A Study of the effects of leisure time on China's economic growth

INTRODUCTION

China's economy has witnessed a fast growth since late 1970s. For example, China's GDP in 1981 was 0.71 trillion US dollars, and this number increased to 17.12 trillion US dollars in 2003(CNBS, 2004). The growth rate of GDP per Capita also maintained 10% for the past 10 years (CNBS, 2007).

The average leisure time that people can enjoy also increased continuously. The total number of official days off &holidays in China between 1978 and 1994 was 62 days. It increased to 97 days in 1995. In 1996, Chinese government employed the"5-days workday" policy, which made the total number of days off &holidays increased to 114 days (CNTA, 1978-2007). The latest adjustment of holidays in China was in 2008, which increases to 147 days in total.

Would increased leisure time have impacts on economic growth? A few studies revealed that the amount of leisure time dose have impacts on economic growth and business cycle (Wilensky, 1961; Kydland and Prescott, 1982;

Eichenbaum, 1988; Hek, 1998; Ladrón-de-Guevara, 1999). They observed that leisure time should enter agent's utility function if economists accept backward curve of labor supply. This means that an individual would prefer more leisure than additional income once his/her average income exceeds certain level. A strong relationship was also found among leisure time, income distribution, aggregate consumption, interest rate and economic growth. In particular, leisure time in utility function may bring to saddle point stability (Ioannides et al, 1992) or the possible existence of multiple growth paths (Ladrón-de-Guevara et al, 1999). Previous researches are creative in introducing leisure time into economic system. Most of previous studies noticed the substitution effects of leisure time on economy, while the compensation effects of leisure time seemed to have been neglected. The substitution effect of leisure time is defined as the effect that the one must reduce work time and income in substitution of more leisure (Buchanan, 1994). The compensation effect of leisure time is defined as the effect that leisure activities may enhance individual efficiency and then improve aggregate output. In this study, we hypothesized that both of these effects could influence the relationship between leisure time and economic growth.

The main purpose of this study was to analyze the impact of leisure time on

economic growth. A theoretic model of neoclassic economic growth was constructed in which leisure time was entered into human capital accumulation and technology accumulation. After that, an empiric model, VAR model, was used to test the conclusion derived from theoretic model. The specific objectives of this study were:

To reveal the net effect of leisure time on economic growth in theory by introducing leisure time into capital accumulation path and technology accumulation path of a theoretic neoclassic growth model; and, to assess the impacts of leisure time on China's economic growth.

LITERATURE REVIEW

The research on Economic Growth Theory is one of the most popular fields in macro-economics. The main research focuses are economic growth and business cycle. The household survey indicated that leisure time can not only yield utility but also generate production as an individual output (Becker, 1965; Gronau, 1977). Since 1960s, many researchers began to analyze the relationship between education time (which belongs to leisure time)and economic growth

(Chase, 1967; Ryder, Stafford ,Stephan, etc, 1976）. The models proposed usually assumed that education does not affect the quality of leisure. In other words, marginal utility of leisure time is not affected by human capital (Ladrón-de-Guevara et al, 1999). The empirical observation at that time was to compare with the process of production activity, technological evolution happened less in the process of leisure activity. Under this assumption, productivity would be improved when the time spent on education increases, because education can enhance the competence of human capital. As a result, time spent on leisure activities would decease because people would like to increase their income by more education and more work (Ladrón-de-Guevara et al, 1999).

Later, researchers used RAM (Representative Agent Model) of the aggregate labor market to further analyze the impacts of leisure time and specific types of leisure time on the economic growth (Lucas and Rapping, 1969; Hall, 1980; Kydland and Prescott，1982; Mankiw, Rotenberg and Summers，1985; Ioannides, 1992; Zhang, 1995）. Some of the hypotheses in the models, however, are illogical. For example, it was hypothesized that there is a common Implicit Price of leisure for all consumers (Rubinstein, 1974; Eichenbaum, Hansen and Richard, 1985). Since 1980s economists have been interested in amending these fallacies and

