APPLYING COBB-DOUGLAS PRODUCTION FUNCTION IN ESTIMATING ECONOMIC GROWTH MODEL IN VIETNAM

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Abstract: ***The article explores the relationship between GDP at current prices (dependent variable) and labor and capital (independent variables) in Vietnam, using the Cobb-Douglas production function. The study uses time series data for the period 1990-2020. The ordinary least squares (OLS) method was used to estimate the model. The results show that there is a statistically significant relationship between labor and capital and GDP in the case of Vietnam. In which, capital has an immediate impact on GDP, but labor only takes effect after 2 years. That is, the change in Vietnam's GDP can be explained by labor and capital.***

• Keywords: *Cobb-Douglas production function, production efficiency, GDP, capital, labor.*

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Tóm tắt: *Bài viết thực hiện tìm hiểu mối quan hệ giữa GDP theo giá hiện hành (biến phụ thuộc) với lao động và vốn (các biến độc lập) Việt Nam, sử dụng hàm sản xuất Cobb-Douglas. Nghiên cứu sử dụng dữ liệu chuỗi thời gian trong khoảng thời gian 1990-2020. Phương pháp bình phương tối thiểu thông thường (OLS) được sử dụng để ước lượng mô hình. Kết quả cho thấy có một mối quan hệ có ý nghĩa thống kê giữa lao động và vốn với GDP trong trường hợp của Việt Nam. Trong đó vốn có tác động ngay lập tức đến GDP nhưng lao động chỉ phát huy tác động sau 2 năm. Nghĩa là, sự thay đổi trong GDP của Việt Nam có thể được giải thích bởi bằng lao động và vốn.*

• Từ khóa: *hàm sản xuất Cobb-Douglas, hiệu quả sản xuất, GDP, vốn, lao động.*

1. Introduction

Economic growth is one of the core issues of the theory of economic development. Economic growth, which is always the primary objectives of each country as well as worldwide, creates high-wage jobs and conditions to improve the standard of life. Sustainable development becomes a popular trend in the world; Digital economy, circular economy, green growth are the development models chosen by many countries. The 2030 Agenda for Sustainable Development of the United Nations has a great influence on the growth model, economic cooperation, trade and investment in the world. Shifting to renewable energy, green energy will be a clearer trend in the coming period.

On September 25, 2020, the Government issued Resolution No. 136/NQ-CP on sustainable development. The resolution sets out 17 sustainable development goals for Vietnam by 2030, including: (1) End all forms of poverty everywhere; (2) Eliminate hunger, ensure food security, improve nutrition and promote sustainable agricultural development; (3) Ensure healthy lives and promote well-being for people of all ages; (4) Ensure quality, equitable, and inclusive education and promote lifelong learning opportunities for all; (5) Achieve gender equality; empower and create opportunities for women and girls; (6) Ensuring adequate and sustainable management of water resources and sanitation facilities for all; (7) Ensure access to affordable, reliable and sustainable energy for all; (8) Ensure sustainable, comprehensive and continuous economic growth; create employment, productivity and decent work for all; (9) Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation; (10) Reducing inequality in society; (11) Sustainable and resilient urban and rural development; ensure a safe living and working

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environment, and reasonably allocate population and labor by region; (12) Ensuring sustainable production and consumption; (13) Timely and effective response to climate change and natural disasters; (14) Conservation and sustainable use of oceans, seas and marine resources for sustainable development; (15) Protect and develop forests sustainably, conserve biodiversity, develop ecosystem services, combat desertification, prevent degradation and restore land resources; (16) Promote a peaceful, democratic, fair, equal and civilized society for sustainable development, create access to justice for all; building effective, accountable and participatory institutions at all levels; (17) Strengthen implementation and promote global partnerships for sustainable development.

The efficiency of a country is measured by Gross Domestic Product (GDP). Over the past two decades, the story of the world economy has been heavily focused on Asia, with its steady economic growth. The Asian economy is no longer just that of Japan. Economic growth in the Asia region has consistently outperformed the West over the past two decades (APO, 2014). This study partly quantifies the level and growth pattern of Vietnam. The research method in this article considers GDP as a function of labor and capital. When capital is invested and labor is used, there is a positive impact on production. In order to keep up with the world economy, it is more necessary for Vietnam to raise the GDP level.

