PROJECTION OF INDONESIA’S ECONOMY USING DYNAMIC MODELING

by Wilson Rajagukguk

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Time	Topic of Seminar	Country/Region
	Chair：Dr. Tomáš Tichý, VŠB-TU Ostrava Czech Republic	
Session 8.1 13：30 | 14：50	1. 15R-010: Antecedents Of Future Market Anticipation: A Better Understanding From The Fashion Industry In Indonesia	Roos Kities Andadari, Indonesia
	2. 15R-021: Projection Of Indonesia's Economy Using Dynamic Modeling	Wilson Rajagukguk, Indonesia
	3. 15R-026: Cash Dividend Announcement Information Content And Effect Of Private Benefit Of Institutional Ownership Of Listed Companies In Indonesia Stock Exchange Period Of 2009-2013	Puji Isyanto, Indonesia
	4. 15R-055: Study of Creation and Development of Small and Medium Scale Enterprises Finance (Case Study of SMEs in District of East Ende, Regency of Ende)	LD Gadi Djou, Indonesia
	5. 15R-148: Efficiency Analysis of Banks at Selected Markets with Various Dea-Based approaches	Tomáš TICHÝ, Czech Republic.
14：50 | 15：00	**Tea Time**	
	Chair：Dr. Muhammad Madyan, Universitas Airlangga, Indonesia	
Session 8.2 15：10 | 16：30	1. 15R-084: The Relationship Between Earnings Quality, Informasion Asymmetry And Cost Of Capital: Test Using Path Analysis	Puput Tri Komalasari, Indonesia
	2. 15R-070: Corporate Governance, Ownership Structure, And Cash Holdings	Muhammad Madyan, Indonesia
	3. 15R-086: Dynamic interactions between housing and stock prices in Indonesia: an empirical analysis	Rahmat Heru Setianto, Indonesia
	4. 15R-202: Effect of the Neutral Style Women's clothing on Purchase Intention with the View of Personality Traits	Chia-Hsu Lin, Taiwan
18：00	**Welcoming Dinner**	Pendopo Royal Ambarrukmo

3. Consumer Behavior

4. Economics and Sociology

5. Education Administration

Projection of Indonesia's Economy Using Dynamic Modeling

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Abstract

Development planning can be done if development macro-aggregate are first projected so that it can be implemented effectively and efficiently. The outputs of economy, gross national product (GNP), consumption, savings and capital stock, technological progress and population are baseline data in development planning. Economic dynamic model was employed in this paper. It is economic growth model that inserts time into each variable used. Cobb-Douglass equation was utilized to estimate output.Capital stock at time t-1 became investment at time t.Base year and baseline values for projection was 2010.Cobb-Douglass model parameters were obtained using non-linear econometrics.Population growth rateswere from the results of Indonesia's population projection in 2000-2025 and 2010-2035.Indonesia's economic macro-aggregate projection for the period of 2010-2035 were produced.

Keywords: Dynamic Modeling, Projection, Non-Linear Econometrics, Cobb-Douglas Function, Indonesia.

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Key words: *dynamic modeling, projection, non-linear econometrics, Cobb-Douglas function, Indonesia.*

I. INTRODUCTION

Output of the economy, such as GNP, consumption, savings, capital stock, technological progress and people, some of macroeconomic variables, are basic data in development planning formulation. These macroeconomic variable data become basis for the estimation of public services, such as active circulation, education, employment, health, family planning, food, water and sanitation, energy, housing and transportation. Furthermore, these variables, specifically people, are market potential for goods and services that further will have impact on economic activity level.

Macro indicators of the economy will affect other development, such as social, culture, politics and environment. Furthermore, these components will determine the patterns of the economy. Therefore, data with its structure and dynamics, both now and in the future, will have strategic role in development planning.

The importance of all macroeconomic factors in development demands the availability of related data that are valid and up to date for future development planning formulation. Development planning as stated in Law No. 25 2004 on National Development Planning System (*Sistem Perencanaan Pembangunan Nasional*/SPPN) includes long-term, mid-term and yearly development planning by government and society at central and regional level. In development planning in all sectors information on development factors is needed, such as output, consumption, savings, capital stock, technological progress and people. The information should be available not only when development planning is formulated, but also in the past and in the future.

