MODELING BULGARIAN BUSINESS CYCLE

Roumen Vesselinov

Paper published in the peer-refereed journal “Statistika” published by the National Statistical Institute and Statistical Association of Bulgaria, 2000, #6.

The main purpose of this study[1] is the analysis and modeling of Bulgarian business cycle with modern econometric instruments despite temporary limited statistical information and short time series. If successful, this analysis will be a good foundation for forecasting the turning points of the business cycle. This is brand new task for Bulgarian statistical practice.

Official statistics and official business cycle indicators are the main source of information for business cycle. In most industrialized countries the main source of information are the official composite indicators for the business cycle – leading, coinciding and lagging [Lahiri and Moore, OECD][2]. Another main source of information are sample surveys of the market, production, consumptions and consumer expectations. They are relatively limited sources, created with different purposes, but they still could be invaluable in some aspects and necessary addition to the official data. The main problem with the official data is that they are published usually after the fact with delay of few months to more than a year and they are corrected sometimes because some components are preliminary. Sample business surveys are published usually monthly and the data are final and never revised. This makes them extremely useful despite their limited character.

For Bulgaria such survey is conducted by the Bulgarian National Statistical Institute (NSI). Two of the main indicators are "Confidence in Industry" (noted with A_t in this study) and "Business Climate in Industry" (noted here with B_t). They are published monthly by NSI [1999] and they are based on information from monthly surveys about production activity in Bulgarian industry. The survey uses European Union methodology. The questionnaire has 15 questions related to the following aspects of the economic activity: current business situation, production, received orders, inventories, production, factors impeding production, expected business situation in the next 6 months, production expectations for the next 3 months, price expectations for own production, production utilization, capacity, expected demand of own production, expected export, and expected layoffs and hiring in the next 3 months,

The question "How do you evaluate current business situation in your company?" has three possible answers: "Good," "Satisfactory," and "Bad". The diffusion index is calculated as difference between the percent "Good" and "Bad" answers while "Satisfactory" answers are excluded. Similarly,

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[1] The author would like to thank his colleagues from Department of Statistics and Econometrics, University of National and World Economy and National Statistical Institute for their help and especially Prof. V.Goev and T.Genova. The author is solely responsible for all remaining errors.

[2] In Vesselinov [2001] the author offers a system of business cycle indicators for Bulgaria based on the experience of USA, EU and other countries.

possible answers for inventories are: "Above Normal," "Normal," and "Below Normal." For production activity possible answers are: "Increased," "Decreased," and "No Change."

"Business Climate in Industry" indicator is a geometric mean from diffusion indices of current business situation and expected business situation for the next 6 months. "Confidence in Industry" indicator is a simple mean from diffusion indices of production orders, expected production activity and level of inventories (reversed).

The respondents are asked to exclude any seasonality in their answers [NSI 1999]. In future this position should change because very few people know how to do this. Instead, NSI should use the standard statistical procedures for eliminating seasonality. On the other hand, the test for seasonally on these two series was negative. This is probably due to the fact that till the end of 1996 the data are collected quarterly and monthly data are extrapolated. Another important characteristic is that this business survey uses extended sample, representative according to the National Sector Classification and uses new system of weights based on the value added by sectors and ownership.

The pre-testing results for the two Bulgarian indicators are as follows. First, both time series are integrated of order two, or they have exactly 2 unit roots[i]. Second, the two series are also cointegrated[ii] of order 1, and third, both time-series are Granger-cause[iii] for each other. After the pre-testing several models are generated by special selecting procedure[iv] that defines the optimal model of given type. Figures 1 and 2 present the dynamic or original data[v] and second consecutive differences.

Figure 1 and 2 here.

Analysis of Internal Relationships

The purpose of this section is to model the Bulgarian business cycle by using the cointegration relationship established in the pre-testing. This approach allows the two series to oscillate and move away from each other and there is a mechanism that kicks off when there is a danger for the long-term equilibrium. At that moment the cointegration equation becomes different from zero and makes the two series come closer. Additional advantage of this approach is that all variables are considered endogenous, or defined by the model.

<u>Error-Correction Model (ECM) for the Bulgarian Business Cycle.</u>

The pre-testing results showed that A_t and B_t are cointegrated of order 1, i.e. they are CI(1), and the ordinary vector autoregressive (VAR) models can not be applied. ECM models are considered and the optimal model has 4 months lag and is presented below (standard error of estimation is shown in parentheses). The first part of the model presents A_t as dependent variable.

$$\Delta A_t = -0.005052\left[A_{t-1} + \underset{(73.9308)}{12.36766}\, B_{t-1} - 62.0065\right] +$$

$$+\underset{(0.1342)}{0.030646}\,\Delta A_{t-1} - \underset{(0.13793)}{0.056733}\,\Delta A_{t-2} - \underset{(0.13622)}{0.176945}\,\Delta A_{t-3} - \underset{(0.14049)}{0.054725}\,\Delta A_{t-4} +$$

$$+\underset{(0.10414)}{0.022201}\,\Delta B_{t-1} + \underset{(0.10341)}{0.287169}\,\Delta B_{t-2} + \underset{(0.11139)}{0.12488}\,\Delta B_{t-3} - \underset{(0.10566)}{0.035152}\,\Delta B_{t-4} + 0.000851$$

