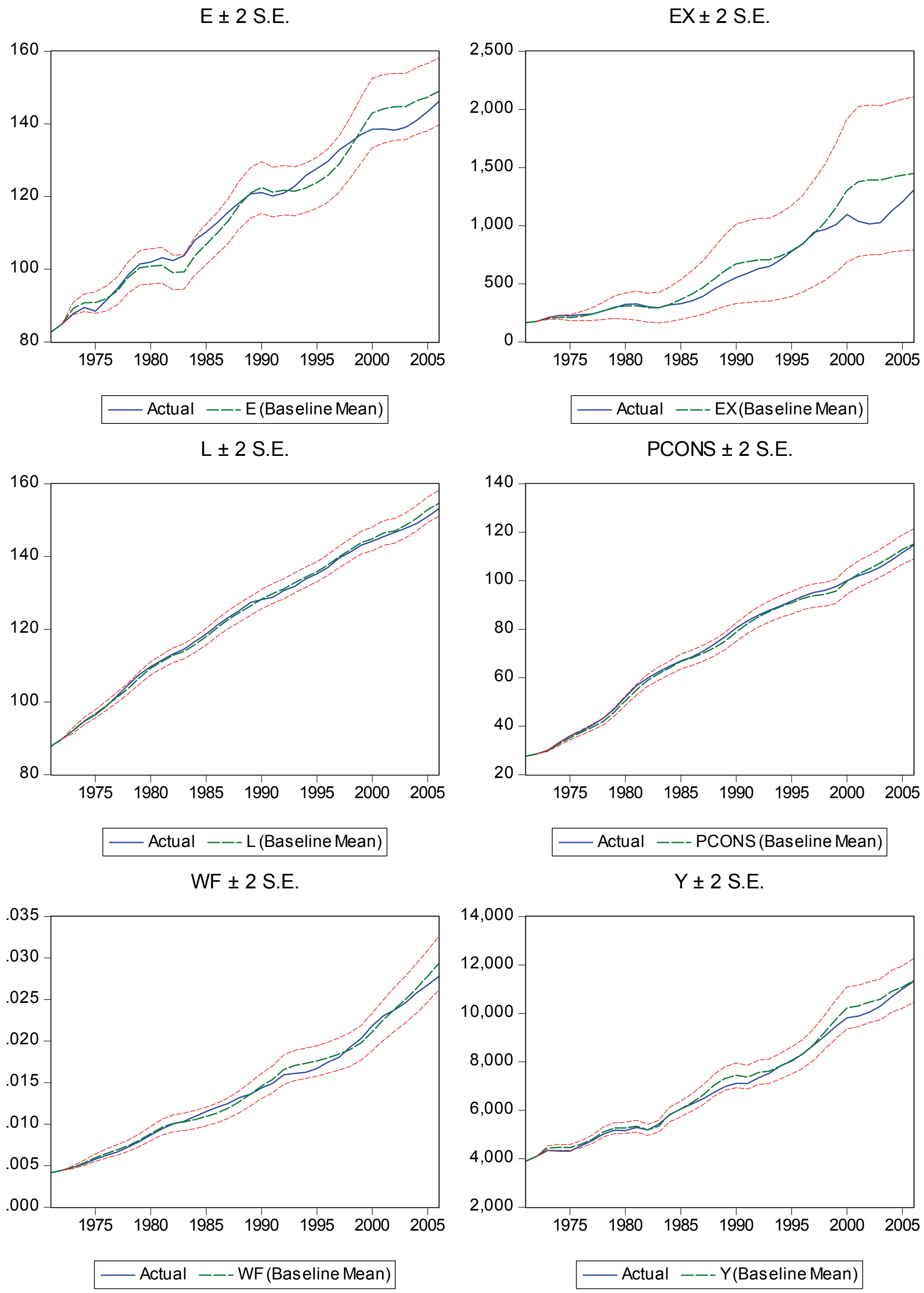

WF ± 2 S.E.
.030
.025
.020
.015
.010
.005
.000
1975
1980
1985
1990
1995
2000
2005
Actual
WF (Baseline Mean)


Y ± 2 S.E.
12,000
10,000
8,000
6,000
4,000
2,000
1975
1980
1985
1990
1995
2000
2005
Actual
Y (Baseline Mean)

Appendix J

Figure 7 Dynamic simulation. Actual and mean +/- 2 std.




E ± 2 S.E.
160
140
120
100
80
1975
1980
1985
1990
1995
2000
2005
Actual
E (Baseline Mean)
EX ± 2 S.E.
2,500
2,000
1,500
1,000
500
0
1975
1980
1985
1990
1995
2000
2005
Actual
EX (Baseline Mean)
L ± 2 S.E.
160
140
120
100
80
1975
1980
1985
1990
1995
2000
2005
Actual
L (Baseline Mean)
PCONS ± 2 S.E.
140
120
100
80
60
40
20
1975
1980
1985
1990
1995
2000
2005
Actual
PCONS (Baseline Mean)
WF ± 2 S.E.
.035
.030
.025
.020
.015
.010
.005
.000
1975
1980
1985
1990
1995
2000
2005
Actual
WF (Baseline Mean)
Y ± 2 S.E.
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1975
1980
1985
1990
1995
2000
2005
Actual
Y (Baseline Mean)