THE RELATIONSHIP BETWEEN GROWTH VOLATILITY AND GROWTH: EVIDENCE FROM TURKISH DATA

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ABSTRACT

This study investigates the relationship between growth volatility and growth using AR(p)-EGARCH-M models applied to quarterly real GDP data for the 1987Q1–2011Q3 period for the Turkish economy. Three different growth definitions and three different specifications of the risk premium are used in the study. In the light of the findings, robust evidence indicate that, for the Turkish economy, volatility has a negative effect on growth and no evidence of asymmetry between growth volatility and growth has been found. The fact that the asymmetric effect has been found statistically insignificant brings policy-making institutions to consider that overgrowth is as harmful as economic recessions.

Keywords: *Growth Volatility, Growth, Business Cycle, EGARCH.*

JEL Classification: *C22, E32, O40.*

ÖZET
BÜYÜME DEĞİŞKENLİĞİ VE BÜYÜME ARASINDAKİ İLİŞKİ: TÜRKİYE VERİLERİNDEN KANIT

Çalışmada, Türkiye'de büyüme değişkenliği ile büyüme arasındaki ilişki;1987 Q1–2011Q3 çeyrek dönemlik reel GSYH verileri kullanılarak AR(p)-EGARCH-M modeli aracılığıyla incelenmiştir. Bu amaçla, üç farklı büyüme tanımı ve üç farklı risk primi spesifikasyonu kullanılmıştır. Elde edilen bulgular, Türkiye ekonomisinde değişkenliğin büyümeyi negative etkilediği ve bu etkileme sürecinde asimetrik etkinin tespit edilmediği yönünde sağlam ampirik kanıtlar sunmaktadır. Ayrıca, asimetrik etkinin istatistiksel olarak anlamlı bulunmaması, politika uygulayıcı kurumların ekonomik kriz kadar aşırı büyümenin de zararlı olduğunu göz önünde tutmaları gerektiğini ortaya koymaktadır.

Anahtar Kelimeler: *Büyüme değişkenliği, Büyüme, Konjonktürel Dalgalanmalar, EGARCH.*

JEL Sınıflaması: *C22, E32, O40.*

1. Introduction

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The traditional distinction between the short-run fluctuations and long-run trends is that the former is attributed to business cycle models and the latter is explained by growth models. The long-run growth was firstly defined by the Solow growth model. This model has shown that growth was determined by labor, capital and exogenous technology. Moreover, endogenous models which were developed afterwards included technology as part of an endogenous variable of the model. However, business cycle models explained output fluctuations around the long-term growth through factors such as the short-run tradeoff, expectations, monetary and fiscal policy. To this end, in many studies conducted in 1990s, the dynamic general equilibrium models developed (with money and temporary nominal price rigidities) were used to account for the output fluctuations around the growth trend (see Clarida et al., 1999). Also most of the Central Banks used similar models for policy evaluation (see Taylor, 1999).It is clear that the investigation of the relationship between growth and volatility of growth rates has important implications for macroeconomic theory since the explanation for growth and business cycle are based on different theoretical approaches and the macroeconomic models are designed according to these theoretical approaches.

The second important point is associated with the policy implications which depend on the sign of the relationship. If the average growth rate and the volatility of growth rates are negatively correlated, policies which reduce short-run movements in the output are likely to increase the long-term growth rate. The case of a negative relationship could be an argument for the short-run "stabilization" policies, which refer to the arrangements aiming at reducing volatility. Especially for the developing countries, reducing fluctuations is, therefore, highly recommended by the World Bank and the IMF so that these countries could achieve higher growth rates. However, studies conducted revealed contradictory results.

The motivation for the study comes from three factors: the inconclusiveness of the existing empirical time series literature; the lack of adequate empirical evidence for developing countries, and the need for further evidence on the asymmetric effect of volatility on growth. This study, therefore, attempts to provide robust evidence on the relationship between the average growth rate and the volatility of growth rates using quarterly real GDP data that span 1987Q1 to 2011Q3 for Turkey, a developing country which has been suffering from high growth volatility. Following Nelson (1991), the various AR(p)–EGARCH(1,1)-M models are estimated in the study. EGARCH models are used to capture the asymmetric effect of volatility on growth. Furthermore, three different specifications of the risk premium and three different growth definitions are used in the study.