The expression in square brackets [] is the cointegrating equation. Some of the coefficients have large standard errors that are due to the small number of observations. The second part of the model presents B_t as dependent variable. Again the standard error of estimation is in parentheses.

$$\Delta B_t = -0.012021\left[A_{t-1} + \underset{(73.9308)}{12.36766}\, B_{t-1} - 62.0065\right] +$$

$$+\underset{(0.14903)}{0.381028}\,\Delta A_{t-1} - \underset{(0.15316)}{0.002004}\,\Delta A_{t-2} + \underset{(0.15127)}{0.112067}\,\Delta A_{t-3} + \underset{(0.15600)}{0.127832}\,\Delta A_{t-4} +$$

$$+\underset{(0.11564)}{0.012318}\,\Delta B_{t-1} + \underset{(0.11483)}{0.154700}\,\Delta B_{t-2} + \underset{(0.12370)}{0.111739}\,\Delta B_{t-3} + \underset{(0.11733)}{0.394316}\,\Delta B_{t-4} + 0.000111$$

Impulse response function and variance decomposition are presented on Figures 3-6. The response function of A_t ("Confidence in Industry Index") shows that one standard deviation shock in its own development leads to 1% to 3% change during one year and the influence decreases in time. One standard shock in B_t ("Business Climate Index") has effect of ±1% over dynamics of A_t. The response function of B_t shows that one standard deviation shock in A_t causes 1%-2% change and this effect increases in first 6 months and gradually decreases in the next 6 months. One standard shock in B_t own development causes 3-4% change in first 5 months and then immediately decreases till the end of the year.

Variance decomposition of A_t shows that almost 100% is due to internal factors while this percent for B_t is 70-75% and it is almost constant for one year, and the rest (25-30%) is due to A_t.

Figures 3-6

ECM gives a detailed picture for the system reaction in the presence of different internal shocks and their distribution in time. Internal as well as external shocks do not have great influence on the two indicators. The impulse response functions show that "Confidence in Industry Index" dynamics is explained largely by its internal changes.

Analysis of Internal Dynamics.

Analysis in this section is aimed at important question related to the variability of the time series. It is relatively new topic for business cycle research and the methodology used here allows to simultaneously model the variance and the mean of the process. This gives the possibility to model asymmetrically the two phases of the business cycle, which follows the fact that in the last 50 years the length of recessions is significantly smaller than the length of expansions. The methodology allows also presenting the reaction of the system to external shocks, and the reaction could depend not only on the size of the shock but also on its direction. One negative destabilizing shock could have big effect and it could cause big change in variation, while one positive shock with the same magnitude could lead to decrease in variation.

Traditional statistical regression-like methods are used to model the conditional mean of a random variable. Autoregressive models with conditional heteroscedasticity (ARCH) are specifically built to analyze the conditional variation of the process.

ARCH models allow conditional mean of given variable to change over time. This change is function of past changes while the unconditional variation stays constant. The variation of the dependent variable is presented as function of its own lag values and other independent or exogenous variables. ARCH models are introduced by Engel [1982] and are further developed as generalized ARCH or GARCH by Bollerslev [1986]. ARCH models are special case of GARCH models.

From econometric point of view GARCH models are specific nonlinear models that allow for deeper analysis on the dynamics of time series. A GARCH model consists of two equations, one for the conditional mean and one for the conditional variance.

GARCH(1,1) is defined as follows:

$Y_t = g X_t + e_t$ Conditional mean equation.

$s_t^2 = w + a e_{t-1}^2 + b s_{t-1}^2$ Conditional variance equation.

It is called conditional variance because variance s_t^2 is dependent of its own lag values, the lag values of residuals and the mean w . The other notations are as follows:

- e_{t-1}^2 is ARCH term. This is information about the dynamics of the previous period measured as lag of squared residuals from the conditional mean equation.
- s_{t-1}^2 is GARCH term, which it is the variance from the previous period.

Notation GARCH (p,q) shows the presence of GARCH term of order p and ARCH term of order q. The regular ARCH model is special case of GARCH model, it is GARCH (0,q), i.e. in ARCH model there are no lag values of variance. GARCH(2,1) for example has GARCH term of order two and ARCH term of order one.

In order to build GARCH model, first the test for presence of ARCH effect in the residuals of the model should be performed. The tests[vi] for both series showed the presence of such effect.

After the presence of ARCH effect is established there are two possibilities: first, to eliminate the effect and continue with ordinary regression models or second, to model this effect with different GARCH models and select the optimal model. In this study the later method is chosen because the dynamics of variance of business indicators is considered very important.