searching for new ways to analyze the impact of leisure time on economic growth. Economists found that the relationship between preference and consumption is not always linear，thus the equilibrium of real interest is not always continuous (Eichenbaum, Hansen and Richard, 1985) . By introducing both consumption and leisure time into service in order to achieve measuring uniformity, it was indicated that multiple equilibriums in economy might exist (Ladrón-de-Guevara et al, 1999).   To be specific, if we use the Cobb-Dauglass utility function and intensification labor production function, the dynamic optimal economy by the planner may be either one or two inner point roots, or one outer point root (when no time is spent on education). This result is obviously different from the analysis when using only one signal steady state equilibrium as in the neoclassical and endogenous economic growth models.

Research on leisure time and economic growth has been brought to a new height in past 10 years. It is worth notice that RBC (Real Business Cycle) theory created a formal framework to deal with leisure time in economy. Classic RBC model assumed that technological shock has a strong negative effect on non-working time, such as leisure time. However the predictions were just based on data from certain western developed countries. No such predictions have been

made for developing countries. Research shows that technological shock sometimes positively affects non-production investment through the R&D (Research and Development). Shea (1998) found that the periodical fluctuation of input factors can be explained partially by technology shock. Further more, with price-sticky model and the actual data from seven western developed countries, Gali (1999) found that technical progress would lead to the decline of working time and increase of leisure time in the short run. Besides, aggregate output derived from demand shock has a notable negative correlation with the change of leisure time. Gali(1999) believed that the major reason for the periodical fluctuation of economy is the demand shock rather than technology shock.

In above frameworks, the increase in return and sustainable growth are explained by activities within the working time such as the exogenous technological shock, R&D (Barro and Sala-I-Martin, 1992; Jones, 1995a; Jones, 1995b) and endogenous knowledge accumulation (Romer, 1986 and 1990; Lucas, 1988). However, the leisure time was ignored as having similar impact on the quality as well as the accumulation of production factors. In fact, individual activities are performed both in working time and leisure time. And it is important to note that leisure time has the compensation effect on individual efficiency and

economic growth (Ragheb and McKinney, 1993; Beatty.J.E. and Torbert.W.R., 2003; Monte.R.N., 2008; Maguire.J.S., 2008).

Some studies used a few new methods or new models to illustrate the effect of leisure time. Ortigueira (2000) applied the term "qualified leisure" to an endogenous economic growth model. Qualified leisure means that leisure time can be adjusted by human capital which represents a certain type of compensation effect of leisure. There is unique globally stabled as well as balanced growth path rather than multiple paths in other leisure-growth models. Weder (2004) used the term "Conspicuous Leisure" to refer to another type of compensation effect of leisure. He revealed that an agent's utility function will be affected by his/her counterparts' amount of leisure time. By introducing this kind of externality of leisure into growth model, he indicated that economy may converge to a saddle stable point. However, Fernandez, Novales and Ruiz (2004) suggested that the competitive equilibrium can be indeterminate for plausible values of the elasticity of inter-temporal substitution of consumption. This is because public consumption and leisure can not be separated in the utility function.

Researchers have tested some compensation effects of leisure recently (Walsh.E.R. 1982; Lu.,L and Argyle.M., 1994; Beatty.J.E. and Torbert.W.R., 2003;

Gould.J. Moore.D. McGuire.F. Stebbins.R., 2008). Few studies assessed the overall effect of leisure on economic growth (Kokoski.M.F,. 1987). However, the specific mechanism and path of compensation effects of leisure has not been figured out clearly. Therefore, this study introduced compensation effects of leisure into the paths of human capital accumulation and technology accumulation, based on Mankiw, Romer and Wei (1992)'s model. As a result, leisure time and its effects as a whole are naturally introduced into the economic growth model. Also further empirical tests using secondary data from China was made to test the propositions derived from the theoretic model.