This paper is organized as follows: the second section briefly reviews both the theoretical and the empirical literature, the third section provides an overview of GARCH models, the fourth section describes the data used, the fourth section presents empirical evidence. Finally, conclusions are drawn in the fifth section.

2. Theory and Literature

Macroeconomic theory offers three possible scenarios regarding the impact of growth volatility on growth. First, volatility and growth could be independent. According to the conventional trend-stationary theories of business cycles, deviations of output from a non-stochastic trend rate of growth are considered to be independent of the long-run growth rate. Friedman's (1968) model of the business cycle in which deviations of output from its natural rate are caused by price level misperceptions. As they are triggered by monetary shocks, these deviations in no way affect the natural rate of output growth which depends on skills, technology and other real factors.

The possibility of a negative relationship between growth volatility and average growth dates back to Keynes (1936), who maintained that entrepreneurs, when estimating the return on their investment, take into consideration the fluctuations in output. The perceived riskiness of investment projects are likely to increase as the output fluctuations become larger. A similar result is obtained by the literature on sunspot equilibria (Woodford, 1990). According to Bernanke (1983) and Pindyck (1991), the negative relationship between volatility and growth is rooted to the investment irreversibilities at the firm level. One of the leading studies that attribute the negative relationship between volatility and growth through learning by doing to endogenous growth is Ramey and Ramey (1991). Ramey and Ramey (1991) indicated that because of the uncertainty in induced planning errors, higher output volatility can result in suboptimal ex post output levels by firms and hence, lower mean output and growth.

Finally, three economic theories could justify the positive effect of growth volatility on growth. Lack of certainty in income could result in a higher savings rate (Sandmo, 1970) and this might, according to Solow's (1956) neoclassical growth theory, lead to a higher equilibrium rate of economic growth. This argument has been advanced by Mirman (1971). Another argument for the positive relationship between volatility and growth rate comes from the Schumpeterian idea (1939) of creative destruction. Schumpeter pointed out that economic fluctuations could be instrumental to reconstruct the economic system effectively. According to him economic downturns could have positive impact because they encourage firms to increase their productivity. Bean (1990), Galiand Hammour (1991), Saint-Paul (1993) and Aghion and Saint-Paul (1998) supported this idea. Black (1987) presented another line of reasoning why the growth volatility and growth may be positively linked. He claimed that economic agents choose to invest in riskier technologies only if the expected rates of return are high enough to compensate for the associated greater risk.

As there is no theoretical consensus, the anticipated relationship between growth volatility and economic growth remains an empirical issue. The empirical evidence to date on the relationship between volatility and growth is quite controversial. Ramey and Ramey (1995) used a panel of 92 countries and a sample of OECD countries for the 1960-1985 period and found robust evidence that countries with higher growth volatility have lower growth. Martin and Roger's (2000) study using a cross-country analysis also presented a negative link. They assumed that when learning-by-doing is at the origin of growth, the long-run growth rate should be negatively related with the short-term economic instability. However, Blackburn and Pelloni (2001) claimed that the link between volatility and growth may be either negative or positive. After taking non-stationary time series properties of stochastic growth given learning-by doing into account, they found that long-run growth is negatively related to the volatility of nominal shocks, but positively related to real shocks.

In a recent study, Kneller and Young (2001) used a panel data framework and found that volatility reduced growth. Norrbin and Yigit (2005) examined the robustness of Ramey and Ramey's results to the time specification with a slightly different set of countries. Their results are sensitive to the selection of countries, but a centered-moving-period volatility provides a robust negative correlation with growth even though it is less robust for OECD countries. Unlike the findings of Ramey and Ramey (1995), Mills (2000) provided evidence of a positive correlation of growth volatility and growth between 1946 and 1994 period. The difference between Mills and Ramey and Ramey could be attributed to Mills's use of different measurements of business cycle volatility. To be more specific, he employed techniques such as linear detrending, an unobservable component approach, the band-pass filter advocated by Baxter & King (1999) and a Hodrick–Prescott (1997) filter.