GARCH(1,1) model for "Business Climate Index" (B_t).

The best model here is the ordinary GARCH(1,1) model. Conditional mean equation is presented below:

$$B_t = -0.051308 - \underset{(0.11728)}{0.722939}\, B_{t-1}$$

Conditional variance equation is as follows:

$$s_t^2 = 2.219787 + \underset{(0.187204)}{0.611201}\, e_{t-1}^2 + \underset{(0.170066)}{0.404252}\, s_{t-1}^2$$

All coefficients are statistically significant which is surprising given the small number of observations. The lag values have significant, negative influence (-0.722939) and again, only one-month lag values are significant, i.e. this series has short memory. From the second equation can be concluded that there are accumulations of similar fluctuations in the variance, i.e. big changes are followed by big changes and the other way around. (0.404252). The size of the shock has positive effect (0.611201) on the variance, or in other words big changes in the economy lead to big changes in the indicator. This ordinary GARCH model cannot give an answer whether one negative shock has bigger influence than a positive shock with the same size. Analysis[vii] of residuals showed that the model had good statistical properties.

Figure 7 presents the smoothed values for "Business Climate Index" based on the GARCH(1,1) model. The only serious deviation and wide confidence interval are present in March, 1997 (trough). The same phenomenon is observed on Figure 8, which presents the dynamic of the variance estimated by the model.

Figures 7 and 8

EGARCH(1,1) model for "Confidence in Industry Index" (A_t).

The optimal GARCH model for this series is EGARCH(1,1). Conditional mean equation is presented below (standard error in parentheses):

$$A_t = 0.110208 - \underset{(0.084860)}{0.376689}\, A_{t-1}$$

Conditional variance equation is as follows:

$$\log\left(s_t^2\right) = 0.866204 + \underset{(0.159631)}{0.285332}\ \log\left(s_{t-1}^2\right) + \underset{(0.256549)}{0.978695}\left|\frac{e_{t-1}}{s_{t-1}}\right| + \underset{(0.191365)}{0.722237}\left[\frac{e_{t-1}}{s_{t-1}}\right]$$

This model shows that the leverage effect is exponential and not quadratic and since the coefficient before $\frac{e_{t-1}}{s_{t-1}}$ is positive the presence of leverage effect is not confirmed. Nevertheless this coefficient (0.722237) is statistically significant which means that the influence in definitely asymmetrical. This is one of the basic characteristics of the business cycle. Interestingly enough all coefficients are significant despite the small number of observations. From the conditional mean equation it is also clear that lag values have significant negative effect (-0.376689) on current values of the indicator. The second equation shows that independent influence of the lag values of the variance has positive effect (0.285332), i.e. big fluctuation in the variance from previous month variation causes big fluctuation in the current value. Only lag values with one month length are statistically significant, i.e. this series has short memory. Both absolute (0.978695) and relative (0.722237) aspects of the shock have positive and significant effects on the variance of "Confidence in Industry Index."

The results in this section show that it is very beneficial to use nonlinear models that allow to model the variance of the process and not only its mean level. This also shows that dynamics of Bulgarian business cycle is no exception from the world experience where the process is influenced by "bad" and "good" news and the former has much stronger influence than the later. These models are also especially appropriate for forecasting of the business cycle indicators.

Analysis of Switching of Business Cycle Phases

Dynamics of the business cycle assumes going through the two main phases: recession and expansion. This process is also called "regime changing" and for this purpose the turning points of the cycle should be defined. Since the business cycle cannot be observed directly the concept of so called "unobservable state variable" is applied here. This variable cannot be observed directly but it could be included in statistical model that allows its indirect estimation.

State-space model is a general form a dynamic system can be represented. The classical linear regression model, ARIMA models can be defined as a special case of a state-space specification. Representing a dynamic system in a state-space form can be beneficial in two directions: first, this will allow to incorporate unobserved variables (known as the state variables) and to estimate their coefficients along with the observable model. Second, state-space models can be estimated using a powerful recursive non-linear algorithm known as the Kalman filter [Kalman 1960]. The Kalman filter is used both to evaluate the likelihood function and to forecast and smooth the unobserved state variables. Examples of unobserved variables are abundant: rational expectations, measurement errors, missing observations, unobserved components-cycles, trends, natural rate of unemployment, etc.

State-space models incorporate two equations: transition (state) equation and measurement equation. Measurement equation describes the relation between observed variables (the data) and unobserved state variables. Transition equation describes the dynamic of state variable: it has the form of first-order difference equation in the state vector.

State-Space Model for "Business Climate Index" (B_t).

The optimal state-space model has one lag of the observed variable and two lags for the unobserved sate variable.

$$B_t = -0.012014 - \underset{(0.146527)}{0.691765} B_{t-1} + S_t$$ - observation equation.

$$S_t = -\underset{(0.137375)}{0.104890} S_{t-1} - \underset{(0.132439)}{0.490717} S_{t-2}$$ - state equation.