2. Literature review

Economic growth had been discussed by classical economists Adam Smith and David Ricardo since the late 17th century and early 18th century, but it was not until the middle of the 20th century that economic growth was studied systematically by scientists. Economic growth is the increase in income of the economy over a certain period of time (usually a year). The nature of growth is to reflect quantitative changes in the economy.

Economic growth theories are also increasingly being improved to clarify theoretical and practical problems posed in economic life. Researching on the origin of economic growth, scientists have divided growth factors into two groups: exogenous factors and endogenous factors. The relationship of factors to output is basically explained in the Cobb-Douglas production function. In economics and econometrics, the Cobb-Douglas production function is a specific form of the production function, widely used to express the relationship between the quantities of two or more inputs (especially are physical capital and labor) and the amount of output that can be produced by those inputs. The Cobb - Douglas function was developed and tested against statistical evidence by Charles Cobb and Paul Douglas between 1927–1947. According to Douglas, the functional form itself was developed earlier by Philip Wicksteed (Cobb & Douglas, 1928).

On the basis of the Cobb-Douglas production function, Solow built an economic growth model, then it became a basic production function for modern economic growth studies. In his model, Solow included the factor of technological progress, however, he only considered technological progress to be an exogenous factor. The most important point of the Solow model was capital accumulation. In addition, the model also assumes that there is a direct relationship between existing capital reserves and new capital accumulation, as the level of saving increases, output also increases. Another factor in the Solow model is population. In which, the concept of population and work-ability population are identical, so an increase in population will lead to a decrease in the capital intensity for working-age population. From there, the model suggests that, in order to ensure a stable state of the economy, it is necessary to ensure a steady growth rate of both capital and labor. Thus, countries with high population growth will have low capital intensity and, therefore, low growth rates. Also from this model, it can be seen that GDP is determined by the total amount of labor and capital that each country uses and the efficiency of exploiting these factors. From there, the source of the increase in GDP will depend on the increase in the total amount of capital and labor and the increase in efficiency or productivity in exploiting these factors.

Up to now, many studies on this topic have been carried out, based on the Cobb-Douglas production

model. For example, the study of Munguisa et al (2019) presents a new approach to estimate the Solow-Cobb-Douglas economic growth model. In this case, the extended Kalman filter is used to estimate the time-varying parameters of the model and the system state, from a subset of partially available economic data measurements. Different from traditional econometric techniques, all the system model parameters are defined as state variables in order to treat them as time-varying parameters. Based on the state-space representation, the observability properties of the system defined by the Solow-Cobb-Douglas economic growth model, are investigated by mean of an extensive nonlinear observability analysis. From this analysis, the necessary conditions for achieving the property of observability are derived, which in turn, is needed for estimating the full system state from different subsets of measured economic data. Experiments with real macroeconomic data are presented to validate the proposed approach. Empirical results show that among the subsets of available economic data, some specific economic data are more relevant than others for better model estimation. Another study by Andaregie et al (2020) identifies the factors affecting the economic efficiency of charcoal production in Northwest Ethiopia using cross-sectional data collected from 372 households. Cobb-Douglas and Tobit production frontier models were used to identify the determinants of economic efficiency. The results show that land area, seedlings and labor are the variables affecting charcoal productivity. The estimated technical efficiency, allocative efficiency, and economic efficiency scores were 85%, 94% and 80%, respectively. The sex and the age of the household head, the size of the household, the duration that the household was producing charcoal, charcoal production as a major livelihood base, producing charcoal for marketing purpose as a major motive, and Acacia decurrence as the major type of tree for producing charcoal were the influential variables of economic efficiency in charcoal production. Since the cropping cycle practiced in Northwest Ethiopia can benefit the environment, and since charcoal production generates income to a very large number of households, the government can use the findings of this study to expand its intervention in the charcoal sector and promote charcoal production and productivity in an environmentally sustainable way. The study by Oryani et al (2021) scrutinized the symmetric/asymmetric impact of energy consumption on the economic growth (RGDP) of Iran in the framework of the extended Cobb-Douglas production function from 1970 to 2017. The linear and nonlinear Autoregressive Distributed Lag (ARDL) confirmed that a positive and negative shock on energy consumption had the same impact on RGDP. The empirically obtained outcomes supported confirmed the positive impact of energy consumption and capital stock on GDP in both the short and long terms. The opposite was true for CO_2 emissions and labour force. The results of a Toda Yamamato (T-Y) test showed bidirectional causality between CO2 emissions and energy consumption. Moreover, CO_2 emissions and energy consumption exhibited a causality effect on economic growth. Furthermore, residual diagnostic/model stability tests and sensitivity analyses based on Fully Modified Ordinary Least Squares (FM-OLS) and Dynamic Ordinary Least Squares (DOLS) verified the perfectness and robustness of the results obtained from the ARDL model, respectively. Based on the growth-enhancing and environment-degrading effects of energy consumption, switching from conventional energy to renewable energy must be considered in national energy policies. Appropriate policy implications were recommended under two categories: market-based interventions (both directly and indirectly) and non-market-based interventions.