The link between business cycles and growth has also been examined from a time-series perspective, rather than using cross-country or panel data. Caporale and McKiernan (1996) investigated the relationship between volatility and output for the

U.K. using monthly post-war data in a GARCH-M model with industrial production. The authors concluded that a significant positive relationship between volatility and output exists for the U.K. Caporale and McKiernan (1998) demonstrated evidence for a positive relationship between economic activity and volatility for the U.S. with data from 1870 to 1993. Speight (1999) found no relationship between output growth uncertainty and output growth in the UK. Similarly, Grier and Perry's study (2000) did not show a significant influence of real uncertainty on output growth for the USA. In another study, Henry and Olekalns (2002) found evidence in favor of a negative association using post-war real GDP data for the United States. Fountas et al. (2004) investigated the link between output volatility and growth using quarterly data from 1961 to 2000 for Japan. Using three different GARCH-model specifications (Bollerslev's, Taylor/Schwert's, and Nelson's EGARCH), they presented robust evidence that the "in-mean" coefficient is not statistically significant, which implies that output volatility does not affect output growth. Beaumont et al. (2008) brought out the time series research has only been done for a few countries, namely the United States, United Kingdom and Japan. They extended the prior research by performing a systematic search over several GARCH in-mean model specifications, including non-Gaussian and asymmetric GARCH models, for 20 OECD countries. The results indicated very little evidence of any connection between volatility and growth.

The number of studies dealing with the relationship between volatility and growth in developing countries, particularly Turkey, is rather scarce. Beaumont et al. (2008) could not observe any ARCH effect on the total industrial production index of Turkey for 1986M1-2000M2 period. Berument et al. (2011) examined the relationship between growth volatility and growth for the 1987Q2-2007Q3 period with respect to GDP in Turkey. Using EGARCH model, they found that there was a statistically significant relationship between growth and growth volatility at the 5% significance level. Moreover, the authors found the asymmetry coefficient positive and significant at the 10% significance level. This suggests that positive shocks increase volatility more than negative shocks for Turkey. Ekinci (2011) investigated the relationship between output volatility and growth in the Turkish economy. He used quarterly data for GDP, monthly industrial production index and electricity consumption series. The growth series were obtained according to logarithmic and H-P trend. The relationship between output volatility and growth was investigated using the GARCH-M, TARCH-M and EGARCH-M models. In the light of the findings, robust evidence indicate that, for Turkish economy, volatility has a negative effect on growth and no evidence of asymmetry between output variability and growth has been found.

3. Methodology

ARCH models were introduced by Engle (1982) and generalized as GARCH by Bollerslev (1986) and Taylor (1986). The standard GARCH (1, 1) model

$$Y_t = X_t^{'}\theta + \varepsilon_t \qquad (1)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (2)$$

in which the mean equation given in (1) is written as a function of exogenous variables with an error term. Higher order GARCH models, denoted GARCH (*p, q*), can be estimated by choosing either *p or q* greater than 1 where is *p* the order of the autoregressive GARCH terms and *q*is the order of the moving average ARCH terms. The representation of the GARCH (*p, q*) variance is:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q}\alpha\varepsilon_{t-1}^2 + \sum_{j=1}^{p}\beta_j\sigma_{t-1}^2 \qquad (3)$$

If the conditional variance or standard deviation into the mean equation is introduced, the GARCH-in-Mean (GARCH-M) model (Engle, Lilien and Robins, 1987) could be obtained:

$$Y_t = X_t^{'}\theta + \lambda\sigma_t^2 + \varepsilon_t \qquad (4)$$

Two variants of this GARCH-M specification use the conditional standard deviation or the log of the conditional variance in place of the variance in (4).

$$Y_t = X_t^{'}\theta + \lambda\sigma_t + \varepsilon_t \qquad (5)$$

$$Y_t = X_t^{'}\theta + \lambda\log(\sigma_t^2) + \varepsilon_t \qquad (6)$$

The Exponential GARCH (EGARCH) model was proposed by Nelson (1991). The specification for the conditional variance is:

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^{q}\alpha_i\left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \sum_{k=1}^{r}\gamma_k\frac{\varepsilon_{t-k}}{\sigma_{t-k}} + \sum_{j=1}^{p}\beta_j\log(\sigma_{t-j}^2) \qquad (8)$$

Note that the left-hand side is the log of the conditional variance. It is possible to deduce that the asymmetric effect is exponential, and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of asymmetric volatility is captured by γ when it takes values significantly different from zero. Especially when $\gamma_i \prec 0$, it implies that negative shocks generate higher volatility than positive shocks of the same magnitude, and vice versa.

