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Furuoka, Fumitaka

Asia-Europe Institute, University of Malaya

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**Human resources, physical resources and economic development:
A foundation of human resource economics**

Fumitaka Furuoka
Visiting senior research fellow
Asia-Europe Institute
University of Malaya
50603 Kuala Lumpur, Malaysia
Tel: (603)-7967-4645, Fax: (603)-7954-0799
Email: fumitaka@um.edu.my, fumitakamy@gmail.com

Abstract

Despite numerous studies on production inputs, such labour and capital, there is still a lack of systematic analysis on the crucial interaction between the human resources (HR) and physical resources (PR) in the process of economic development. Thus, the current paper aims to describe how these production resources would jointly determine the dynamics process of economic development. This holistic role of the HR in the economic development can be a foundation for the human resource economics.

Key words

Human resources, physical resources, economic development, human resource economics

JEL codes

O15, J24

1. Introduction

There is little doubt that two main production inputs, labour (L) and capital (K), has played an important role in the economic development. There are several prominent studies to examine the relationship among labour and capital in the economic development process. In the middle of the 19th century, Karl Marx (1867) warned the increasing dominant role of capital under the market economy. Furthermore, Roy Harrod (1939) and Evsey Domar (1947) proposed a neo-Keynesian growth model which is known as the Harrod-Domar (HD) model in the first half of the 20th century. This model focuses on the role of capital in the economic development. Robert Solow (1956) and Trevor Swan (1956) modified the HD model by including the role of labour in the economic development process. This modified neo-classical growth model is known as the Solow-Swan (SS) growth model. In the 1960s, Nicholas Kaldor (1961) pointed a social regularity that states a proportional relationship between capital and labour in the economic development process. More recently, Thomas Piketty (2014) published his seminal book entitled “Capital in the twenty-first century” in 2014. In his book, Piketty describes the relationship between capital stock and economic development. He asserted a dominant role of capital stock in the economic development and an increasing income inequality in developed countries.

Despite numerous literatures on the labour-capital nexus, there is still a lack of systematic analysis on crucial interaction of human resources (HR) and physical resources (PR) in the economic development. More precisely, there is little analysis on both quantitative and qualitative aspects of labour. It seems that existing literature focuses on the quantitative, rather than qualitative, aspect of labour. These studies paid little attentions to the qualitative aspect of labour which is known as the human capital (HC). Thus, this paper uses the proposition of the HR which incorporate both quantitative and qualitative aspects of labour and examines the relationship between the HR and PR in the process of economic development. In other words, the current paper aims to describe how these two production resources, namely the HR and the PR, would jointly determine the dynamics process of economic development.

This paper consists of four sections. Following this introductory section, the second section briefly reviews some prominent theories to examine the relationship among labour, capital and output. The third section offers the theoretical framework for the production function with human resources and physical resource to capture the holistic roles of human resources and physical resource in the dynamic process of economic development. The final section is conclusion.

2. Theoretical perspective

Since the 19th century, numerous researchers have proposed various economic theories to examine the relationship among labour, capital and national output. This section briefly reviews some prominent theories on the labour-capital nexus in economic development (Marx, 1867; Harrod, 1939; Domar, 1947; Solow, 1956; Swan, 1956; Kaldor, 1961; Piketty, 2014). First of all, Marx (1867) introduced a theory of surplus values and examined the labour-output relationship in the middle of the 19th century. He warned the increasing dominant role of capital under the market economy. Secondly, Harrod (1939) and Domar (1947) proposed a theoretical model to examine the role of capital in the economic development which is known as the Harrod-Domar model. Also, Solow (1956) and Swan (1956) modified the HD model by adding the role of labour in the economic development which is known as the Solow-Swan (SS) growth model. The model has been used to

fundamental theoretical tool to understand the process of economic development. In some standard textbooks for economic growth, such as the *Economic Growth* by Barro and Sala-i-Martin (2003), this model is used as the most fundamental and crucial theory to explain the whole process of economic development. Thirdly, Kaldor (1961) pointed several social regularities to describe some interesting characteristics in the relationship between capital and labour in the economic development process. These regularities are known as the Kaldor's facts. Barro and Sala-i-Martin (2003) pointed that "Kaldor's facts" fitted with the reality of economic development. More recently, Piketty (2014) published his seminal book entitled "Capital in the twenty-first century" in 2014. In his book, Piketty describes the relationship between capital stock and economic development. He asserted a dominant role of capital stock in the economic development and an increasing income inequality in developed countries.

