Does Black's Hypothesis for Output Variability Hold for Mexico?

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Abstract:

Using two data series, namely GDP and the index of industrial production, we study the relationship between output variability and the growth rate of output. Ng-Perron unit root test shows that the growth rate of GDP is non-stationary but the growth rate of industrial output is stationary. Thus, we use the ARCH-M model for the monthly data of industrial output. A number of specifications (with and without a dummy variable) are used. In all cases, the results show that output variability has a negative but insignificant effect on the growth rate of output.

Keywords: economic growth, volatility, variability, business cycle fluctuations, GARCH models.

JEL classification: C22, C51, C52, E32

I. Introduction

The mechanism by which output growth and the variability of output growth may influence long term economic growth has attracted a renewed level of interest in recent years. This literature has primarily evolved into three broad schools of thought. The first school of thought, commonly attributed to Keynes (1936), suggests an inverse relationship between output variability and economic growth and argues that excessive volatility can lead to an increased level of uncertainty regarding the long-run profitability of investment, which may reduce the level of investment and output growth *ex post*. It is argued that this is detrimental to long term growth. Studies that support this hypothesis primarily rely on the irreversibility of investment decisions creating an increased level of uncertainty at the firm level (Pindyck, 1991; Bernanke, 1983; Ramey and Ramey, 1995; Martin and Rogers, 2000). Macri and Sinha (2000) and Rafferty (2005) find evidence that supports this hypothesis.

The second school of thought, commonly attributed to Schumpeter's (1942) notion of 'creative destruction', argues that output volatility is positively related to long-term growth and that policies designed to ameliorate volatility may actually harm an economy's potential output. In other words, investment will only be undertaken if the expected rates of return are sufficiently high to compensate for the greater risk. In other words, economies face a positive risk-return trade-off (Black, 1987; Caporale and McKiernan, 1996, 1998; Kormendi and Meguire, 1985; Mills, 2000). This is also known as the Black's hypothesis.

The third school of thought, commonly attributed to Friedman (1968, 1977), argues that there is no *a priori* relationship between output variability and economic growth. It is implicitly argued that fluctuations of output about its natural growth path are independent phenomena. In other words, fluctuations in output around a non-stochastic trend are caused by price misperceptions due to monetary shocks and as a consequence lead to temporary deviations from their natural levels. In other words, the growth rate of output is determined by real factors such as skills, technology and other real factors (Fountas et al., 2004). Employing the Ramey and Ramey methodology, Dejuan and Gurr (2004), find, at best, a weak positive relationship. The advocates of this school argue that these results provide some support for the hypothesis that business cycle theory and long-term economic growth are independent phenomena.

Our objective in this paper is to study the effect of output variability on the growth rate of output using the ARCH-M model (Engle, Lilien and Robins, 1987).

II. Data and Estimation

Our data source is the International Monetary Fund (2006). Following previous literature, two data series are used. The first is the deseasonalized quarterly real GDP data from quarter 1, 1980 to quarter 1, 2006. The real GDP data (base year is 1993) are billion pesos. We calculate the growth rate of GDP by taking the first difference of the natural log of GDP. We denote the growth rate of GDP by *GGDP*. The second series is the index of deseasonalized monthly industrial production data from

January, 1980 to April, 2006. Again, we calculate the growth of industrial production by the same method and denote it by *GIP*.

Our first task is to test for stationarity of the data. We use the Ng-Perron (2001) unit root tests. The relatively newer Ng-Perron tests are more powerful than the more widely used augmented Dickey-Fuller and Phillips-Perron unit root tests. The traditional tests often over-reject the unit root hypothesis. Since the test is new, a brief description if it follows.