The EGARCH model has several advantages over the GARCH specification. First, when the $\log(\sigma_t^2)$ is modeled, then even if the parameters are negative, σ_t^2 will be positive. Therefore, there is no need to artificially impose non-negativity constraints on the model parameters. Second, asymmetries are allowed for under the EGARCH formulation. Accordingly, if the relationship between volatility and growth is negative, γ will be negative.

4. Data

The data set used in this paper is quarterly data for Turkey from 1987Q1 to 2011Q3 gathered from the Turkish Statistical Institute (TurkStat).The original source contains two quarterly estimates of GDP: the 1987 benchmark year for 1987Q1-2007Q3 and the 1998 benchmark year for 1998Q1 to 2011Q3. The first historical real GDP series in 1987 prices, which I convert to 1998 prices by multiplying by 608 (equals the ratio of the 1998 currency value to 1987 currency value in the overlap quarter 1998Q1). Thus, the two real GDP series are spliced, measured in 1998 prices.[1] The seasonality of the real GDP series is adjusted employing Census X-12.

Three different growth definitions are used in the study. Log definition of growth is well-known and most used definition of growth in the time series literature. Chatterjee and Shukayev (2006) argues that the use of the log definition for growth rates may create a bias towards finding a negative relationship between average growth rates and the volatility of growth rates. Hence, the standard definition of growth rate is used as an alternative definition in this study. Mills (2000) suggests implementing a mechanical filter, like those advocated by Hodrick & Prescott (1997), or Baxter & King (1999). The main advantage of such filters is that they refer to fluctuations of a length often seen as typical of business cycles. Therefore, in this paper, a Hodrick-Prescott (H-P) filter with the penalty parameter set equal 1600 is used. The growth rates used in this study can be formulized as

[1] Diebold and Senhadji (1996) use this method to splice the real GNP series in US.

follows:

Log definition: $g_t^L = (\log y_t - \log y_{t-1}) * 100$

Standard definition: $g_t^S = (y_t / y_{t-1}) / y_{t-1} * 100$

H-P definition: $g_t^{H-P} = y_t - y_{H-P} * 100 = cycle_t * 100$

where g_t is the real GDP growth rate (in percentage) , y_t is the seasonally adjusted quarterly real GDP and y_{H-P} is H-P trend GDP (smoothed series).

5. Results

Conventional unit root tests, i.e. Augmented Dickey–Fuller (ADF) and Phillips-Perron (PP), have been carried out for the real GDP growth series for identifying the existence of unit roots (see Table 1). It can be observed that all ADF and PP test statistics are statistically significant at the 1 percent level, thereby indicating that all the series are stationary.

Table 1.Unit Root Test Results

	g_t^L	g_t^S	g_t^{H-P}
ADF(constant)	-10.30***	-10.37***	-4.19***
ADF(constant+trend)	-10.25***	-10.32***	-4.17***
PP (constant)	-10.30***	-10.37***	-4.47***
PP(constant+trend)	-10.25***	-10.32***	-4.45***

Notes: Spesifications for ADF tests: The optimal lag legth based on SIC, maxlag=12. Spesifications for PP tests: Spectral estimation method: Barlett-kernell, the optimal lag legth based on Newey-West bandwidth.
*** Significance at 1 percent level.