Here the only lag value of the indicator has a negative and significant coefficient (-0.691765), and the same goes for the second equation where both lag values of the state variable have negative coefficients. On Figures 9 and 10 some large fluctuations can be observed, e.g. the big drop in the beginning of 1997. This again could serve as confirmation of the determination of the cyclical turning points made in previous sections.

Figures 9 and 10

State-space Model for "Confidence in Industry Index" (A_t).

The model is presented below and the standard error is included in parentheses. It includes one lag for the observed variable and two lags for the unobserved state variable.

The observation equation is as follows:

$$A_t = -0.015412 - \underset{(0.144957)}{0.6165} A_{t-1} + S_t \,,$$

where S_t is the unobserved state variable, which in this case is the unknown phase of the business cycle.

The state equation has the following form:

$$S_t = -\underset{(0.169006)}{0.051092} S_{t-1} - \underset{(0.125462)}{0.3888674} S_{t-2}$$

From the first equation is evident that here, the lag value of "Confidence in Industry Index" has significant negative effect (-0.6165) on the current values of the indicator. The state equation shows that the two lag values negatively influence the current values of the state of the business cycle. Figure A18 shows smoothed values of the unobserved state variable. This presentation lends the idea that there are two waves of the Bulgarian business cycle with turning point at the beginning of 1997. Figure A19 shows the one-step ahead forecasts and their confidence interval. Some additional elements are visible here: the trough in March, 1997 and slowdown in June 1999.

The analysis in this section showed statistically significant result despite the limited information for Bulgarian business cycle. In Vesselinov (2001) the forecasting abilities of similar type models are presented and tested.

Literature

1. VELICHKOVA, N. (1981): *Statistical Methods*, Part 2, Sofia, Bulgaria.
2. VESSELINOV, R. (2001, PHD THESIS): *Econometris Analysis and Forecasting of the Business Cycle. The Case of USA and Bulgaria*, Sofia, Bulgaria.
3. BOLLERSLEV, T. (1986): "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics*, 31, 307-327.
4. BOX, G. E.P. AND G. M. JENKINS (1970): *Time Series Analysis: Forecasting and Control*, Holden-Day.
5. DICKEY, D.A. AND W.A. FULLER (1979): "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, 74, 427-431.
6. ENGLE, R.F. (1982): "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of the U.K. Inflation," *Econometrica*, 50, 987-1008.
7. GRANGER, C.W.J. (1969): "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, 37, 424-38.
8. HAMILTON, J.D. (1994): *Time Series Analysis*, Princeton University Press.
9. JOHANSEN, S. AND K. JUSELIUS (1990): "Maximum Likelihood Estimation and Inferences on Cointegration – with applications to the demand for money," *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
10. KALMAN, R.E. (1960): "A New Approach to Linear Filtering and Prediction Problems," *Transactions ASME Journal of Basic Engineering*, D82, 35-45.
11. LAHIRI, K. AND G.H. MOORE (Eds.) (1990): *Leading Economic Indicators: New Approaches and Forecasting Records*, Cambridge University Press.
12. NATIONAL STATISTICAL INSTITUTE (NSI, 1999): "Current Business Survey, Sofia, Bulgaria.
13. OECD (1997): *Main Economic Indicators. Sources and Definitions*, Statistics Directorate.
14. PHILLIPS, P.C.B. AND P.PERON (1988): "Testing for Unit Root in Time Series Regression," *Biometrica*, 75, 335-346.
15. WHITE, H. (1980): "A Heteroscedasticity-Consistent Covariance Matrix and a Direct Test for Heteroscedasticity," *Econometrica*, 48, 817-838.

Figure 1. Confidence and Business Climate in Industry.
Monthly data.