To obtain past and future information, projection needs to be done. It is usually conducted to produce yearly or five-yearly projection for 25 years to come. These projections are based on the assumptions of growth rate components. To determine the underlying assumptions for future growth level, past and current trend data, determinants of each component, the relationships between components and targets that want to be achieved or expected in the future are needed.

1.1. Modern Economic Growth Theory

How do we know economic growth? Studies on growth itself experience a sharp growth in recently. The history of modern economic growth theory is described in the following.

Classical economists, such as Adam Smith (1776), David Ricardo (1817), Thomas Malthus (1798), Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944) and Joseph Schumpeter (1934) propose some basic formulations that appear in modern growth theory. Their ideas include basic approach of competitive and dynamic equilibrium, the role of diminishing return and its relationship on physical capital and human capital accumulation, causal relationship between income per capita and population growth rate, the effect of technological progress on forms of labor specialization improvement, new goods discovery, production methods and the role of monopoly as an intensive for technological progress.

The contribution of traditional neoclassical theory was found since the 1950s. The methodology and discussion of neoclassical theory are placed on concepts, such as aggregate capital stock, aggregate production function and utility function on representative consumer (that often have unlimited horizon). Later, modern dynamic optimization method and differential equation were used.

In chronological perspective, the initial point of modern growth theory is classical article from Ramsey (1928), a masterpiece that preceded its era for several decades. Ramsey treatment about household optimization (over time) stepped away beyond growth theory application. It is difficult to discuss consumption theory, asset pricing, and business-cycle theory without involving optimal condition that was introduced by Ramsey (and Fisher (1930)). Intertemporal utility function that can be separated (separable utility function) from Ramsey is widely used today and known as Cobb Douglas production function (Barro and Marthin 1995).

Ramsey and at the end of the 1950s, Harrod (1939) and Domar (1946) tried to add Keynes analysis with elements of economic growth. They used production function by adding a little among inputs to argue that capitalist system inherently unstable. Why? It is because they wrote it during and shortly after Great Depression. Their arguments were accepted sympathetically by some economists. Although this contribution triggered a number of researches at that time, today only a few of their analyses have roles.

Later, Solow (1956) and Swan (1956) gave a very good contribution. The key aspect of Solow-Swan model is neoclassical form of production function, a specification that assumes constant return and diminishing return to scale from each input, and some positive and smooth substitution elasticity among inputs. This production function is combined with a constant-saving-rate law to generate a very simple general equilibrium model.

Cass (1965) and Koopmans (1965) again utilized Ramsey analysis on consumer optimization into neoclassical growth model and that prepared endogenous determination of saving rate. This development allowed richer transitional dynamics, but tended to maintain conditional convergence hypothesis. The endogeneity of saving also did not eliminate the link of per capita growth rate on exogenous technological progress.

Cass-Koopmans equilibrium version from neoclassical growth model can be supported by decentralization and competitive framework where production factors, labor and capital are accounted for on their marginal products. Total income then dispenses total product because of the assumption that production function meets constant return to scale. Further, decentralization outcome is Pareto optimal.

Arrow (1962) and Sheshinkski (1967) constructed a model where idea is not meant for production or investment, a mechanism known as learning by doing theory. In this model, every discovery is soon spread (spill over) to the whole economy. Instant diffusion process may happen because knowledge is nonrivalrous. Later, Romer (1986) showed that competitive framework can be maintained to obtain an equilibrium rate from technological benefit, but produces growth rate that is no longer Pareto optimal.

Competitive framework results its findings in part from research and development effort and happens if individual innovation is spread gradually to other producers. In this pattern, a decentralization theory from technological progress requires fundamental change in neoclassical growth model into imperfect competition model. This additional never appeared until Romer's research (1987, 1990) in the end of the 1980s.

The work of Cass (1965) and Koopmans (1965) completed the fundamental neoclassical growth model. Later, growth theory becomes too much techniques and far away from empirical application. On the contrary, economists requested to give advice to ill countries, left an application perspective and tended to use model that technically is not too sophisticated but empirically can be used. Development economics and growth economics subject become more away from one another and are almost separated perfectly.