About domestic research, there has been a qualitative study by Do Van Duc (2016) which analyzes the main factors for deep economic growth and origin of economic growth in recent years. On that basis, the article comes to the conclusion that our country's economic growth in the coming time must rely on accumulating and improving the quality of human capital and effectively promoting institutional capital. Another domestic study by Chu Thi Thu and Hoang Thi Dung (2013) used the Cobb-Douglas function to analyze the factors affecting coal mining output in Vietnam. That is, the problem of using the Cobb-Douglas function to analyze economic growth in Vietnam is still a gap for the authors to conduct this study.

3. Research model and data

Cobb-Douglas production function is one of the most widely used production functions in economic analysis. Cobb-Douglas production function not only reflects the basic economic law, but is also easy to calculate and interpret the estimated parameters. The purpose of applying Cobb-Douglas function is to estimate the coefficients of the inputs that affect total output and returns to scale. The Cobb-Douglas function has the following form:

$$Y = AK^{\alpha}L^{\beta}$$

where the output Y is a function of labor (L) and capital (K), A is the total factor productivity.

The Cobb - Douglas production function can be converted to a linear model by taking the logarithm of both sides of the equation:

$$LnY = LnA + \alpha LnK + \beta LnL$$

A is the total factor productivity, α represents the output elasticity of capital, β represents the output elasticity of labor. α + β represents returns to scale.If α + β>1 represents increasing returns to scale, α + β<1 represents decreasing returns to scale, α + β = 1 represents the constant returns to scale.

4. Research results

Table 1. Descriptive statistics of variables in the model

	GDP	K	L
Mean	1898004.	544906.7	45.19957
Median	914001.0	308543.0	44.25255
Maximum value	6293145.	1699865.	55.89882
Minimum value	41955.00	5272.000	32.73797
Standard deviation	2007238.	535829.1	7.988347
Skewness	0.912504	0.749427	0.006307
Kurtosis	2.420659	2.241086	1.506649
Jarque-Bera Test	4.735628	3.645744	2.880747
p-value	0.093685	0.161561	0.236839
Observations	31	31	31

Source: Authors

The research data collected includes gross domestic product (calculated at current prices of Vietnamese Dong, billion VND), accumulated fixed assets (calculated at current prices of Vietnamese Dong, billion VND), total number of employees (million people) from 1990 to 2020 from the World Bank. The variables are denoted by GDP, K and L respectively. The descriptive statistics of the research variables are presented in Table 1.

For the convenience of estimation, the time series are taken as natural logarithms, denoted LOG_GDP, LOG_K, LOG_L. First, we test the stationarity of the data series, using the Augmented Dickey-Fuller test. The results are presented in Table 2.