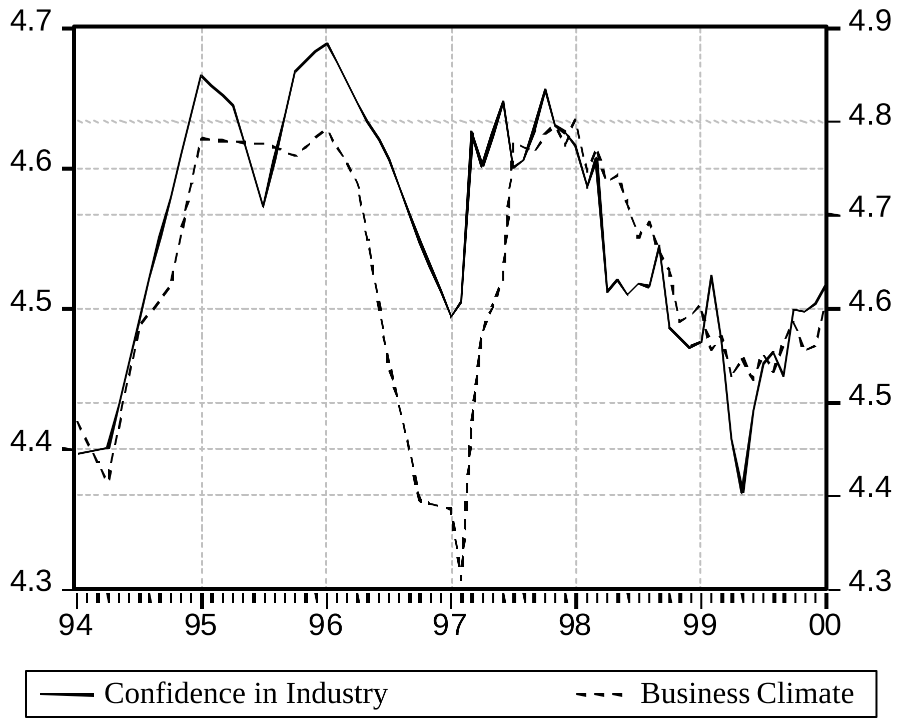


Figure 2. Confidence and Business Climate in Industry.
Second consecutive differences

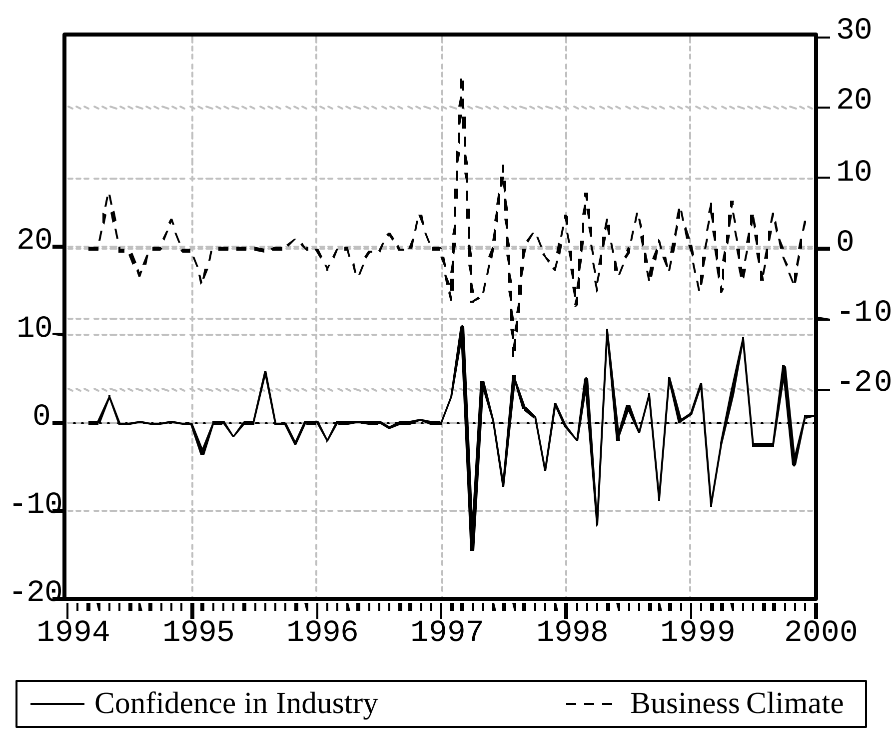


Figure 3. Impulse Response of Confidence in Industry.

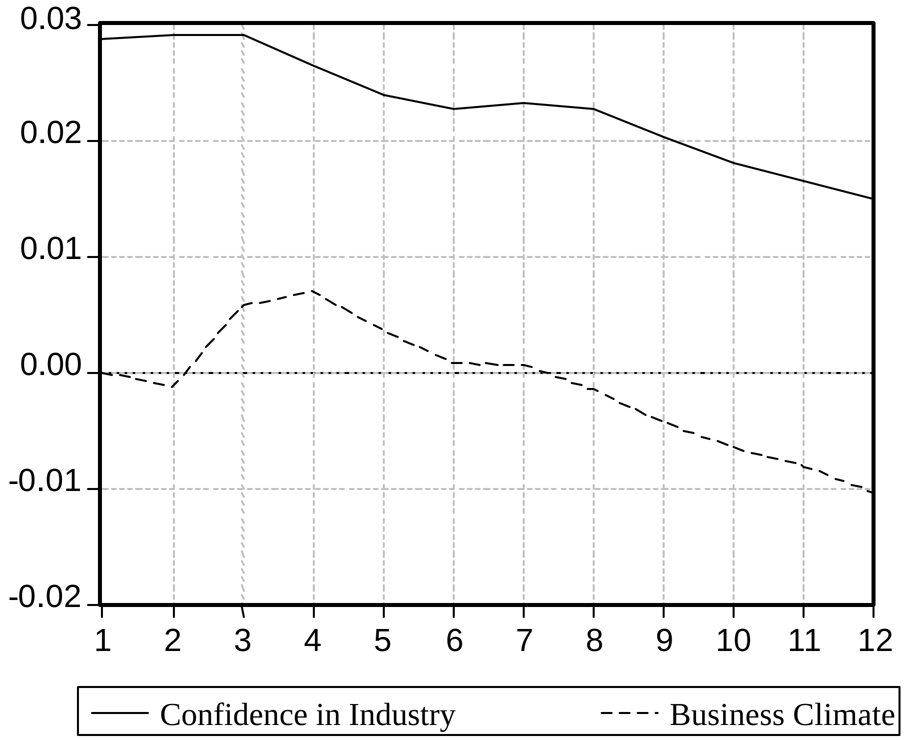


Figure 4. Impulse Response of Business Climate.