It is possible because growth theory is weak in its empirical relevance, as an active research field, it can be said undeveloped at the beginning of the 1970s, the year of the birth of rational expectation and oil shocks revolution. For 15 years, macroeconomic research focused on short-run fluctuation. One of its great contributions is the involvement of rational expectations in business-cycle model, improving the approach on policy analysis and the application of general equilibrium method in real business-cycle theory.

Since the mid of the 1980s, research on economic growth grew with passion, started by Romer (1986) and Lucas (1988). The motivation of their research is the observation or recollection that the determinants of the growth of the economy in the long-run is a very important issue, much more important than the mechanism of business cycle or countercyclical effects of monetary and fiscal policy. However, the knowledge of the significance of long-run growth was the new step. Someone must walk farther from neoclassical model, where long-run growth rate is pegged by the exogenous technological progress. The recent contribution is to determine long-run growth rate in the model, known as endogenous growth model.

The new wave of new research, Romer (1986), Lucas (1988) and Rebelo (1991), built on the work of Arrow (1962), Sheshinki (1967), and Uzawa (1965 and 1991), did not seriously introduce a technological change theory. In their models, growth can happen because of return of investment in capital goods, including human capital, did not have to be diminishing, when the economy is developing. This idea came from Knight (1944) that argued that spillover of knowledge among producers and the external benefit from human capital is a part of this process, but only because of helping diminishing return trend on capital accumulation.

The involvement research and development (R&D) theory imperfect competition in growth framework was pioneered by Romer (1987, 1990) and also the contribution from Aghion and Howitt (1992) and Grossman and Helpman (1991). In their models, technological advance is produced from purposive R&D activities. These activities are generated through monopolistic power. If there is no tendency that the economy goes outside this frame, then growth rate will be positive in the long-run. Growth rate and the number of discovery activities is not Pareto optimal because of distortion related to goods creation and new production method. In this framework, long-run growth rate depends on government action, such as taxation, law enforcement and laws, infrastructure service provision, intellectual right protection, international trade regulation, financial market and other aspects of the economy. Therefore, government has great power on the good and the bad of the economy through its effect on long-run growth rate.

The new research also includes models about technological unification. One benefit of followers is that the results of analysis of discovery that relates to technological progress rate can be taken from the leader of economy only by imitating. Diffusion model predicts a model from conditional convergence that is similar by predicting from neoclassical growth model because imitating tends to be cheaper than innovation.

Another exogenous variable from neoclassical growth is population growth rate. The higher population growth rate the lower steady state level of capital and output per worker. This tends to lower growth rate per capita given initial level of per capita output. However, standard model does not consider the effect of income per capita and wage level on population growth, a type that was emphasized by Malthus, and also does not question resources level used in the process of raising children. A new movement in economic research is to treat population growth endogenously by including fertility preferences in neoclassical model. The result is consistent with empirical regulation that fertility rate tends to decline with income per capita, although it may increase with income per capita in poorest countries.

The additional models also developed in relation to making endogenous labor supply in a growth context is migration and working or leisure choice.

The clearest difference between growth theory in 1960, 1980 and 1990 is that the newest research pays closer attention on the empirical implications and relationship between theory and data. Some applied perspectives are the empirical applications of the older theories, in particular the prediction of neoclassical model on conditional convergence. Other closer analyses with new endogenous growth theory include the role of increasing return, activity of research and development, human capital and technology diffusion. In general, all theories above are analyzed using regression and have not included times in them. When the data have time variable, then dynamic model can be used for analysis. Heer and Maubner (2005), McCandles (2008), Rajagukguk (2010), Weber (1998), Wickens (2008) and Yamaguchi (2012) employed dynamic model in their works, in particular in long-run growth macroeconomic modeling.

Based on the development of the analysis of economic growth above, in general this study aims to develop a currently growing dynamic modeling. Specifically, the study aims to project GNP, consumption, savings, capital stock, technological progress and population in the period of 2011-2035. The projections of macro indicators of the economy are important for development planning, including for the national and regional development planning, international partners and private sectors that need long-run planning.

II. RESEARCH METHODS AND MODEL

2.1. Data Sources

Data used in this study are Indonesia's gross national product (GNP) obtained from Statistics Indonesia and Bank of Indonesia, capital stock obtained from the Ministry of Finance of the Republic of Indonesia (capital stock) and population from Bappenas et al. (2005 and 2012).