The conventional unit root tests might be biased toward a false unit root null when the data has structural change. Therefore, following Perron (1997) two different breakpoint ADF models have been performed with a one-time break besides the standard unit root tests. Breakpoints in the models have been determined by minimizing the Dickey-Fuller t-statistic and lag lengths are based on SIC. Model 1 assumes an innovation outlier break, with a non-trending data and Model 2 assumes an innovation outlier break, with trending data.[2] Furthermore,

[2] Model 1: $y_t = \mu + \theta DU_t(T_b) + \omega D_t(T_b) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + u_t$

specific breakpoint dates, 1994Q2, 2009Q1 and 2009Q2, have been selected for the same models. The results of breakpoint ADF tests are reported in Table 2 and imply that we can treat the growth rate of GDP as a stationary process.

Table 2.BreakpointUnit Root Test Results

	g_t^L	g_t^S	g_t^{H-P}
Model 1	-11.68***	-11.64***	-4.62**
Model 2	-11.60***	-11.56***	-4.64***
Model 1(1994Q2)	-11.68***	-11.64***	-4.47***
Model 2 (1994Q2)	-11.60***	-11.56***	-4.39***
Model 1(2009Q1)	-10.70***	-10.78***	-4.46***
Model 2 (2009Q1)	-10.64***	-10.73***	-4.38***
Model 1(2009Q2)	-10.03***	-10.11***	-3.92**
Model 2 (2009Q2)	-10.02***	-10.10***	-3.81**

Notes: The Vogelsang critical values for rejection of the hypothesis of a unit root at 0.01, 0.05 significance levels are -4.94, -4.44 for Model 1 and -3.94, -3.35for Model 2 respectively.
** Significance at 5 percent level.
*** Significance at 1 percent level.

An AR model for the growth rate series is constructed. The Final Prediction Error Criteria (FPE) plays a determining role on the order of AR process. According to Jansen and Cosimova (1988), the presence of the ARCH effect is wrongly indicated by auto correlated residuals. The optimum lag is defined by the FPE criteria in a way residuals are not correlated, which, in fact, removes the problem. Berument at al. (2011) used FBE criteria for determining the lag order of AR(p) process for Turkey also. As such outliers could affect GARCH tests, dummy variables are included in the mean equation. D94Q2 is equaling one on the 1994Q2 for g_t^L, g_t^S and g_t^{H-P} growth series and D09Q12 is equaling one on the 2009Q1 and 2009Q2 for g_t^{H-P}. They are clear outliers associated with the deep economic crises in 1994 and 2009.

Table 3.AR(p) Models Residual Diagnostics

Model 2: $y_t = \mu + \beta t + \theta DU_t(T_b) + \omega D_t(T_b) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + u_t$

where $DU_t(T_b)$ represents the intercept break variable and takes the value 0 for all dates prior to the break, and 1 thereafter. $D_t(T_b)$ is a trend break variable and takes the value 0 for all dates prior to the break, and is a break date re-based trend for all subsequent dates. $D_t(T_b)$ indicates the one-time break dummy variable which takes the value of 1 only on the break date and 0 otherwise.

Growth Series	Mean Model	JB	Q_6	Q_{12}	Q_6^2	Q_{12}^2	A_1	A_6	A_{12}
g_t^L	AR(4)	1.90	1.95	8.60	15.24***	17.48**	9.25***	12.74**	17.73
g_t^S	AR(4)	1.41	2.29	8.60	16.01***	17.78**	9.79***	13.45**	17.42
g_t^{H-P}	AR(5)	0.55	1.13	7.58	9.12***	12.12***	5.21**	8.03	13.75

Notes: JB is the Jarque-Bera normality test of the null hypothesis of normality; Q_i is the ith order Ljung-Box test of the null of residual serial independence with degrees of freedom adjusted for ARMA parameter estimation; Q_i^2 is the ith order Ljung-Box test of serial independence in the squared residuals; A_i is the ith order Engle ARCH LM test of the null of conditional homoscedasticity.
* Significance at 10 percent level.
** Significance at 5 percent level.
*** Significance at 1 percent level.

Residual diagnostics for mean models are reported in Table 3, and include Jarque-Bera normality test for residuals, Ljung-Box Q test statistics for residual serial correlation, Ljung-Box diagnostics for serial dependence in the squared residuals (Q^2) and ARCH Lagrange Multiplier tests. For all of the AR(*p*) models, the Jarque-Bera test does not reject normality, Ljung-Box Q test statistics for autocorrelation up to twelve do not reject the null hypothesis of residual serial independence; Ljung-Box statistics of the squared residuals (Q^2) and ARCH Lagrange Multiplier statistics confirm the presence of heteroskedasticity for all models.

