ECONOMIC GROWTH IN OECD COUNTRIES: QUANTILE REGRESSION APPROACH

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ABSTRACT: *Economic growth, because of being an important subject for investigators, has been examined by using different econometric methods. In this paper, the aims are to investigate the sensitivity of economic growth rate to the choice of different quantiles and show how any conditional quantile depends on policy variables in OECD countries. For this reason we form a growth model which likes Solow Model. The descriptive statistics show that the distribution of economic growth is non–gaussian and have outliers, so we used Quantile Regression instead of Ordinary Least Squares to estimate the growth equation. The quantile regression model introduced by Koenker and Basset (1978) is more flexible than OLS and allows for studying effects of covariates on the whole distribution of the dependent variable. While ordinary least squares and most estimation approaches are focusing on the central distribution, the quantile regression model focus on the whole conditional distribution and it allows us to analyze the effects of policy variables on the entire conditional distribution of GDP growth rates. As a result, we find that policy variables have different effects on the GDP growth rate for fast-growing countries and for slow-growing countries.*
Key words**:** *Quantile Regression, Solow Growth Model.*

Introduction

In the simplest term "Growth" is a rational increase in a variable. Economic growth is the rate of increase in the national income. National income is obtained from the financial measurement of the total production in the country. The growth in the national product is related to many other factors. As capital savings increase, labor force and investment are raising the national income, technological development also cause an increase in the national income.

In general, capital savings take its' source from savings in the country. For this reason an increase in savings has positively effect on growth. Also an increase in capital savings can be based on the debts which will be taken from abroad and making investment with these debt sources will increase production and in this way national income increase.

Increasing of Labor force is important in terms of the sectors that require human force. Sufficient number of experienced labor force provide further more production. In the result of an increase in the population, the labor force increase and that affects the number of consumers and workers.

Increasing of investment in a country is important in terms of being an indicator of production. The ratio of investments to national income or gross national income can be used to show the measurement of the amount of investments. The increase in the ratio of investments to gross national income will increase the growth.

Technological development increase growth especially in the long run. Becuse of new products are developed by technological development, the production and consumption will positively affect national income. Finally efficiency and production increase and national income will also increase.

The examination of depreciation proportion must also be taken into consideration. The instruments which are used in the production will become old in time and they need to be regenerated.

Economic growth, because of being an important subject for investigators, different type of growth theories have been developped. In this paper, neoclassical growth theory and endogenous growth theory will be examined.

Neoclassical Growth Theory

Neoclassical Growth Theory was proposed by Solow (1956) [1]. The assumptions of Neoclassical Growth Model which is known as Solow Growth Model can be summarised as follows: closed economy, competitive markets, rational acting individuals, decreasing returns to scale for production factors, capital and labor force, a production technology that propose a constant return for production function. An increase in the population and labor force are exogen like technological change in this model. Under these assumptions, the model is balanced growth model which per capita capital shows the same ratio of increase with the per capita production or consumption. When balance is mentioned, the ratio of increase in per capita income and consumption will be equal to the technological development speed. In other words, technology, which is an exogen variable in the model, is the only factor that provides an increase in per capita income and the growth speed at the equilibrium level appears independently from saving tendency.

Solow (1956) growth model propose that countries with the same technological parameters and preferences differing only in the initial level of wealth and in the long run they should converge to the same level of steady-state income per capita. This result is known as unconditional β convergence in the literature. When countries show differences in the microeconomic conditions, they have different levels of steady-state per capita income level.

Solow Growth Model propose that after controlling the differences, poor countries will grow faster than developing countries. This forecasting of the model is known as conditional β convergence [2].

Endogenous Growth Theory

There is a consensus in the economic literature that Endogenous Growth Theory is based on Romer (1986) and Lucas (1988) [3,4]. These studies propose that growth is endogenously come through by the interaction of some factors in the economic system' s own dynamics. In this respect this theory is dramatically different from neoclassical growth model which connects growth to the factors that is out of the economic system.

Endogenous Growth Theory defines the repulsive power of growth and explaines the working process of growth. Endogenous Growth Models can be examined in three main groups considering the factors defined as the repulsive power of growth [5].

i. The models which require population and human capital savings as a decision variable

ii. The models that connect the technological change to the decision of market-driven entrepreneurs

iii. The models which regard the role of public as an independent variable.

Convergence tests are used not only for setting income convergence, also used for seperating the growth theories from each other. Income convergence shows that the growth model is the neoclassical growth model. Some endogeneous growth theories propose the sign of initial income coefficient is positive. At that there is a divergence from income per capita, in other words when initial icome rises, growth rate rises as well. If the sign of initial income coefficient is positive then the model as mentioned is endogenous growth model. Therefore it is important to determine the sign of initial income coefficient.

In the applications concerning growth models the statistical difficulties are encountered. In the Conditional convergence applications generally Least Squares Etimation Method, which the coefficients of political variables are restricted to be the same for all countries, is used. As it is the effect of a change occured in one of the political variable on the gross domestic product of developed countries will be the same on the gross domestic product of poor countries and this will not reflect the reality. So the coefficients of political variables must depend a meausure concerning the developing degree of the country.