METHODS

Theoretic Model and Propositions

In the present framework, the individual's leisure time is divided into three parts: The first part is called "education (leisure) time". It is the time used for education and training, pursuing knowledge and skills. We use l_1 to present it; the second part is called "necessary leisure time", Individuals use this part of time to

get some necessary relaxations and housework. We use l_2 to represent it; the third part is called "enjoyment leisure time". It is the time used for traveling, entertaining, exercising and other leisure activities. We use l_3 to represent it. As usual, for a representative agent, l_2 (time spent on necessary relaxations and housework) is steady and constant. However, the amount of time spent in education (l_1) and leisure (l_3) varies and is subject to different period of time, i.e. $l_1 = l_1(t)$, $l_3 = l_3(t)$. Here t represents time (Wei, 2005).

Under this condition, the effect of leisure time was substitute into neoclassic growth model. In addition, two compensation effects of leisure time were also identified in this study. The two compensation effects are:

"Advancing by Leisure". The amount of enjoyment leisure time (l_3) is another determinant for human capital. The forming of human capital endowment can be promoted through enjoying leisure activities. This is because individuals may gain more knowledge, relax themselves and improve their intelligence in this process（Csikszentmihalyi, 1981）. In this study, this process is named as "Advancing by Leisure" effect. This is especially true with a society characterized by knowledge economy. The benefit brought by healthy and positive leisure activities is remarkable. However this is ignored by traditional human capital

theory (Maguire, 2008). It should be noted that some leisure activities (if they are unhealthy or depraved) could harm the human capital. In this situation, the enjoyment leisure time should be considered to have as a negative factor for human capital (Dunlop, 2006).

"Learning by Leisure". The enjoyment leisure time (l_3) has externality to the technological level as a whole. If the activities are healthy and positive (e.g. exercise, travel, exploration and extreme sports), the individual participant can enhance his/her willpower and creativity. This could inspire innovative ideas. The creativity and the originality of the society as a whole could be improved if all individuals participate more in healthy and positive leisure activities. It may further promote the technological level of the society, either directly or through the externality (Romer, 1990; Jones, 1995a; Jones, 1998). However, a single individual's impact on economy is limited and weak. An Individual enjoys his/her leisure time because it is worthwhile for himself/herself. However, the accumulation effect of the enjoyment leisure time could contribute to the economy by enhancing the technological level incidentally (Gould et al, 2008). In this way, the enjoyment leisure time has positive externality to the technological level. In this study, this process is named as "Learning by Leisure" effect, a

similar concept like "Learning by Doing" (Romer, 1986). However, the externality effect of enjoyment leisure time (l_3) to the technology is different from that of capital accumulation in which the latter is endogenous within the model while the former is exogenous.

In the present framework, the effect of "Advancing by Leisure" is entered into the accumulation path of human capital; the effect of "Learning by Leisure" is entered into the accumulation path of technology. This changed the structure of dynamics in neoclassic economic growth model. Thus the long-run growth path of per capita output with leisure is reformulated as follows (see Appendix 1 for proof):

$$\frac{\dot{y}}{y} = (\alpha + \beta)\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{h}}{h} + \gamma\frac{\dot{l_3}}{l_3} + \beta n \qquad (1)$$

$$= (\alpha + \beta)\frac{\dot{k}}{k} + (1-\alpha)(\psi_1 \dot{l_1} + \psi_3 \dot{l_3}) + \gamma\frac{\dot{l_3}}{l_3} + \beta n \qquad (2)$$

Where, k is the capital stock per capita, $n = \frac{\dot{L}}{L}$ is exogenous constant population growth rate. α and $1-\alpha$ are the elasticity of physical capital and human capital to output respectively. β is the elasticity of capital stock to technology level and it exists $0 < \beta < 1$. γ is the elasticity of technology affected by externality of enjoyment leisure time. Here, $\gamma < 1$ in that externality

of the enjoyment leisure time to the technological level is decreasing return to scale. When the accumulation of leisure time l_3 is good for the improvement of the technological level, we have the parameter $\gamma > 0$. By contraries, $\gamma < 0$. ψ_1 is the speed of human capital accumulation promoted by education time (l_1),i.e. $\frac{d \ln H}{dl_1} = \psi_1$; ψ_3 is the speed of human capital accumulation promoted by enjoyment leisure time (l_3), i.e. $\frac{d \ln H}{dl_3} = \psi_3$. The hat " $\bullet$ " on the variable means the increment of this variable in this year.