Following Nelson (1991), this study estimates the various AR (*p*)–EGARCH (1,1)-M models employing Bollerslev and Wooldridge's (1992) quasi-maximum likelihood estimation (QMLE) technique, assuming normally distributed errors and using the Marquardt algorithm. Furthermore, there is a need to choose the form in which the time-varying variance enters the specification of the mean to determine the "risk premium". This is a matter of empirical evidence. Caporale and McKiernan (1996) used the logarithm of the conditional variance as a regressor in the mean equation. However, as noted by Pagan and Hong (1991), the use of $\log(\sigma_t^2)$ is possibly unsatisfactory. First, for $\sigma_t^2<1$, $\log(\sigma_t^2)<0$, which leads to a negative sign for the "risk premium". Second, as $\sigma_t^2 \to 0$, conditional volatility in logs becomes very large and, therefore, the implicit relationship between conditional volatility and Y_t is overstated. Speight (1999) assumed linearity between the conditional variance and the growth of output. Henry and Olekalns (2002) used the conditional standard deviation as a regressor in the conditional mean. However, Fountas et al. (2004) employed all three specifications for the functional form of the "risk premium". Berumentet al. (2011) used the conditional variance of growth in the mean equation for Turkey. This study allows for three different specifications of the "risk premium": (a) the conditional variance (σ_t^2); (b) the conditional standard deviation (σ_t); (c) the natural log of the conditional variance ($\log(\sigma_t^2)$).

Table 4. AR(4)-EGARCH(1,1)-M Model for g_t^L

Mean Equation	σ_t	σ_t^2	$\log(\sigma_t^2)$
C	3.566***	2.752***	3.349***
	(1.162)	(0.549)	(1.204)
D94Q2	-10.190***	-10.388***	-9.908***
	(1.669)	(1.591)	(1.764)
AR(1)	-0.227**	-0.287**	-0.204*
	(0.116)	(0.129)	(0.112)
AR(2)	0.023	-0.004	0.036
	(0.096)	(0.092)	(0.097)
AR(3)	-0.076	-0.101	-0.072
	(0.093)	(0.094)	(0.094)
AR(4)	-0.325***	-0.351***	-0.323***
	(0.085)	(0.085)	(0.085)
"in mean effect"	*-0.975***	*-0.249****	*-1.244**
	(0.474)	*(0.087)*	*(0.681)*
Variance Equation			
ω	0.320	0.370	0.403
	(0.352)	(0.368)	(0.401)
α	0.411**	0.390**	0.413**
	(0.196)	(0.163)	(0.196)
γ	*-0.146*	*-0.163*	*-0.137*
	(0.116)	*(0.117)*	*(0.117)*
β	0.640***	0.626***	0.590***
	(0.170)	(0.164)	(0.203)
Diagnostic Tests			
JB	7.33**	6.13**	6.32**
Q_{12}	12.642	12.179	11.538
Q_{12}^2	4.3827	5.499	4.872
BDS	-0,001	-0.002	0.001
	(0.008)	(0.008)	(0.008)

Notes: JB is the Jarque-Bera normality test of the null hypothesis of normality; Q_i is the ith order Ljung-Box test of the null of standardized residual serial independence; Q_i^2 is the ith order Ljung-

Box test of standardized serial independence in the squared residuals; BDS is the Brock, Dechert, Scheinkman and LeBaron (1996) test (two dimension, $\varepsilon = 0.7$, bootstrapt:5000) of the null hypothesis is that data in a time series is independently and identically distributed (*iid*).
* Significance at 10 percent level.
** Significance at 5 percent level.
*** Significance at 1 percent level.