To simplify the discussion and to extract most salient theoretical perspective, this paper makes two assumptions. First of all, it assumes that there is no depreciation in the capital stock. In other words, the change in the capital stock is equal to the amount of investment. It also made addition assumption that production function would exhibit the tendency of constant to returns to scale. It means that the marginal product is equal to the average product. More importantly, under this condition, production function can be expressed in intensive form. It means that production function of capital and labour could be transformed into a intensive form of production function of capital/labour ratio.

2.1 Marx's theory of surplus values

Before Piketty, Karl Marx (1867) is one of first economists who claimed an increasing dominant role of capital stock in the economic development process. In the perpetual circulations of commodities under the market economy, the value of commodity tends to remain the same level. Marx explains the process of commodity circulation as follows:

$$C_1 \rightarrow M \rightarrow C_2 \quad (1)$$

where C_1 is the first commodity, C_2 is the second commodity and M is money. In this process, a commodity is brought to a market and is exchanged with money. Then, the money is used to purchase another commodity. In this process, the value of the first commodity is equal to the value of the second commodity. The relationship between two commodities can be expressed as:

$$C_1 = C_2 \quad (2)$$

It means that the commodity is materialised social labour and the value of commodity will not increase its value in the economic development process. By contrast, in the circulation of moneys, the value of money tends to increase. Marx explains the process of money circulation as follows:

$$M_1 \rightarrow C \rightarrow M_2 \quad (3)$$

where M_1 is the value of money before the transaction, M_2 is the value of money after the transaction and C is commodity. In this process, money is brought to a market and is exchanged with a commodity. Then, the commodity is sold at the higher price. In this process,

the value of the money before the transaction is less than the value of the money after the transaction. The relationship between two values of moneys can be expressed as:

$$M_1 < M_2 \quad (4)$$

It means that the money tend to increase its role in the economic development process. The key equation of the Marx's theory on money can be expressed as:

$$M_2 = M_1 + \Delta M_1 \quad (5)$$

where ΔM_1 is increase of values in the money in the economic transaction under the market economy. Marx defines the increased value as the surplus value. In the Equation (5), the concept of the surplus value is set as the central pillar of Marx's analysis on the relationship between labour and capital in the economic development. In the multiplying process of money circulation, the money would be transformed into the capital stock. As Equation (4) shows, the stock of money or capital would increase its value in the economic development because the capital would multiply itself by producing surplus values. By contrast, as Equation (2) shows, the commodity or the materialised social labour would not increase its value in the economic development because the materialised social labour would not produce surplus values.

2.2 Harrod-Domar model and Solow-Swan Model

Roy Harrod (1939) and Evsey Domar (1947) are among pioneer economists who claim the importance of capital in the economic development. These two economists jointed development a systematic theory to explain the economic development process which is known as the Harrod-Domar (HD) growth model. The most prominent characteristic of this growth model is that this model focuses solely on role of capital in the economic development. In other words, the HD model views the capital as the only source of economic development. In the HD model, the national output can be expressed as:

$$Y = F(K) \quad (6)$$

where Y is the national output or the Gross Domestic Product (GDP) and K is capital. This equation indicates that the national production is solely determined the amount of capital stock. More precisely, the relationship among national output (Y), saving (S), investment (I) and capital (K) under the HD model can be expressed as:

$$S = s \times Y = I = \Delta K \quad (7)$$

where S is total amount of saving, s is saving rate, I is total amount of investment and ΔK is increase in the capital stock. This relationship can be re-formulated as:

$$s \times Y = \Delta K = \frac{\Delta K}{\Delta Y} \Delta Y = C \times \Delta Y \quad (8)$$

where C is the value of increase in capital stock divided by increase in the national output. In other words, C is the value of capital stock required to produce a unit of national output. By definition, C is proportion to the multiplicative inverse of the marginal product of capital (MP_K).