2.2. Model

Dynamic model is used to study the relationships among variables within a system. In the economy, many variables are believed to affect output. Some models capture these variables with time. Therefore, the model can be written as follows.

$$Y = f(t) \quad \text{...1}$$

where Y = output of the economy and t = time.

In this model, all determinant variables are represented by one unique variable that is time. This model can be developed to study the effect of an independent variable on a dependent variable, in this case, output of the economy. One way to accommodate this is to include macroeconomic theory in growth function. For example, Solow model writes that output of the economy is a function of technological progress, capital stock and labor. Later, this function is written as follows.

$$Y = A.K^{\alpha}.L^{\beta} \quad ....2$$

where A = technological progress, K = capital stock, L = labor, α = share of capital stock, and β = share of labor. Time variable is then imposed into each variable. If time variable is included in a model, the model can be used for forecasting.

This study presented a collaboration among capital stock, population and technological progress with time variable within it. The interaction among them is presented in a Cobb-Douglas output growth equation. It starts from time t, this output growth, by the people, a part will be used for consumption and a part for saving.

Saving at time t will become investment at time t+1. At time t+1, investment at time t plus capital stock will become capital stock at time t+1. At time t+1, capital stock together with technological progress and population will become inputs into output growth equation and so on the loop goes on until a determined time.

Why did Solow choose Cobb-Doulgas model? In projecting economic growth, sometimes economic trends are made in parallel with the demand of consumption goods (although insignificant) or with the projection of international trade. However, if analyzed further, demographic and labor changes sometimes have more impacts on economic growth instead. Without adequate theory and economic growth model, it is difficult to interpret the impacts of globalization or unemployment on a macroeconomy.

The economic growth model in this paper was analyzed using a dynamic growth model that is a growth model with time variable in it. It is consider necessary to project the future economic growth. For example, the output of the current economy is used for current consumption and savings. Further, current savings can be used as people's investment in the future. The future investment together with other growth variables will be used as growth factors at its time. This condition will last until the last time of projection.

Modeling steps

1. Determine parameters and initial value

   Model parameters can be obtained using non-linear econometrics. If Cobb-Douglas model used as follows

   $$Y = AK^{\alpha}L^{\beta} \qquad \text{...} 3$$

   where Y = output of the economy, K = capital stock, L = population, parameter A = technological progress, parameter α = share capital stock in the economy, and parameter β = population share in the economy.

   Parameters obtained using non-linear econometrics are A, α, and β. Initial value for Y, K, and L are obtained from data for projection base year.

2. Obtain other needed parameters from other sources. Population growth rate was obtained from the projection of Indonesia's population by Bappenas et al. (2005 and 2012) and saving rate from the Ministry of Finance of the Republic of Indonesia. Further, these parameters were used as model benchmark (Table 1).

Table 1

Benchmark for Parameters

Parameter	Benchmark value
Alpha	0.38
Beta	0.80
A	0.36
Population Growth Rate	1.49
Consumption Rate	0.56
Saving Rate	0.44

3. Construct the model in Berkeley Madonna program.
4. Conduct simulation to obtain the projection.

Integrated Dynamic Modeling and Basic Structure of Dynamic Model

The system of thinking contains the meaning of thinking in cause and effect network. It also contains the understanding of a production behavior by that network. The system of thinking can be supported through dynamic modeling. A large number of writers have contributed to the development of dynamic system modeling. In ecology, Howard Odum is known as the founder of ecological system. He developed a method of system modeling that was based on energy flow. The same method can be used in economics.

Jay W. Forrester (1950s) developed a method called "System Dynamics" with an approach on simulation. Forrester used his method in "Industrial Dynamics", "Urban Dynamics" and "World Dynamics". Another scientist who contributed in this field was Carl Walters, who wrote several books, such as "Adaptive Management of Renewable Resources" (MacMillan). He was one among scientists who developed an ecosystem simulation program, later known as Ecosim computer program.