Eq.(1) and (2) showed the theoretic model by adding leisure to standard neoclassic growth model (Mankiw, Romer & Weil，1992). This model is to test the relationship between leisure and long-run economic growth including both substitution and compensation of leisure.

From Eq.(1) and (2), the approach of economic growth displays not only the traditional effect from physical capital and effect from "Learning by Doing" but also some new characteristics. Specifically, the dynamical impact of leisure time on economic growth leads to two propositions as follows:

Proposition.1. In the economy along balanced growth path，it is appropriate to reduce the enjoyment leisure at certain extend to insure an optimal economic

growth rate (see Appendix 2 for the proof for the proposition).

According to proposition 1, education time and working time should be maintained at a relatively high level while enjoyment time has to be controlled under a moderate level. This is due to the impact from the individual's activities in leisure time on technological level and human capital level. This could explain, to some extent, why America has acquired relatively higher economic growth than that of France or Italy, since people of the latter two countries who would like to relax more.

Proposition.2. When leisure is considered normal goods, active and healthy enjoyment leisure time promotes economic growth along non-balanced path (see Appendix 2 for the proof for the proposition).

Hence we could see a reason for civilization and morality from economic perspectve. It is worthy to not only pay attention to the formal education activities but also encourage the individuals to participate in more active, instructive and virtuous leisure activities since the human capital is shaped both by education time as well as enjoyment leisure time.

In sum, without regard to the effect of R&D intended, activities of research and development, two kinds of externality may maintain sustainable growth of an economy: one is the externality of "Learning by Doing" which happens at the process of physical capital accumulation, and the other is the externality of "Advancing by Leisure" and/or "Learning by Leisure" from external enjoyment leisure time.

Data and Period

Secondary data sources were used in the study. The selection of data was based on data availability, reliability, sufficiency and ability of the variable to be measured in the model. Data was mainly collected from "Statistics Yearbook of China, 1980-2004" published by the State Statistical Bureau of the P.R. China.

Firstly, data were collected to evaluate the labor force, population growth rate and economic growth rate. In this study, L represents all the untrained "primitive labor force", so the total population in the society is regarded as labor force L. Accordingly, the population growth rate is calculated based on the number of total population per year.

Secondly, the human capital growth rate is estimated based on the method of Cai and Du (2003) and Song (2003). It regards that the number of the labor's human capital increased every year as that of the society's. The human capital increased every year（h_t）equals to the number of graduates at each educational phase(people who do not accept further education, plus the number of educational years). The calculating formula is: $h_t = \Sigma(g_i - r_i)y_i$, where, g_i is the number of graduates in some phase, r_i is the number of students recruited in some educational phase, y_i is the number of finished educational years, concretely, 6，9，12，16 represent the fixed number of educational years for primary school, middle school, high school and university respectively in China. The data of base year adopt the average educational year of the Chinese population who were 15 years old in 1981, and the human capital stock for 1981~2003 can be calculated by the formula followed, $H_{t+1} = (H_t + h_{t+1})/P_{t+1}$. In addition, the human capital stock of the society would be decreased due to death and so on. The impact of death on the human capital stock could be estimated by natural mortality (δ_t). Because the natural mortality of the population at 15-64 years old is much lower than the per capita mortality of the whole society, the natural mortality of the population at 15-64 years old is estimated at about 1/3 of the whole society

according to Song's (Reference Year) method. And the formula for computing

capital stock per capita is: $h_{t+1} = h_t(1 - \delta_{t+1})/P_{t+1}$.

Thirdly, for the evaluation of data on growth rate of physical capital, the total

amount of capital established is impacted by inflation rate every year. Therefore,

the per capita growth rate of physical capital could be worked out using the

amount of physical capital in past years.