$$s \times Y = C \times \Delta Y = \frac{\Delta Y}{MP_K} \quad (9)$$

This equation means that the total amount of saving is equal to the change in national output divided by the marginal product of capital (MP_K). The relationship can be further simplified as:

$$s \times MP_K = \frac{\Delta Y}{Y} = g \quad (10)$$

where g is the value of increase in national output divided by the total amount of national output. In other words, g can be seen as the growth rate of national output. The Equation (10) shows that growth rate of national income is determined the saving rate and marginal product of capita or the level of productivity. Thus, under the HD model, the relationship among saving, productivity and economic development can be expressed as:

$$s \times MP_K = g \quad (11)$$

where s is saving rate, MP_K is marginal product of capital and g is growth rate. As Equation (11) shows, the growth rate of national output (g) would be determined by the saving rate (s) and the marginal product of capital (MP_K) or the level of productivity. The HD model assumes that the marginal product of capital is proportion to the level of technology progress. It means that the national output is determined by the propensity for the saving and level of technology under the HD model.

On the other hand, Robert Solow (1956) and Trevor Swan (1956) independently developed a growth model which is a logical extension of the HD model. Their growth model is known as the Solow-Swan (SS) model. The most important feature of this modified model is that the production is jointly determined by labour and capital. In other words, the SS model views the capital and labour as two important sources for the economic development. In the SS model, the national output can be expressed as:

$$Y = F(K, L) \quad (12)$$

where Y is the national output or the Gross Domestic Product (GDP), K is capital and L is labour. It means that national output is jointly determined by capital stock and the amount of labour. This production function under the SS model can be expressed as:

$$Y = F(K, L) = L \times F(K/L, 1) = L \times f(k) \quad (13)$$

where k is capital/labour ratio. The per capita output (Y/L) can be expressed as:

$$\frac{Y}{L} = y = f(k) \quad (14)$$

where y is the per capita output. The equation (14) means that the per capita output is function of the capital/labour ratio. The increase in the capital/labour ratio (k) can be expressed as:

$$\Delta k = k_{t+1} - k_t = \frac{K_{t+1}}{L_{t+1}} - \frac{K_t}{L_t} \quad (15)$$

where k_t is the capital-labour ratio at time t , k_{t+1} is the capital-labour ratio at time $t+1$, K_t is the capital stock at time t , K_{t+1} is the capital stock at time $t+1$, L_t is the amount of labour at time t and L_{t+1} is the amount of labour at time $t+1$. The equation can be modified into

$$\frac{K_{t+1} \times L_t - K_t \times L_{t+1}}{L_{t+1} \times L_t} = \frac{K_{t+1} \times L_t - K_t \times L_{t+1} + K_{t+1} \times L_{t+1} - K_{t+1} \times L_{t+1}}{L_{t+1} \times L_t} \quad (16)$$

The Equation (16) can be further re-formulated as:

$$\frac{L_{t+1} \times (K_{t+1} - K_t)}{L_{t+1} \times L_t} - \frac{K_{t+1} \times (L_{t+1} - L_t)}{L_{t+1} \times L_t} = \frac{\Delta K}{L_t} - n \times k_{t+1} \quad (17)$$

where n is growth rate of labour ($(L_{t+1} - L_t)/L_t$). These relationships can be simplified as:

$$\Delta k = \frac{\Delta K}{L_t} - n \times k_{t+1} = \frac{s \times Y_t}{L_t} - n \times k_{t+1} = s \times y - n \times k_{t+1} \quad (18)$$

In the steady state, increase in capital/labour ratio is zero. It means that Δk is equal to zero. The Equation (18) can be transformed into a simple relationship under the steady state:

$$s \times y = n \times k \quad (19)$$

This means that per capita saving is calculated as the labour growth rate (n) multiplies capital/labour ratio (k). The capital/output ratio (c) is expressed as:

$$c = \frac{K}{Y} = \frac{K/L}{Y/L} = \frac{k}{y} = \frac{s}{n} \quad (20)$$

where c is the capital/output ratio, k is capital/labour ratio, y is per capita output, s is saving rate and n is labour growth rate. The Equation (20) shows that the capital/output ratio is jointly determined by the saving rate and labour growth rate in the steady state. Thus, under the SS model, the relationship among saving, capital and national output in the steady state can be expressed as:

$$c = \frac{s}{n} \quad (21)$$

It means that the capital/output ratio is jointly determined by the saving and the labour growth. The SS model assumes that national output will grow at the rate of labour growth (n) in the steady state. It means that the capital/output ratio is jointly determined by the saving rate and growth rate.