Figure 5. Variance Decomposition of Confidence in Industry.

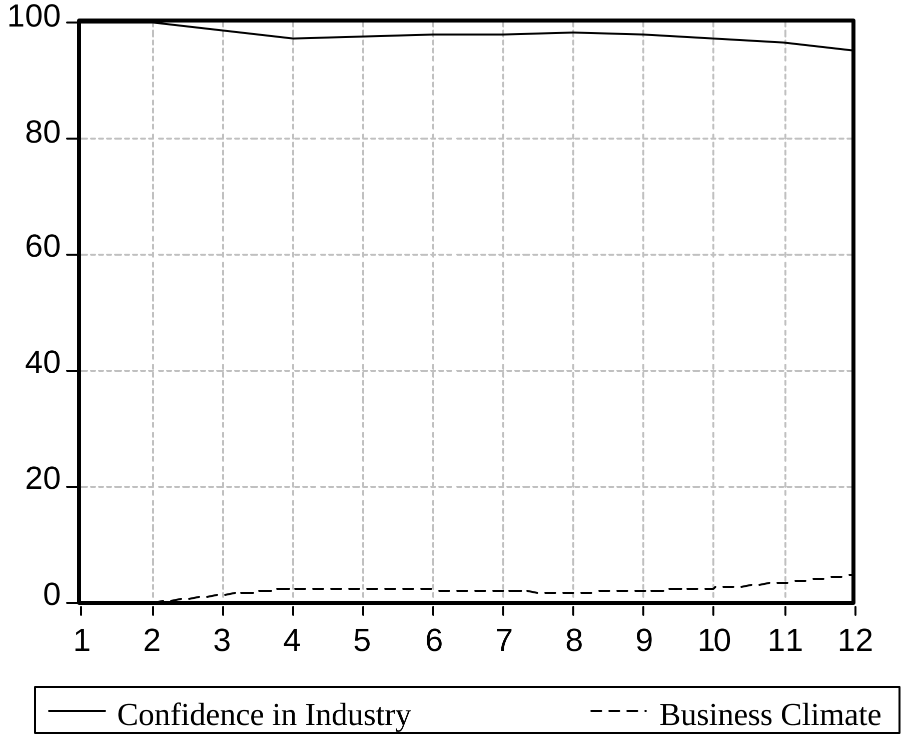


Figure 6. Variance Decomposition of Business Climate.

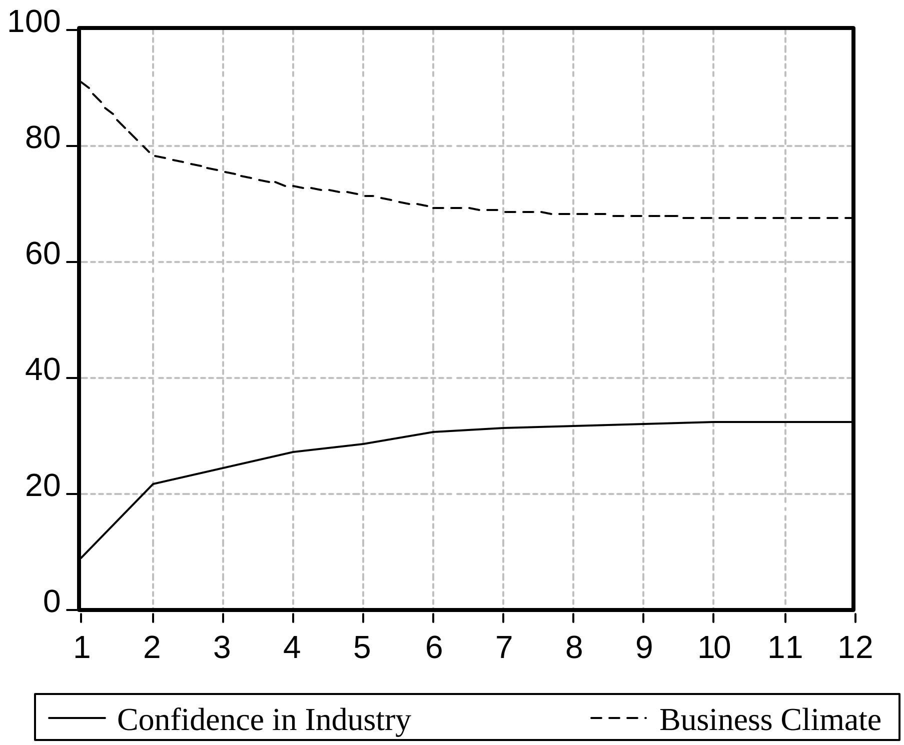


Figure 7. GARCH(1,1) Model of Business Climate. Estimates.