Table 2. The results of testing the stationarity of the research variables

Time series	Chain yield	t-value in Augmented Dickey–Fuller Test	Conclusion
Origin	LOG_GDP	-1,555	Non- Stationary
	LOG_K	-3,199**	Stationary
	LOG_L	-1,682	Non- Stationary
The first difference of a time series	D(LOG_GDP)	-5,629***	Stationary
	D(LOG_K)	-4,816***	Stationary
	D(LOG_L)	-2,710*	Stationary

*Note: *,**,***significant at 10%, 5%, 1% respectively*

Source: Authors

Table 3. Estimation results of Cobb-Douglas production function

Dependent Variable: D(LOG_GDP)
Method: Least Squares
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.043428	0.022160	1.959763	0.0604
D(LOG_K)	0.547081	0.070333	7.778472	0.0000
D(LOG_L)	1.024544	1.123530	0.911897	0.3699
R-squared	0.742757	Mean dependent var		0.167021
Adjusted R-squared	0.723702	S.D. dependent var		0.110532
S.E. of regression	0.058100	Akaike info criterion		-2.758650
Sum squared resid	0.091143	Schwarz criterion		-2.618530
Log likelihood	44.37975	Hannan-Quinn criter.		-2.713824
F-statistic	38.97949	Durbin-Watson stat		1.642961
Prob(F-statistic)	0.000000			

Source: Authors' estimation

Thus, in the natural logarithmic series of the original data series, LOG_K is stationary, and the two series LOG_GDP and LOG_L are non-stationary. But after taking the first difference,

we get 3 stationary series. Therefore, the first-difference series will be used to estimate the Cobb-Douglas model. The results of Cobb-Douglas function estimation for Vietnam are presented in Table 3.

The main objective of the study is to examine whether both labor and capital can contribute significantly to the growth of manufacturing in Vietnam, and empirical results using the Cobb-Douglas production function help provide these results. From the estimation results in Table 3, the elasticity of GDP to capital is 0.547. That is, if capital is increased by 100%, Vietnam's GDP will increase by 54.7%. However, the impact of the labor force on economic growth has not been found. To improve the model, the author chooses a lag after 2 years for the labor variable to get the results as shown in Table 4.

Table 4. Estimation results of Cobb-Douglas function with lagged variable of labor

Dependent Variable: D(LOG_GDP)
Method: Least Squares
Date: 04/15/22 Time: 15:51
Sample (adjusted): 1993 2020
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.060499	0.021661	2.793006	0.0099
D(LOG_K)	0.282184	0.097716	2.887797	0.0079
D(LOG_L(-2))	2.059447	1.050394	1.960643	0.0612
R-squared	0.447163	Mean dependent var		0.144354
Adjusted R-squared	0.402936	S.D. dependent var		0.063880
S.E. of regression	0.049360	Akaike info criterion		-3.078402
Sum squared resid	0.060910	Schwarz criterion		-2.935666
Log likelihood	46.09763	Hannan-Quinn criter.		-3.034766
F-statistic	10.11064	Durbin-Watson stat		1.788802
Prob(F-statistic)	0.000606			

Source: Authors' estimation

The results show that both capital and labor have an impact on GDP, but capital has an immediate impact, but labor has an impact after 2 years. The elasticity of GDP for capital is 0.282, for labor is 2.059. That is, if capital is increased by 100%, Vietnam's GDP will increase by 28.2%. At the same time, if the labor force is increased by 100%, after 2 years Vietnam's GDP will increase by 205.9%.

5. Conclusions and recommendations

The main objective of this paper is to find out the impact of Vietnam's labor force using time series data from 1990-2020 based on the Cobb-Douglas production model. The results confirm that capital contributes significantly to productivity as measured by GDP in Vietnam, and the impact of labor is larger than the impact of capital, but the effect of labor has a lag of 2 years. From the results of this study, the authors propose some recommendations towards promoting economic growth as follows:

***Firstly*,** in order to maintain the positive impact of capital on economic growth, Vietnam needs to increase capital generation from the internal resources of domestic economic sectors. For example, speeding up the economic restructuring process from mining, agriculture and fishery sectors with low resource efficiency to high value-added manufacturing industries and services, with higher resource efficiency. Or establish socio-economic institutions that effectively promote economic management.

***Secondly*,** change the perception of human capital and increase accumulation, improve the quality of human capital through human resource development, improve the quality, qualifications and skills of workers combined with efficient use of labor resources to reduce the lag of labor impact on economic growth. That is to increase the speed of the impact of labor on economic growth.

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