2.3 Kaldor's facts and Piketty's criticism

Nicholas Kaldor (1961) spelled out well-known six empirical regularities in the economic development process which is known as the Kaldor's stylised facts, namely 1) continued growth in output and productivities; 2) continued growth in capital per worker; 3) steady rate of return on capital; 4) steady rate of capital/output ratio; 5) steady share of profits from capitals and of wages from labours in national output; 6) differences in the rates of growth of labour productivities and of the total output in different countries.

In his fourth empirical regularity, Kaldor (1961) pointed the tendency that output and capital would grow at the same rates. In other words, the average growth rates of capital stock are approximately same as the average growth rates of national output. The standard textbook for the growth theory by Robert Barro and Xavier Sala-i-Martin (2003) stated that the Kaldor's fourth empirical regularity fits well with some long-run data for the developed countries. It claims that there is the stability of the long-run ratios of capital to national output in five developed countries, namely United States, Italy, Germany, Japan and United Kingdom. In the context of the relationship between capital (K) and output (Y), Kaldor's fourth empirical regularity can be expressed as:

$$\frac{\Delta Y}{Y} = g = \frac{\Delta K}{K} = g_K \quad (22)$$

where g is the growth rate of the national output and g_K is the growth rate of the capital. Furthermore, in his fifth empirical regularity, Kaldor (1957) asserted that share of labours from wages and share of the profits from capital in national output are constant in the long-run. In other words, the average growth rates of the national output generated by labour (Y_L) are approximately equal to the average growth rates of the national output generated by the capital (Y_K). Barro and Sala-i-Martin (2003) supported this empirical regularity stated that there was a long-run stability of factor share in United States, Canada, Hong Kong, Singapore, South Korea, Taiwan, France, Germany, Italy and Japan. It means that the growth rate of national income generated by the labour is equal to the growth rate of national rate generated by the capital when the elasticity of substitution between labour and capital would be one. Under this unity substitution condition, the labour-capital nexus can be expressed as:

$$\frac{\Delta R_{K/L}}{R_{K/L}} = \frac{\Delta R_{w/r}}{R_{w/r}} \quad (23)$$

where K is capital, L is labour, w is wage or the price of labour and r is rent or price of capital, $R_{K/L}$ is the capital-labour (K/L) ratio or the amount of the capital per one unit of labour and $R_{w/r}$ is the wage/rent ratio or the ratio of price of capital to the price of labour. If the capital-labour (K/L) ratio would increase, the wage/rent ratio would also increase at the same proportion. In other words, the unity substitution condition makes sure that share of income generated by labour would be equal to the share of income generated by capital. In the

context of the relationship between labour share (Y_L) and capital share (Y_K), Kaldor's fifth empirical regularity can be expressed as:

$$\frac{\Delta(w \times L)}{w \times L} = \frac{\Delta Y_L}{Y_L} = g_{YL} = \frac{\Delta(r \times K)}{r \times K} = \frac{\Delta Y_K}{Y_K} = g_{YK} \quad (24)$$

where Y_L is the national output generated by labour, Y_K is the national output generated by capital, g_{YL} is the growth rate of the labour share and g_{YK} is the growth rate of capital share.

In his influential book, Thomas Piketty (20 14) vividly describes the relationship between the capital stock and the national income and also points an alarming income inequality in developed countries. In the context of the labour-capital nexus, Piketty's theory can be summarised into two famous equations to describe the fundamental social regularity under the market economy. The first social regularity is known the "first fundamental law of capitalism". The second regularity is known as the "second fundamental law of capitalism". The first law describe the relationship between the stock of national wealth (capital stock) and the flow of national income (Gross Domestic Product or GDP). The first fundamental law of capitalism is formulated as:

$$\alpha = r \times \beta \quad (25)$$

where α is the share of income from capital in national income, r is the rate of return on capital and β is the capital/income ratio. It means that the Equation (1) describe how the stock of national wealth would be transformed into the flow of national income. If the rate of return on capital stock is low, the larger stock of capital would produce national income less than expected. By contrast, if the rate of return on capital stock is high, the smaller stock of capital would produce national income more than expected.