Firstly, the logaritmic growth definition is used and AR(4)-EGARCH(1,1)-M model parameters are reported for three alternative risk premium in Table 4. As shown in the results, the ‘‘in-mean’’ effect for each of the three alternative risk premium are negative and statistically significant. Thus, the conditional variance, the conditional standard deviation and the logarithm of the conditional variance are statistically significant at 1, 5 and 10 percent, respectively. The insignificant estimate of γ suggests that positive shocks and negative shocks do not exert different effects on growth volatility. The Jarque-Bera test statistics reject normality for the standardized residuals at the 5% significance level, The Ljung-Box Q test statistics (12 lags) for the standardized residuals and the squared standardized residuals are indicating no autocorrelation and heteroskedasticity.BDS test statistics fail to reject the null hypothesis that the data in a time series is independently and identically distributed (*iid*). Hence, on the basis of these diagnostics, it is possible to conclude that the estimated models are not subject to misspecification.

Table 5. AR(4)-EGARCH(1,1)-M Model for g_t^S

Mean Equation	σ_t	σ_t^2	$\log(\sigma_t^2)$
C	3.083***	2.716***	3.460***
	(1.165)	(0.537)	(1.071)
D94Q2	-9.770***	-9.606***	-9.516***
	(1.628)	(1.570)	(1.566)
AR(1)	-0.202*	-0.291**	-0.208*
	(0.108)	(0.128)	(0.113)
AR(2)	0.039	-0.040	-0.012
	(0.102)	(0.092)	(0.094)
AR(3)	-0.068	-0.093	-0.078
	(0.095)	(0.098)	(0.099)
AR(4)	-0.319***	-0.367***	-0.365***
	(0.091)	(0.092)	(0.092)
“in mean effect”	*-0.766**	*-0.237****	*-1.261***
	(0.475)	*(0.086)*	*(0.608)*
Variance Equation			
ω	0.218	0.296	0.224

	(0.306)	(0.335)	(0.289)
α	0.413**	0.407***	0.398**
	(0.205)	(0.163)	(0.194)
γ	*-0.140*	*-0.155*	*-0.108*
	(0.118)	*(0.109)*	*(0.105)*
β	0.695***	0.655***	0.693***
	(0.149)	(0.153)	(0.163)
Diagnostic Tests			
JB	4.869*	4.788*	5.132*
Q_{12}	10.358	11.102	11.208
Q_{12}^2	4.699	4.864	3.9593
BDS	-0.002	-0.006	-0.002
	(0.008)	(0.008)	(0.008)

Notes: JB is the Jarque-Bera normality test of the null hypothesis of normality; Q_i is the ith order Ljung-Box test of the null of standardized residual serial independence; Q_i^2 is the ith order Ljung-Box test of standardized serial independence in the squared residuals; BDS is the Brock, Dechert, Scheinkman and LeBaron (1996) test (two dimension, $\varepsilon = 0.7$, bootstrapt:5000) of the null hypothesis is that data in a time series is independently and identically distributed (*iid*).
* Significance at 10 percent level.
** Significance at 5 percent level.
*** Significance at 1 percent level.

Secondly, AR(4)-EGARCH(1,1)-M model parameters are reported for three alternative risk premium in Table 5 for the standard growth definition. The 'in-mean effect' for each of the three alternative risk premium are negative and statistically significant. Thus, the conditional variance, the logarithm of the conditional variance and the conditional standard deviation are negative and statistically significant at the 1, 5 and 10 percent level of significance, respectively. All of the EGARCH models have insignificant negative asymmetric coefficients. The Jarque-Bera test rejects normality at the 10% significance level. The Ljung-Box Q test statistics (12 lags) for the standardized residuals and the squared standardized residuals indicate no autocorrelation and heteroskedasticity. BDS test statistics fail to reject the null hypothesis that the data in a time series is independently and identically distributed (*iid*).