In principle, all of these methods were based on ordinary differential equations (ODE) system. An analytical solution is an equation with independent variable time t. For example, Employment (t) = function of discovery, initial capital and training. The solution of this function can be very appropriate and can give employment rate if time unit is specified on a number of required occupations. However, this solution does not occur. For numerical integration solution, differential equation system must be transformed into ODE form. The suitable method for numerical integration is Euler and Runge-Kutta different orders method.

Mathematically, basic characteristic of dynamic model is (ODE) that has the following features.

- Unknown variable is a function.
- This equation involves one or more derivative differential.

The simplest form of ODE is shown as follows.

Suppose there is differential equation as follows.

$$\frac{dx}{dt} = \dot{x} = f(t) \qquad \text{.. 4}$$

This equation is then solved using ordinary integral with a slight algebraic manipulation and becomes Kemudian persamaan ini diselesaikan dengan integral biasa dengan sedikit manipulasi aljabar menjadi

$$dx = f(t).dt \qquad \text{.. 5}$$

From this equation the solution in x then can obtained.

$$x = \int f(t)dt + C \qquad \text{.......................... ....6}$$

where C is integral constant.

In general, ODE can be classified into two types, that is ODE with constant coefficient (outonomus) and ODE with nonconstatnt coefficient (non-autonomous).

If only one variable moves dynamically (in the above example is x), then the concept is called single ODE. In economic analysis, there might be more than one variable that moves, such as capital stock, population and technological progress. For that purpose, a dynamic system approach that accomodates more than one dynamic variables is required.

Examples of ODE for two dynamic variables are as follows.

$$\frac{dx}{dt} = \dot{x} = ax + by \quad \text{..7}$$

$$\frac{dy}{dt} = \dot{y} = cx + dy \quad \text{..8}$$

The above equations are the type of dynamic system equations that describe the relationship between x variable and y variable. They are also a linear dynamic system shown by a,b,c, dan d variables that interact linearly with x dan y. Solving these dynamic systems will result various behaviour that lead to equilibrium, depending on the characteristic root of the above equations. The magnitude of characteristic root will determine the trajectory property toward equilibrium.

If there are many variables, then a set of more complex dynamic system is required. In practice, dynamic system method emphasizes objectives how behaviour appears from policy structure in a system. A dynamic phenomenon emerges as a the results of interaction from physical structure and decision structure imposed by interacted decision maker. Physical structure is formed by the accumulation (of stock) and the network of goods, people, energy and material flows. Meanwhile, decision making structure is formed by the accumulation (of stock) and information network that are used by actors in system that describes the decision making process norms.

Basic form of exponential model follows the following form. A capital stock K that changes by time is the sum of capital inflow and outflow. Growth is defined as exponential changes of K per time unit with the following equation

$$\frac{dK}{dt} = K_t - K_{t-1} \quad \text{... 9}$$[1]

[1] Equation $\frac{dK}{dt} = K_t - K_{t-1}$ is obtained by the assumption that growth model follows exponential or logarithmic pattern. $\frac{dK}{dt}$ notation is written as $\dot{K}$.

The growth is exponential if the growth of $\dot{K}$ depends on capital stock K and a certain growth rate, n (Figure 1). This equation is written as $\dot{K} = K_{t-1}.n$.

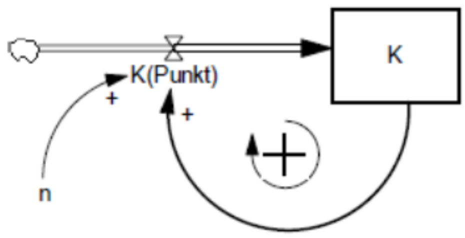

Figure 1. Basic Scenario of Exponential Growth

Solow, *AK*, Uzawa-Lucas, Romer and endogenous model can be formulated using dynamic method. Further, in this study Solow model was used to model Indonesia's economic growth, where the endogeneous variable is capital accumulation. Technological progress and population are trated as exogenous variables. This model is started from Solow growth model with growth equation as follows. This model ini was produced using Berkeley Madonna computer programme as the simulation tool. The model is displayed in Figure 2.