The second law describes the determinants of the stock of national wealth (capital stock). It describes the saving/growth ratio is the key factor to determine the level of national wealth. The second fundamental law of capital is formulated as:

$$\beta = s / g \quad (26)$$

where s is the saving rate and g is the growth rate. It means that the Equation (2) describes how saving rate and growth rate would jointly determine the capital stock. If the economic growth is high, the higher level of saving rate would produce the capital stock less than expected. By contrast, if the economic growth is low, the lower level of saving rate could produce the capital stock more than expected.

More importantly, Piketty posed a question about two well-accepted conventional wisdoms in the Kaldor's facts, namely a constant capital/output ratio and a stable capital share in the national income. First of all, contrary to the prediction by the Kaldor's fourth social regularity, Piketty pointed out that the capital/output ratio (β) was not constant. Piketty convincingly demonstrated that the capital/output ratios have sharply increased in four developed countries, namely United States, France, Germany and United Kingdom, since the 1970s. Piketty explained that the growth rates of national incomes in these developed countries are relatively low in the recent decades. These slow growths of national incomes seem to cause increases in

the capital/output ratios. In the context of the relationship between capital stock (K) and national output (Y), Piketty's criticism can be expressed as:

$$g_Y < g_K \quad (27)$$

where g_Y is growth rate of national output and g_K is growth rate of capital stock. In other words, Kaldor (1961) made his well-known proposition on the constant capital/output ratio through his analysis of relatively high growth rates of national incomes in the 1940s and the 1950s. By contrast, Piketty (2014) asserted his proposition on the rapid increase in the capital/output ratio through his observation of relatively low growth rates of national incomes since the 1970s.

Secondly, Piketty (2014) also questioned about the stable wage share and the capital share in the national income. He argues, contrary to the prediction by the Kaldor's fifth social regularity, there is no constant wage and capital share. In other words, the elasticity of substitution between labour and capital is more than one. Under this condition, the labour-capital nexus can be expressed as:

$$\frac{\Delta R_{K/L}}{R_{K/L}} > \frac{\Delta R_{w/r}}{R_{w/r}} \quad (28)$$

In other words, in the case that the elasticity of substitution would be greater one, the growth rates of national income generated by the labour is less than the growth rate of national rate generated by the capital:

$$g_{YL} < g_{YK} \quad (29)$$

where g_{YL} is growth rate of national output generated by labour and g_{YK} is growth rate of national output generated by capital. Thus, Piketty pointed the increasing share of rental income from the capital stock and the decreasing share of wage income the labours since the 1970s in developed countries. It means that there have been the global trends of increasing capital/income ratio (β) and increasing share of output from capital (α) in the recent decades.

3. Human resources and physical resources in economic development

Despite numerous studies on relationship among labour, capita and nation income, there is still a lack of systematic analysis on a dynamic role of labour in the economic development. Previous literatures pay little attention to both quantitative and qualitative aspects of labour. Existing literature focuses mainly on the quantitative aspect of labour. Thus, this paper incorporates the qualitative aspect of labour which is known as the human capital in its analysis. It paper employs the proposition of the human resources (HR) which includes quantitative and qualitative aspects of labour. In other words, this paper examines the relationship between the HR and its counterpart, the physical capital (PC), in the process of economic development. The current paper aims to describe how these two production resources, namely the HR and the PR, would jointly determine the dynamics process of economic development.

From a theoretical perspective, the current study is based on two prominent growth models which are known as the Harrod-Domar (HD) model (Harrod, 1939; Domar, 1947) and the

Solow-Swan model (Solow, 1956; Swan, 1956). Piketty's seminal study on the income inequality also is based on these standard growth models (Piketty, 2014). In other words, the current study uses the HD growth model and the SS growth model to examine the roles of the human resources (HR) and the physical resources (PR) in the dynamics process of economic development.

In this paper, the national output can be considered as the function of the HR and the PR. The human resources include the quantitative aspect of labours and the qualitative aspect of labours which is known as the human capital (HC). In other words, the total amount of human resource is equal to the total number of labour supply and the cumulated stock of the HC. On the other hand, the physical resources are all non-human resources which would contribute to national output, including the capital stock, the financial resources, the natural resources, land and so on (Lim *et al.*, 2007; Lim *et al.*, 2010). The national output can be expressed as:

$$Y = F(HR, PR) \quad (30)$$

where Y is the national output or the Gross Domestic Product (GDP), HR is the human resources and PR is the physical resources.