Economic growth, because of being an important subject for investigators, has been examined by using different econometric methods. Many studies show that the economic growth mostly have non -gaussian distribution. If the series have non -gaussian distributions Ordinary Least Squares can give suspicious results. For this reason, robust regression models can be used to explain the economic growth for countries. Especially Quantile Regression is rapidly expanding in the empirical literature.

In this paper, the aims are to investigate the sensitivity of economic growth rate to the choice of different quantiles and show how any conditional quantile depends on policy variables in OECD countries. For this reason we form a growth model like Solow Model.

Quantile Regression

The quantile regression model introduced by Koenker and Basset (1978) is more flexible than OLS and allows for studying effects of covariates on the whole distribution of the dependent variable [6]. While ordinary least squares and most estimation approaches are focusing on the central distribution, the quantile regression model focus on the whole conditional distribution and it allows us to analyze the effects of policy variables on the entire conditional distribution of GDP growth rates.

Quantile regression is based on the minimisation of this statement:

$$\min_{\beta} \frac{1}{n} \left\{ \sum_{i: y_i \geq \beta} \theta \left| y_i - \beta \right| + \sum_{i: y_i < \beta} (1-\theta) \left| y_i - \beta \right| \right\}$$

When this statement is generalized for $y_i = x_i^{'}\beta + e_i$ linear regression model θth quantile regression $(0 < \theta < 1)$ will be estimated by the minimisation of

$$\min_{\beta} \frac{1}{n} \left\{ \sum_{i: y_i \geq x_i^{'}\beta} \theta \left| y_i - x_i^{'}\beta \right| + \sum_{i: y_i < x_i^{'}\beta} (1-\theta) \left| y_i - x_i^{'}\beta \right| \right\}$$

$$\min_{b} \frac{1}{n} \sum_{i=1}^{n} \rho_{\theta} (y_i - x_i^{'}\beta)$$

and this is called as θth quantile of y. $x_i^{'}$ is the vector of explanatory variables, β is the vector of coefficients and e_i is i.i.d. errors with the distribution of F.

Computation difficulties in quantile regression are solved by using linear programming methods. Standard errors for the coefficients vector are obtainable by using the bootstrap method described in Buchinsky(1998) [7]. The quantile regression has a number of useful features. In addition to allowing the full characterization of the conditional distribution of the dependent variable, such as: the quantile regression objective function is a weighted sum of absolute deviations resulting in a robust measure of location so that the estimated coefficient vector is not sensitive to the outlier observations on the dependent variable and when the error term is non-normal quantile regression estimates may be more efficient than OLS estimators. Quantile regression analysis estimates the regression function for different quantiles of the conditional wage distribution. This analysis has several advantages over the typical mean regression estimation method.

Since the quantile regression is estimated by minimizing the sum of absolute values of residuals instead of the sum squared residuals, it is robust to heteroscedasticity and outlier observations. Also it is possible to examine different conditional quantiles of the distribution, not just the conditional mean of the dependent variable. [8]

Data

In this study a growth model is estimated using cross-sectional data of 27 OECD countries in the years of 1985 and 2000. Data is available at http://pwt.econ.upenn.edu/php_site/pwt61_form.php . The model developed by Mankiw, Romer and Weil (1992) is used to explain increasing rates of growth [9]. This model is similar to Solow model. The estimated regression model is,

$$\ln (Y_{00}/Y_{85}) = \alpha_0 + \alpha_1 lnY_{85} + \alpha_2 \ln (I/GDP) + \alpha_3 \ln (n + g + \delta) + \varepsilon_i$$

Where the dependent variable is the logarithmic growth rate obtained from real GDP per capita for the year 2000 over real GDP per capita for the year 1985 $ln(Y_{00}/Y_{85})$, $ln(I/GDP)$ is the investment share of real GDP and obtained from $(I_{85}/GDP_{85}) / (I_{00}/GDP_{00})$, n is the the growth rate of the real GDP per capita, g is the technological growth rate, and δ is the rate of depreciation. As is seen from the variables this is not exactly Solow Model,but during the estimation the rate of savings which is used in Solow Model, are used instead of technological growth rate. The depreciation rate δ is taken constant equals to 0,10.

Empirical Results

First of all the model is estimated by Ordinary Least Squares (LS). All the results are reported in Table 1.

Table 1. The Results of Least Squares Method.

Dependent Variable: $ln(Y_{00}/Y_{85})$				
Variables	Coefficients	Std. Er.	t	Prob.
Constant	4,1655	1,0757	3,87	0,001
$\ln(Y_{85})$	-0,2328	0,0883	-2,64	0,015
$\ln(I/GDP)$	0,0510	0,0305	1,67	0,108
$\ln(n+s+\delta)$	0,6407	0,1842	3,48	0,002
R^2=0,4133,		$F_{0,05;4-1;27-4} = 5,40$		
$\sum e_i^2 = 0,643702$		*Prob(F statistic)* =0,0058		

It is seen that only the coefficient of investment share of real GDP variable is insignificant from the results of t-test. The descriptive statistics show that the distribution of economic growth is non–gaussian, and heteroscedasticity is determined with Breusch-Pagan Test [10].