The starting point is the Dickey-Fuller test (ADF) (Dickey and Fuller, 1979, 1981). $\Delta y_t = \alpha y_{t-1} + x_t^{/}\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots\ldots\ldots \beta_p \Delta y_{t-p} + v_t$ (1)

The null hypothesis of unit root involves testing $\alpha = 0$ against the alternative hypothesis $\alpha < 1$ using the conventional *t*-test. Since the statistic does not follow the conventional Student's t-distribution, Dickey and Fuller (1979) and Mackinnon (1996), among others, simulate the critical values. For ADF tests, one can include a constant and/or a linear time trend. Elliot, Rothemberg and Stock (ERS hereinafter) (1996) modify the ADF tests for two cases – one with a constant and the other with a constant and a trend, as follows. First, a quasi-difference of y_t is defined. The quasi-difference of y_t depends on the value of a representing the specific point against which the null hypothesis below is tested:

$d(y_t|a) = y_t$ if $t = 1$ and $d(y_t|a) = y_t - ay_t$ if $t > 1$

Second, quasi-differenced data $d(y_t|a)$ is regressed on quasi-differenced $d(x_t|a)$ as follows: $d(y_t|a) = d(x_t|a)^{/}\,\delta(a) + \eta_t$ (2)

where x_t contains a constant or a constant and a trend. Let $\hat{\delta}(a)$ be the OLS estimate of $\delta(a)$

For a, ERS recommend using $a = \overline{a}$ where $\overline{a} = 1 - 7/T$ if $x_t = \{1\}$ and $\overline{a} = 1 - 13.5/T$ if $x_t = \{1, t\}$

GLS detrended data, y^d_t are defined as follows. $y^d_t \equiv y_t - x_t^{/}\hat{\delta}(\bar{a})$

In ERS, GLS detrended y^d_t is substituted for y_t.

$$\Delta y^d_t = \alpha\, \Delta y^d_{t-1} + \beta_1 \Delta y^d_{t-2}\ \Delta y_{t-1} + \ldots\ldots\ldots + \beta_p \Delta y^d_{t-p} + v_t \qquad (3)$$

Just like the ADF test, the unit root test involves the test on the coefficient α.

The ERS Point Optimal test is as follows. Let the residuals from equation (2) be $\hat{\eta}_t(a) = d(y_t|a) = d(x_t|a)^{/}\hat{\delta}(\bar{a})$ and let the sum of squared residuals, SSR(a) = $\hat{\eta}_t^{\,2}(a)$.

The null hypothesis for the point optimal test is α = 1 and the alternative hypothesis is $\alpha = \bar{a}$. The test statistic is $P_T = (\mathrm{SSR}(\bar{a}) - \mathrm{SSR}(1))/f_0$ where f_0 is an estimator of the residual spectrum at frequency zero.

The four tests of Ng-Perron involve modifications of the following four unit root tests: Phillips-Perron Z_α and Z_t, Bhargava R_1 and ERS Optimal Point tests. The tests are based on GLS detrended data, Δy^d_t. First, let us define $\kappa = \sum_{t-2}^{T} (y^d_{t-1})^2 / T^2$

The four statistics are listed below.

$$MZ^d_\alpha = (T^{-1} y^d_T)^2 - f_0) / 2\kappa \qquad (4)$$

$$MZ^d_t = MZ_\alpha \text{ x } MSB \qquad (5)$$

$$MSB^d = (\kappa / f_0)^{1/2} \qquad (6)$$

$MP^d_T = (\bar{c}^{\,2}\kappa - \bar{c}\,T^{1})(y^d T)^2)/ f_0$ if $x_t = \{1\}$ and $MP^d_T = (\bar{c}^{\,2}\kappa + (1 - \bar{c})T^{1}(y^d T)^2)/ f_0$ if $x_t = \{1, t\}$ where $\bar{c} = -7$ if $x_t = \{1\}$ and $\bar{c} = -13.5$ if $x_t = \{1, t\}$ (7)

The results of the Ng-Perron unit root tests are in Table 1. All the four statistics give us the same results that *GIP* has no unit root while *GGDP* has a unit root. Since ARCH and GARCH methodology is applicable only to the stationary time series, we work with *GIP* from now on.

As noted earlier, we use the ARCH-M model. In selecting the right model, we use both the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). We estimate the model with and without a dummy variable. An examination of the data reveals that we need to use a dummy variable for these months:

(1) March to December 1986 and (2) February to May 1995. These are due to the effects of the debt crisis due to the collapse of world oil prices and the peso crisis respectively. The dummy variable takes a value of 1 during the mentioned months and 0 otherwise.