To simplify the discussion, this paper makes several assumptions. First of all, it assumes that the production function in this model would exhibit the constant returns to scale, the change in a production resource would take place independently when another production resource remains same level and there would be no significant difference between a change and an infinitesimal change in these production equations. Under these assumptions, the marginal product of the HR and the marginal product of the PR will be constants. The marginal product of the HR is equal to the average product of the HR. It also means that total derivatives of the production resources would be equal to the partial derivatives. These assumptions can be expressed as:

$$MP_{HR} = \frac{\partial Y}{\partial HR} = \frac{dY}{dHR} = \frac{\Delta Y}{\Delta HR} = \frac{Y}{HR} \quad (31)$$

$$MP_{PR} = \frac{\partial Y}{\partial PR} = \frac{dY}{dPR} = \frac{\Delta Y}{\Delta PR} = \frac{Y}{PR} \quad (32)$$

where MP_{HR} is the marginal product of the HR and MP_{PR} is the marginal product of the PR. This simplification of the production resources relations is important because it would transform Harrod's notion of the marginal product (Harrod, 1939) into Piketty's notion of the average product or the capital/output ratio (Piketty, 2014). In other words, a certain value of the production resource required for a unit production of output would be equal to the average value of the production resource required for a unit production of output.

Secondly, the current study assume that the total investment would be divided into two types of investments, namely the investments on the HR development (HRD) and the investments on the PR development (PRD), and there would be no depreciation in the stocks of the human resources (HR) and the physical resources (PR). It means that the acquired knowledge and skills in the HR stock and the purchased machineries and other equipments in the PR stock

would remain at same level with the well-coordinated and continuous efforts for the maintenances and necessary repairing works. It also implies that the number of new employees who would enter the labour market would be equal to the number of retired employees who would leave the labour market. Under these simplified assumptions, investments are considered as only the determinants for the level of the stock of the HR and the PR. It means that the change in the human resources would be equal to the total amount of investment on the HRD and the change in the physical resources would be equal to the total amount of investment on the PRD. These assumptions can be expressed as:

$$I = I_{HRD} + I_{PRD} \quad (33)$$

$$\Delta HR = I_{HRD} \quad (34)$$

$$\Delta PR = I_{PRD} \quad (35)$$

where I is total amount of investment, I_{HRD} is the total amount of investment on the HRD and I_{PRD} is the total amount of investment on the PRD.

Thirdly, the total amount of saving (S) is calculated as the saving rate (s) times output (Y). It assumes that the total saving is divided into two type of saving, namely the saving for the HRD and the saving for the PRD, the saving rates would be considered as the exogenous variables and the total amount of saving (S) would be equal to the total amount of investment (I). The saving rates for the HRD is denoted as s_1 while the saving rate for the PRD is donated as the s_2 . The saving for the HRD includes the saving for the education, medical cares, training and so on while the saving for the PRD includes the saving for the purchases of machineries, financial assets, real estates and so on. Similarly, it assumes that the total investment is divided into two type of investment, namely the investment for the HRD and the investment for the PRD. The relationship among output, saving and investment can be expressed as:

$$S = sY = I \quad (36)$$

$$S = S_{HRD} + S_{PRD} \quad (37)$$

$$I = I_{HRD} + I_{PRD} \quad (38)$$

$$s_1 = \frac{S_{HRD}}{Y} = \frac{I_{HRD}}{Y} \quad (39)$$

$$s_2 = \frac{S_{PRD}}{Y} = \frac{I_{PRD}}{Y} \quad (40)$$

$$s = \frac{S}{Y} = \frac{S_{HRD} + S_{PRD}}{Y} = \frac{(s_1 \times Y) + (s_2 \times Y)}{Y} = s_1 + s_2 \quad (41)$$

where S_{HRD} is the amount of saving for the HRD, S_{PRD} is the amount of saving for the PRD, S is total amount of saving, s is the saving rates, I_{HRD} is the amount of investment for the HRD,

I_{PRD} is the amount of investment for the PRD. Furthermore, the saving-investment relationship can be re-formulated as:

$$s_1 \times Y = I_{HRD} = \Delta HR = \frac{\Delta HR}{\Delta Y} \times \Delta Y = \frac{HR}{Y} \times \Delta Y \quad (42)$$

$$s_2 \times Y = I_{PRD} = \Delta PR = \frac{\Delta PR}{\Delta Y} \times \Delta Y = \frac{PR}{Y} \times \Delta Y \quad (43)$$