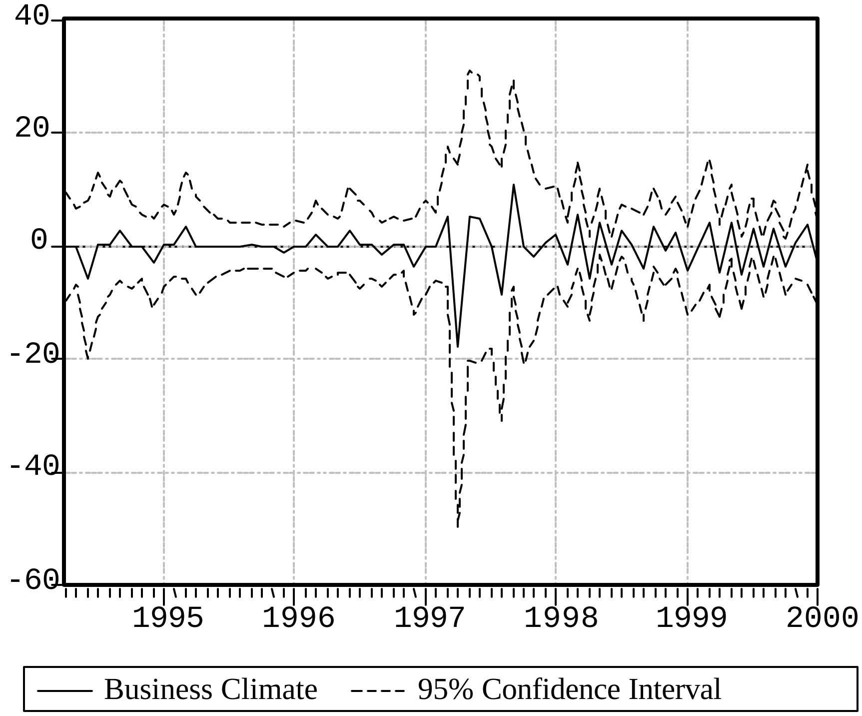


Figure 8. GARCH(1,1) Model of Business Climate. Variance.