Fourthly, when estimating time, it is difficult to find accurate data of

enjoyment leisure time. Hence the weighed method is employed to make

estimation. Because of the positive relationship between expense and time on

leisure, annual national holidays are weighed by leisure expenditure per year to

gauge the amount of real enjoyment leisure time.

Empiric Model

The empiric model established derived from Eq.(2) in the theoretic model.

The general empiric model in this study is as follows:

$$g_y = \alpha + \beta_1 g_k + \beta_2 g_k(-1) + \beta_3 g_k(-2) + \beta_4 g_h(-1) + \beta_5 g_h(-2) + \beta_6 g_l(-1) + \beta_7 g_l(-2) + ... + \mu$$

where,

g_y : the growth rate of output per capita;

g_k : the growth rate of physical capital per capita;

g_h : the growth rate of human capital per capita;

g_z : the growth rate of enjoyment leisure time;

μ : the statistic error.

(-1) and (-2) means 1 and 2 lagging term.

To test whether the long-run equilibrium relationship or co-integration relationship among variables exist, the model was first tested through Unit Root ADF Test. In this framework, the trend parameter was estimated by the utmost 2-lag test.

RESULTS

The results revealed that the original serial and the first-order difference serial of the model were both unstable. Thereby, the second-order difference of the original series was done by ADF test. The results are shown in Table 1.

Table.1. Results of ADF test

Variables	ADF Statistic	Test level	Critical Values	D-W d-Statistics
gy	-3.406123		-3.8877	1.937883
			-3.0521	
			-2.6672	
gk	-4.261835		-3.8877	2.112346
			-3.0521	
			-2.6672	
gh	-4.784304		-3.8877	1.683468
			-3.0521	
			-2.6672	
gz	-3.182287		-2.7057	1.626796
			-1.9614	
			-1.6257	
n	-4.501757		-3.8572	2.173111
			-3.0400	
			-2.6608	

From Table 1, all the variable serials are second-order integrative and uncorrelated series, which indictes that it is possible to co-integrate dependent variables and independent variables.

Based on the above estimation, the lag1 co-integration test on the variables could be fulfilled. The test results are shown as in Table 2. The results of the co-integration test on the 1% level showed that there are four co-integrated vectors for the model.

Table.2. Results of the co-integration test

Eigen value	Likelihood Statistics	5% test level	1%test level	Original hypothesis
0.940771	121.7102	68.52	76.07	None
0.728289	65.18328	47.21	54.46	At most 1
0.672659	39.12297	29.68	35.65	At most 2
0.518558	16.78790	15.41	20.04	At most 3
0.102754	2.168512	3.76	6.65	At most 4

To find global relationship between leisure time and the growth, the short-run fluctuation equation was done by the use of VAR model. After that the long-run co-integration equation was derived from the short-run equation. The VAR model are of 2-lag. We excluded those variables whose lag variables failed to pass t-test from right side of the VAR equation. Then remainder variables were estimated by OLS method, residuals were adjusted continuously. As a result, the Akaike info criterion and the Schwartz criterion were minimized. The short-run equation based on VAR is as follows:

$$g_y = 0.047808+0.526818 \ g_k + 0.068553g_k(-2)+0.129420g_h(-1)$$

$$+ 0.040293g_z(-1) -0.048908g_z(-2) \tag{3}$$

Then the long-run equilibrium equation is derived as follows：

$$g_y = 0.047808+0.595371g_k +0.129420g_h -0.008615g_z \tag{4}$$

The result of VAR and OLS indicated that the impact of leisure time change

on China's economic growth is weak but significant.

Moreover, to further study the transferring effects of the interaction between the leisure time and the economic growth, it is necessary to do a Granger Causality Test with an utmost 2- lag on the growth rate of the leisure time and the economic growth rate. The results are shown in Table 3.