Table 6. AR(5)-EGARCH(1,1)-M Model for g_t^{H-P}

Mean Equation	σ_t	σ_t^2	$\log(\sigma_t^2)$
C	-0.815	-1.379	-1.724
	(1.293)	(1.758)	(1.627)
D94Q2	-7.848***	-7.923***	-7.975***
	(1.118)	(1.591)	(1.195)
D09Q12	-2.354***	-2.034**	-2.672***
	(0.881)	(0.898)	(0.762)
AR(1)	0.773***	0.704***	0.718***
	(0.103)	(0.114)	(0.102)
AR(2)	0.227***	0.258***	0.283***
	(0.092)	(0.102)	(0.086)
AR(3)	-0.243***	-0.175**	-0.237***
	(0.073)	(0.080)	(0.079)
AR(4)	-0.198***	-0.174**	-0.177**
	(0.078)	(0.084)	(0.078)
AR(5)	0.199***	0.166***	0.197***
	(0.057)	(0.067)	(0.056)
"in mean effect"	*-0.783****	*-0.122***	*-1.135****
	(0.252)	*(0.063)*	*(0.346)*
Variance Equation			
ω	0.411	0.243	0.261
	(0.295)	(0.348)	(0.354)
α	0.915***	0.789***	0.848***
	(0.172)	(0.166)	(0.179)
γ	*-0.095*	*-0.104*	*-0.104*
	(0.116)	*(0.117)*	*(0.113)*
β	0.242	0.446**	0.374*
	(0.194)	(0.225)	(0.218)
Diagnostic Tests			
JB	1.262*	0.543*	0.284*
Q_{12}	5.827	7.578	5.872
Q_{12}^2	7.692	8.482	8.618
BDS	0.008	0.005	0.018*
	(0.008)	(0.006)	(0.008)

Notes: JB is the Jarque-Bera normality test of the null hypothesis of normality; Q_i is the ith order Ljung-Box test of the null of standardized residual serial independence; Q_i^2 is the ith order Ljung-Box test of standardized serial independence in the squared residuals; BDS is the Brock, Dechert, Scheinkman and LeBaron (1996) test (two dimension, $\varepsilon = 0.7$, bootstrapt:5000) of the null hypothesis is that data in a time series is independently and identically distributed (*iid*).
* Significance at 10 percent level,
** Significance at 5 percent level.
*** Significance at 1 percent level.

Lastly, the Table 6 shows the empirical results for the three alternative

AR(5)-EGARCH(1,1)-M models for the H-P growth definition. The estimated coefficients of σ_t , $\log(\sigma_t^2)$ and σ_t^2 are negative and statistically significant at the 1, 1 and 5 percent level, respectively. As shown in the results, for each of the three conditional variance functions the asymmetric coefficients (γ) are negative but insignificant. The Jarque-Beratest rejects normality at the 10% significance level. Ljung-Box statistics of the standardized residuals and squared residuals (Q^2) are all insignificant. BDS test statistics reject the null hypothesis at the 10 percent level for $\log(\sigma_t^2)$ and fail to reject for σ_t , σ_t^2 .

6. Conclusion

The central question of this study is to examine whether there is a relationship between the average growth rate and the volatility of the growth rates for Turkey, a small open economy with high growth volatility. The relationship in three dimensions -whether the choice of definition of growth rate matters, whether the relationship is consistent for either of three different specifications of the risk premium, and whether there is the asymmetric effect of volatility on growth- is tested.

The three different growth definitions ($g_t^L, g_t^S \, and \, g_t^{H-P}$) and the three different specifications of the risk premium(σ_t ,σ_t^2 and $\log(\sigma_t^2)$) are used in the study and all of the nine ‘‘in-mean’’ coefficients are found negative and significant at the 10 percent level or smaller. In contrast to Chatterjee ve Shukayev (2006), a negative relationship has also been found when using the standard definition of growth rates. Therefore, the study indicates that definition of growth rate does not matter. Furthermore, all of the asymmetric coefficients in EGARCH models have been found to be statistically insignificant.

In the light of the findings, robust evidence indicates that, for Turkish economy, volatility has a negative effect on growth, and no evidence of asymmetry between growth volatility and growth has been found. The negative relationship between economic fluctuations and growth indicates that the theories of growth and business cycle should be considered together not as separate research areas. Furthermore, the negative relationship provides the empirical evidence to the institutions committed to implementing and recommending stabilization policies in reducing volatility, such as the IMF, the World Bank, governments and central banks. Moreover, the fact that the asymmetric effect has been found statistically insignificant brings policy-making institutions to consider that overgrowth is as harmful as economic recessions.

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