The HR stock/output ratio (HR/Y) can be denoted as β_1 and the PR stock/output ratio (PR/Y) can be denoted as β_2 . The gross rate of national output (g_Y) can be calculated as the change in output (ΔY) divided by the total output (Y) or it could be considered to be the same as the output change/output ratio ($\Delta Y/Y$). The important relationship between the growth rate and the saving rates could be expressed as:

$$\beta_1 = s_1 \times \frac{Y}{\Delta Y} = \frac{s_1}{g_Y} \quad (44)$$

$$\beta_2 = s_2 \times \frac{Y}{\Delta Y} = \frac{s_2}{g_Y} \quad (45)$$

The equation (45) describes the determinants of the PR stock/output ratio which is similar to Piketty's second fundamental law of capitalism. The equation means that the PR stock/output ratio would be jointly determined by the saving rate for the PR stock and the growth rate of national output. If the growth rate is high, the higher level of the saving rate for the PR would produce the PR stock less than expected. By contrast, if the growth rate is low, the lower level of saving rate for the PR would produce the PR stock more than expected. Similarly, the equation (44) describes the determinants of the HR stock/output ratio. It means that the HR stock/output ratio would be jointly determined by the saving rate for the HR stock and growth rate.

Finally, the relationship between stocks of production resources and flows of national output can be expressed by using the notion of the production resources shares. The national income paid for the HR stock (Y_{HR}) could be calculated as the price of the HR stock or the wage rate (w) times the HR stock. The share of income paid for the HR stock can be denoted as α_1 which is the fraction of national income generated by the HR stock (Y_{HR}/Y). Similarly, the national income paid for the PR stock (Y_{PR}) could be calculated as the price of the PR stock or the rental rate (r) times the PR stock. The share of income paid for the PR stock can be denoted as α_2 which is the fraction of national income generated by the PR stock (Y_{PR}/Y). Another important relationship between production resources stock and income distribution can be expressed as:

$$\alpha_1 = \frac{Y_{HR}}{Y} = \frac{w \times HR}{Y} = w \times \frac{HR}{Y} = w \times \beta_1 \quad (46)$$

$$\alpha_2 = \frac{Y_{PR}}{Y} = \frac{r \times PR}{Y} = r \times \frac{PR}{Y} = r \times \beta_2 \quad (47)$$

$$\alpha_1 + \alpha_2 = \frac{Y_{HR} + Y_{PR}}{Y} = \frac{Y}{Y} = 1 \quad (48)$$

The Equation (47) describes the determinants of the PR share in national income which is similar to Piketty's first fundamental law of capitalism. This equation means that the PR share in total national income would be jointly determined by the rental rate and the PR stock/output ratio. If the rental rate is low, the higher level of the PR stock would receive the fraction of national income less than expected. By contrast, if the rental rate is high, the lower level of the PR stock would receive the fraction of national income more than expected. Similarly, the Equation (48) describes the determinants of the HR share in national income. It means that the HR share in national income would be jointly determined by the wage rate and the HR stock/output ratio.

4. Conclusion

Despite numerous studies on labour and capital, there is still a lack of systematic analysis on the holistic roles of human resources (HR) and physical resources (PR) in dynamic process of economic development. Thus, the current paper aims to describe how these two production resources would jointly determine the dynamics process of economic development. This paper captures two fundamental characteristics of interaction between HR and PR in the economic development. The first one describes the relationship between production resources and economic development. The second one describes the relationship between production resources and income distribution.

Firstly, the ratio of production resources stocks to national output is jointly determined by the saving rate for the production resources and the growth rate of national output. If the growth rate of national income is high, the higher level of the saving rate for the production resources would produce its stock less than expected. By contrast, if the growth rate of national income is low, the lower level of saving rate for the production resources would produce its stock more than expected.

Secondly, the production resources' share in total national income is jointly determined by the price of the production resources and the ratio of production resources stock to national output. If the price of production resources is low, the higher level of the production resources stock would receive the fraction of national income less than expected. By contrast, if the price of production resources rate is high, the lower level of the production resource stock would receive the fraction of national income more than expected.

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