Table.3. Results of Granger Causality Test

Null hypothesis	F value	Probability
gz is not the Granger reason of gy	4.6533	0.02678
gy is not the Granger reason of gz	0.3286	0.72496

As it is shown in Table 3, the growth rate of leisure time (g_z) is the Granger Cause of economic growth rate (g_y), however, g_y is not the Granger Cause of g_z , which explains that the change of leisure time could give the reason for the variety of economic growth in China.

Based on the results of above empiric model, physical capital accumulation is an engine of Chinese economy either in the short run or long run. In other words, China economy is driven by investment. And at the same time the negative

relationship between leisure time and China's economic growth is significant. The change of real leisure time can cause the economy to fluctuate although the impact is not robust--impact from the rate of leisure time change on the economy is less than 1%.

As to the leisure time, Eq. (3) indicates that former enjoyment leisure time makes a slight negative contribution to sequential economic growth. The reason may be that China's economic growth is not along the balanced growth path in which the average output (Y/K) fluctuates in a large range. This means that China is on the way to the industrialization.

To summarize, the real leisure time of Chinese people has increased with the implementation of "5 day working week" and "golden week". Also the quality of life of people and the social economy improved due to increased leisure time. However, it is worth to notice that China is still in the development of industrialization phase and is far away from post- industrialization society in which the positive impact from leisure on economy usually is stronger (Cheng Jiagui, Huang Qunhui2003; Wu Jinglian, 2005; Teamwork of economy department of Social Science Institute, 2008). Therefore, a weak but negative effect of leisure activities on economy still restrains the economy of China

nowadays. However, seeing from developed countries' experience, the establishment of a harmonious society requires the improvement of life quality, the transition from industrialized society to welfare society, diversified demand of consumption and increased civilization (ChenJiagui, HuangQunhui, 2005; WuJinglian, 2006; ChengJinhua,WuQiaosheng, 2007;LuoZhaoci,2008).All these indicate that the impact of leisure on economy would be strengthened. The positive effects such as "Advancing by Leisure" and "Learning by Leisure" of leisure would surpass the negative effects and bring the economy into "Wealthy with abundant leisure" in the future. Such a developing way of post- industrialized society has been proved partially in some developed countries in North Europe and North America (Wei, 2007).

CONCLUSIONS

This study revealed that leisure time can effect on economic growth as leisure time affects human capital accumulation by improving individual's intelligence, creativity and learning capacity. Meanwhile, leisure time has externality to the technological level and generates "Learning by Leisure" effect

similar as "Learning by Doing".

Models in this paper proved that China is still on the way to industrialization and investment is still the main driving force of Chinese economy. Leisure time had a weak negative effect on the economic growth according to empiric test of China from 1981 to 2003. Low-level income of Chinese people during the process of industrialization and relevant low preference for leisure are the main reasons.

Special attention should be paid to the effect of leisure time on human capital accumulation, namely the effect of informal education and "long life learning" on economy. This study suggests that culture and civilization have not only great political but also economical significance.

In conclusion, the degree of the impact of leisure is depended on the stages of economic development. At industrialization stage, the leisure time should be controlled and arranged to a relatively moderate level. It should be noted that the requirements on leisure time in industrial economy and welfare economy is different. As the society gets to harmonious economy and welfare economy, people's consumption would become diversified gradually, increasing their preference to leisure and reducing the substitution effect of leisure. Thus, with the transition from industrialization to after-industrialization, leisure time level would

be increased step by step, and different leisure system should be arranged according to the phases.

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Appendix.1. The setup and solution of the theoretic model

The impact of work and leisure on economic growth fully considers individual's time allocation. Before we start the analysis, assuming the production function of representative agent as follow:

$$Y = AK^{\alpha}H^{1-\alpha} \qquad\qquad (A1)$$

Where, Y is output, A is the level of technology, K is physical capital, H is human capital, α and $1-\alpha$ are the elasticity of physical capital and human capital to output respectively and the technological progress is Hicksian neutral.

It is assumed that economy is perfect competitive for convenience, so knowledge capital accumulation is ignored in this paper.