To specify the outliers the results of DFFITS, COOKSD and DFBETA tests are reported in Table 2. [11]

Table 2. The Results of DFFITS, COOK D and DFBETA.

Observations	DFFITS	COOKS D	DFBETA 1	DFBETA 2	DFBETA 3
13	*1,0139360	*0,2261328			*0,8335320
17	*1,1156130				
18	*1,5294460				*1,3889480
19				*0,8639424	
26		*2,6309510	*3,9955200		

(i) Calculated values are compared with $2\sqrt{p/n}=2\sqrt{3/27}=0,666$ for DFFITS, 4/n=0,148 for COOKS D, $2/\sqrt{n} = 0,384$ for DFBETAS.
(ii) * indicates outliers at these observations.

Standardised Residuals, diagonal values of HAT matrix and Studentised Residuals are also computed for detecting outliers [12]. Table 3 shows these results.

Table 3. The Results of Standardised Residuals, Studentised Residuals and diagonal values of HATmatrix

Observ.	stdresid	studtresid	Hat
12			*0,2590117
17	*2,2911820	*2,5507380	
18			*0,5592614
19			*0,3209996
23			*0,3260917
26			*0,4630749

(i) Calculated values are compared with 2 for Standardized Residuals, $t_{0,05;27-4} = 2,069$ for studentised residuals, $2p/n = 0,222$ for HAT matrix.
(ii) * indicates outliers at these observations.

According to tests it is confirmed that residuals do not have normal distribution, there is heteroscedasticity and there are outliers. If the series have non -gaussian distributions Ordinary Least Squares can give suspicious results. For this reason, robust regression models can be used to explain the economic growth for countries. We analysed the growth equation at different quantiles [0.1 - 0.90]. Quantile regression results are reported in Table 4.

Table 4. The Results of Quantile Regression

Dependent Variable: $\ln(Y_{00}/Y_{85})$						
	Quantile Regression					
Variables	LS	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Constant	4,1655 (1,0757)	1,4832 (1,3074)	1,4181 (0,6376)	5,6908 (1,4041)	6,0414 (1,4551)	8,0588 (0,3984)
$\ln Y_{85}$	-0,2328 (0,0883)	-0,0978 (0,1262)	-0,1351 (0,0549)	-0,3283 (0,1099)	-0,3757 (0,1174)	-0,5238 (0,0281)
$\ln(I/GDP)$	0,0510 (0,0305)	0,0561 (0,0232)	0,0606 (0,0278)	0,0592 (0,0394)	0,0275 (0,0272)	0,0711 (0,0079)
$\ln(n+g+\delta)$	0,6407 (0,1842)	0,1214 (0,1302)	-0,0949 (0,1309)	0,8661 (0,1805)	0,7816 (0,2087)	0,9636 (0,0738)
R^2	0,4133					
Pseudo R^2		0,2774	0,1664	0,1748	0,4562	0,6449
F	5,40					
Number of iteration		5	8	4	9	6

According to Table 4 it can be seen that in slow growing countries (10^{th} quantile) investment share of real GDP variable ($\ln(I/GDP)$) has influence on growth, except that variable all coefficients are statistically insignificant. In average growing countries (50^{th} quantile) only the coefficient of $\ln(I/GDP)$ is insignificant contrary to slow growing countries. The results at the 50^{th} quantile also shows the median regression results. In Fast growing countries (90^{th} quantile) all of the variables have significant influence on growth.

The coefficient of Real GDP per capita for the year 1985 ($\ln(Y_{85})$) variable is negative in both LS and quantile regression, this is an indicator of conditional convergence.

Conclusion

This paper analyzes the sensitivity of economic growth rate to the choice of different quantiles. For this reason we form a growth model like Solow Model and estimate it by using cross-sectional data of 27 OECD countries in the years of 1985 and 2000.

The descriptive statistics show that the distribution of economic growth is non – gaussian and have outliers, so we used Quantile Regression instead of Ordinary Least Squares to estimate growth equations. While ordinary least squares and most estimation approaches are focusing on the central distribution, the quantile regression model focus on the whole conditional distribution and it allows us to analyze the effects of policy variables on the entire conditional distribution of GDP growth rates.

As a result, we find that policy variables have different effects on the GDP growth rate for fast-growing countries and for slow-growing countries. Although Ordinary Least Squares have suspicious results in non –gaussian distribution, we also estimated the relationship between growth rate and the policy variables by using Ordinary Least Squares to show the differences of coefficients which have been estimated by different methods. While only logarithmic investment share of GDP variable is affecting growth rate in slow growing countries, each one of the logarithmic investment share of real GDP, logarithmic real GDP per capita for the year 1985 and $\ln(n+s+\delta)$ variables affect growth rate in fast growing countries. The coefficient of Real GDP per capita for the year 1985 ($\ln(Y_{85})$) variable is negative in both LS and quantile regression, this is an indicator of conditional convergence.

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