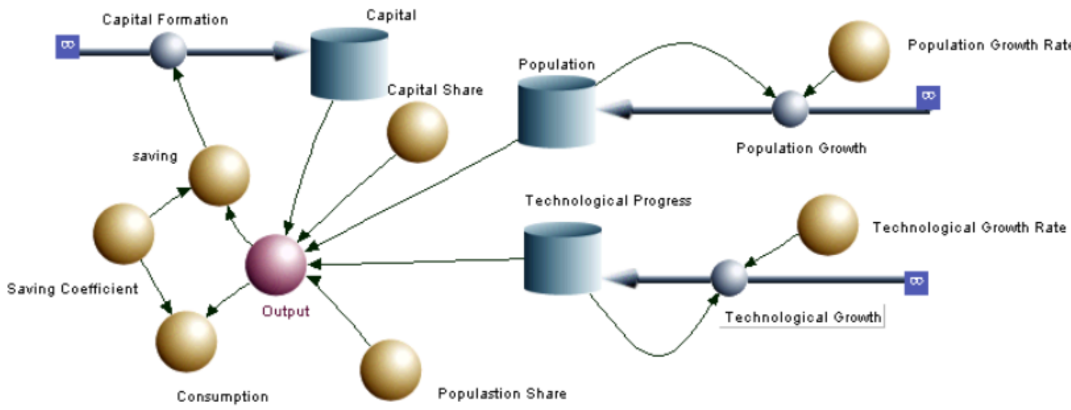

Figure 2. Simulation Model

III. RESULTS

The results are the projection of GNP, population, technological progress, consumption, savings and capital stock Indonesia for the period of 2011-2035, presented in

Figure 3. It can be seen that the output of the economy, consumption, investment and population of Indonesia was respectively Rp.907,138 billion, Rp.340,938 billion, Rp.566,200 billion and 151,9 million people in 1980. It is respectively projected to be Rp.7,746,732 billion, Rp.3,778,170 billion, Rp.2,968,562 billion and 345,2 million people in 2035.

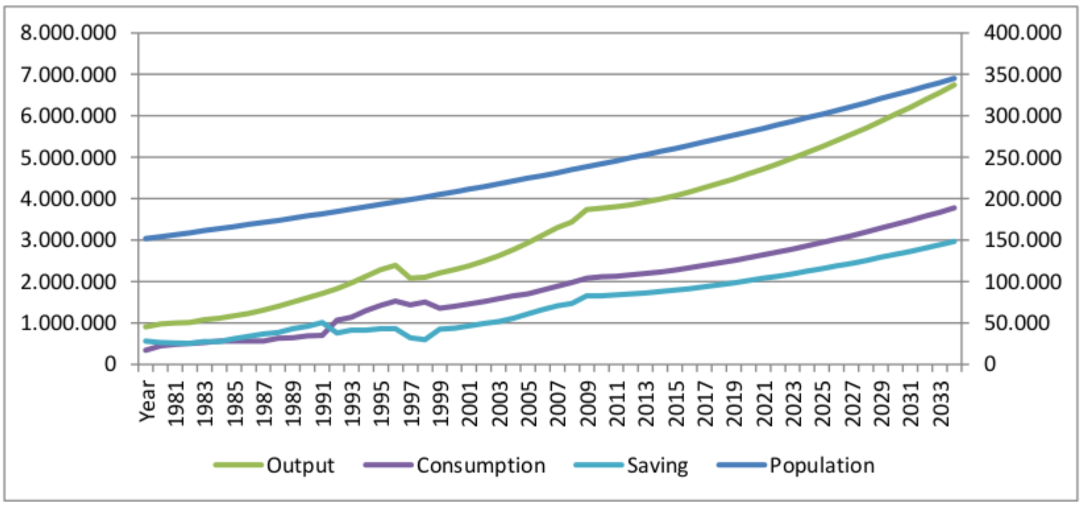

Figure 3. Macro-aggregate of the Economy: Indonesia 1980-2035

IV. CONCLUSIONS AND SUGGESTION

The designed model shows that in the future Indonesia's economy will grow positively. This growth is a long-run economic growth regardless economic shock. The results of projection show that output, consumption, investment and population will be, respectively, Rp.7,746,732 billion, Rp.3,778,170 billion, Rp.2,968,562 billion and 345,2 million people in 2035.

Based on this study it is suggested to develop the model for other economic variables and indicators.

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