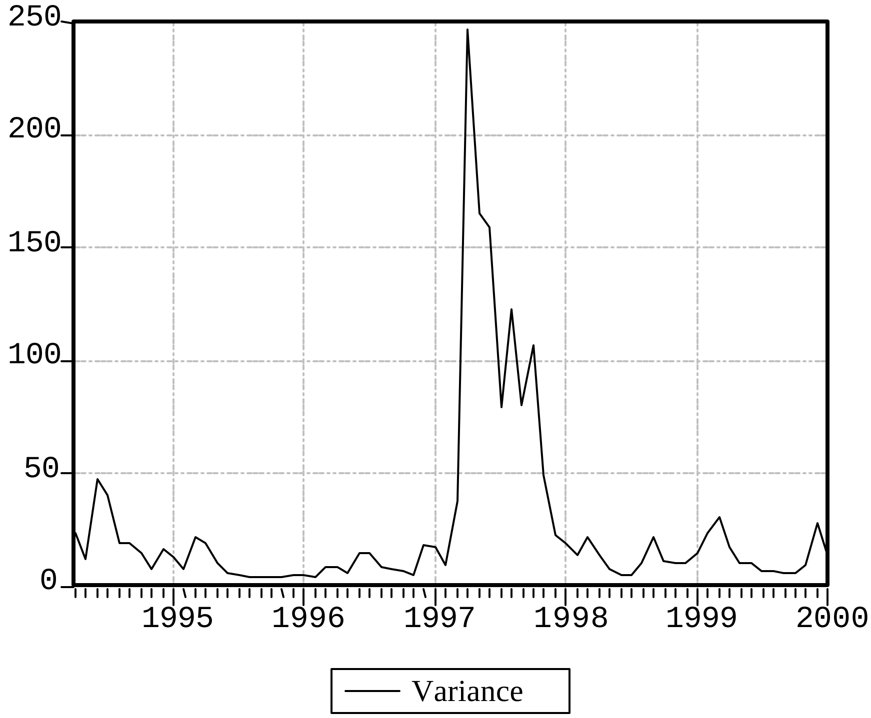
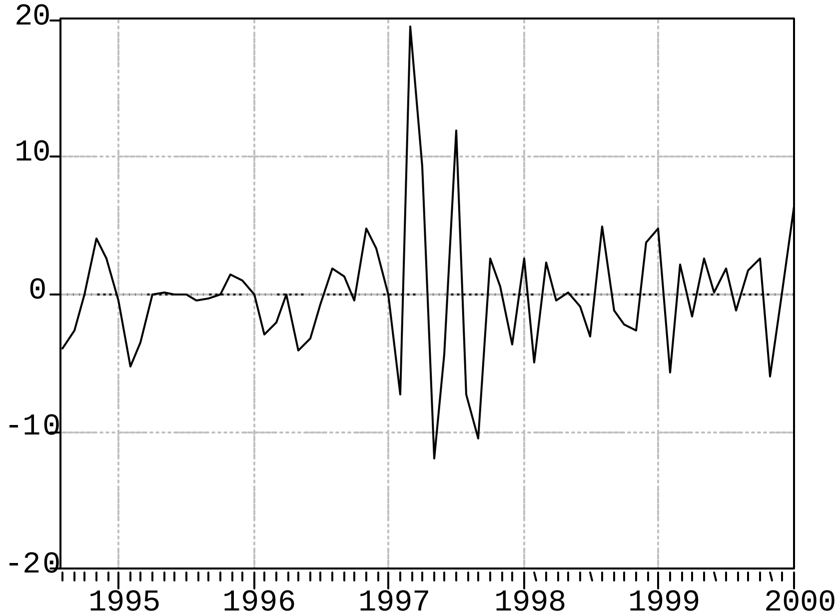
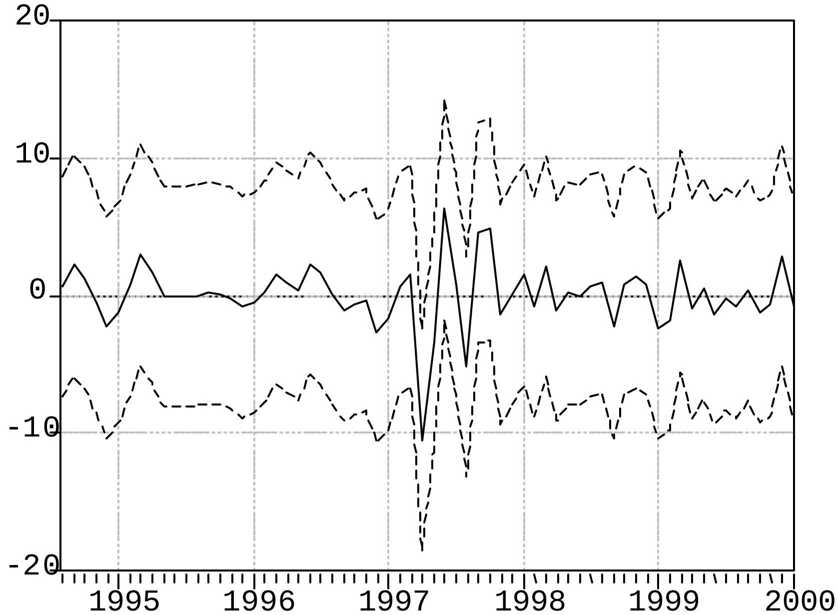


Figure 9. State-space Model of Business Climate.
Estimates.



—— State Variable

Figure 10. State-space Model of Business Climate.
One-step ahead estimates.



—— State Variable
- - - - 95% Confidence Interval

Notes:

[i] Two tests for unit roots are applied here: the Augmented Dickey-Fuller test and Philips-Peron test. The former is parametric and the later is non-parametric test. Using two different tests for unit roots is recommended in the literature for more accuracy.

[ii] Johansen's test is used for cointegration testing.

[iii] Granger-cause test is used here..

[iv] More details are included in Vesselinov [2001]. The selection procedure uses Akaike (AIC) and Scharz (SIC) information criteria:

$$AIC(\mathrm{p}) = n\log\left(\hat{s}^{2}\right) + 2\,\mathrm{p}$$

$$SIC(\mathrm{p}) = n\log\left(\hat{s}^{2}\right) + \mathrm{p}\log\left(n\right),$$

where, n – number of observations, $\hat{s}^{2} = \dfrac{RSS}{n-p}$, RSS = $\Sigma\, \hat{e}_t^2$ and p - number of parameters.

[v] The original data are monthly for January 1994 – January 2000. The logs are taken, as first 100 is added to eliminated the negative signs. The presence of two unit roots requires using second consecutive differences, except for the Error-correction model which is specifically designed for this purpose.

[vi] Two tests are used: Engel's test and White's test. Using two tests is recommended in the literature.

[vii] Two additional tests are performed because the theory requires that if the GARCH model is statistically significant then the residuals should be normally distributed with no ARCH effect present. Engel's and White's tests are used. The standard test for normality is Jarque-Bera (JB) test:

$JB = \left[\dfrac{N-k}{6}\right]\left[S^{2} + \dfrac{\left(K-3\right)^{2}}{4}\right] \square\ c_{2}^{2}$, where S is skewness, K is kurtosis, k – number of coefficients, and N – number of observations..