For estimating the ARCH-M model, we use the Berndt et al (1974) numerical optimization algorithm to get the maximum likelihood estimates of the parameters. The reported z-statistics (given in the parentheses) for parameters are robust to departures from normality using the consistent variance-covariance estimator of Bollerslev and Wooldridge (1992). Three different specifications are estimated. The mean and the variance equations are denoted by (a) and (b) respectively. (8a) and (8b) give the results of the specification selected by the AIC criterion. (9a) and (9b) give the results of the specification selected by the SBC criterion. Finally, (10a) and (10b) give the results when a dummy variable (denoted by DUM) as defined earlier is included. In this case, both AIC and SBC criteria select the same specification. An asterisk indicates significance at least at the 5% level. Ljung-Box Q-statistics up to 12 lags do not show any problem of serial correlation in any of the cases.

$$\begin{aligned}GIP = {} & \underset{(1.6471)}{0.0041} + \underset{(9.2895^*)}{1.0355}AR(1) - \underset{(-2.3820^*)}{0.21570}AR(2) - \underset{(-14.7529^*)}{1.1635}MA(1) + \underset{(10.3308)}{0.5437}MA(2)\\ & - \underset{(-0.6620)}{0.1924}\sigma_t \end{aligned} \tag{8a}$$

$$\sigma_t^2 = \underset{(1.3300)}{0.000004} + \underset{(2.8809^*)}{0.0779}\varepsilon^2_{t-1} - \underset{(25.6424^*)}{0.8970}\varepsilon^2_{t-2} \tag{8b}$$

$$GIP = \underset{(2.4515^*)}{0.0059} - \underset{(-3.9168^*)}{0.6039}AR(1) + \underset{(3.1028^*)}{0.5327}MA(1) - \underset{(-1.1412)}{0.2602}\sigma_t \tag{9a}$$

$$\sigma_t^2 = \underset{(1.3012)}{0.000006} + \underset{(3.0007^*)}{0.1135}\varepsilon^2_{t-1} + \underset{(13.7692^*)}{0.8521}\varepsilon^2_{t-2} \tag{9b}$$

$$GIP = 0.0051 + 1.0471AR(1) - 0.2154AR(2) - 1.2188MA(1) + 0.5458MA(2)$$
(1.8640) (8.5230*) (-2.0627*) (-13.4934*) (9.4953*)

$$- 0.0153DUM - 0.2266\sigma_t \qquad (10a)$$
(-5.9717*) (-0.6987)

$$\sigma_t^2 = 0.000006 + 0.0693\varepsilon^2_{t-1} + 0.9030\varepsilon^2_{t-2} \qquad (10b)$$
(1.2184) (2.4507*) (22.8153*)

All the different specifications give us the same result. The coefficient on σ_t in the mean equation shows the effect of volatility on the growth rate of output. The coefficient is negative but insignificant in all three cases. This means that output variability has a negative but insignificant effect on the growth rate of output.

III. Conclusion

This study has examined the growth-volatility relationship for Mexico for the period 1980-2006. Using the ARCH-M model we find a negative, but insignificant effect of output variability on the growth rate of output. These results seem to suggest, along with some other empirical studies, that the growth-volatility nexus varies from country to country because the final results may be contingent and sensitive to country specific factors.

Table 1. Ng-Perron Unit Root Tests (No Trends)

Variable	MZ^{d}_{α}	MZ^{d}_{t}	MSB^{d}	MP^{d}_{T}
GIP	-9.8230 (-8.1000)	-2.0888 (-1.9800)	0.2126 (0.2330)	2.9948 (3.1700)
GGDP	-2.2043 (-8.1000)	-1.0062 (-1.9800)	0.4565 (0.2330)	10.7743 (3.1700)

Notes: *GIP* and *GGDP* stand for the growth rates of industrial production and GDP respectively. The critical values are in parentheses.

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