Firstly, during the working time, which is set in the perfect competition market, we consider only one endogenous accumulation path of agent's production technology, which is called "Learning by Doing" (Arrow, 1962; Romer, 1986) as follows:

$$A = B'K^{\beta} \qquad\qquad (A2)$$

Where, B' is a constant, β is the elasticity of capital stock to technology level. Here we assume $0 < \beta < 1$ because accumulating knowledge in this way (by doing) is decreasing return to scale.

Secondly, human capital theory asserts that individuals should be educated before they become human capital, i.e. the amount of time invested in education (say l_1) is a determinant that affects the forming of human capital (Lucas，1988；Mankiw, Romer & Weil，1992). Moreover, the amount of enjoyment leisure time l_3 is another determinant for human capital through the effect of "Advancing by Leisure". It is assumed that the growth rate for accumulation of human capital is fixed, so the human capital is expressed as:

$$H = e^{\psi_1 l_1 + \psi_3 l_3} L \qquad (A3)$$

Where, L is aggregate labor force, ψ_1 is the speed of human capital accumulation promoted by education time (l_1), i.e. $\dfrac{d \ln H}{dl_1} = \psi_1$; ψ_3 is the speed of human capital accumulation promoted by enjoyment leisure time (l_3), i.e. $\dfrac{d \ln H}{dl_3} = \psi_3$.

Thirdly, the effect of "Learning by Leisure" can be expressed as:

$$A = B'' l_3^{\gamma} \qquad (A4)$$

Where, B'' is a constant, γ is the elasticity of technology affected by externality of enjoyment leisure time. Here, $\gamma < 1$ in that externality of the enjoyment leisure time to the technological level is decreasing return to scale. When the accumulation of leisure time l_3 is good for the improvement of the technological level, we have the parameter $\gamma > 0$, and by contraries, $\gamma < 0$.

Eq. (A1) and (A4) are combined to reformulate as follows:

$$A = BK^{\beta} l_3^{\gamma} \quad （B \text{ is a constant } ） \qquad (A5)$$

It is worth to notice that technical progress results not only from endogenous capital accumulation and the externality of the exogenous leisure time accumulation but also from intended R&D programs. Hence the externality effects towards A is decreasing return which suggests that $0 < \beta < 1$, $|\gamma < 1|$ and $\beta + \gamma < 1$.

From Eq. (A3) the accumulation path of human capital is formulated as follows:

$$\frac{\dot{h}}{h} = \psi_1 \dot{l}_1 + \psi_3 \dot{l}_3 \qquad (A6)$$

Here, $h = \frac{H}{L} = e^{\psi_1 l_1 + \psi_3 l_3}$ (h is human capital per capita)

The accumulating path of physical capital per person is given by

$$\frac{\dot{k}}{k} = \frac{sy}{k} - d - n \qquad (A7)$$

Where, s is investment rate of physical capital, d is depreciation rate, $n = \frac{\dot{L}}{L}$ is exogenous constant population growth rate, k is the capital stock per capita. From Eq. (A5) and (A7) the accumulation path of technological level is formulated as follows:

$$\frac{\dot{A}}{A} = \beta(\frac{\dot{k}}{k} + n) + \gamma \frac{\dot{l}_3}{l_3} = \beta(\frac{sy}{k} - d) + \gamma \frac{\dot{l}_3}{l_3} \qquad (A8)$$

Put the formula for per capita output as following

$$y = Bk^{\alpha+\beta} h^{1-\alpha} l_3^{\gamma} L^{\beta} \qquad (A9)$$

Further, the long-run growth path of per capita output with leisure is:

$$\frac{\dot{y}}{y} = (\alpha + \beta)\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{h}}{h} + \gamma \frac{\dot{l}_3}{l_3} + \beta n \qquad (A10)$$

$$= (\alpha + \beta)\frac{\dot{k}}{k} + (1-\alpha)(\psi_1 \dot{l}_1 + \psi_3 \dot{l}_3) + \gamma \frac{\dot{l}_3}{l_3} + \beta n \qquad \text{(A11)}$$

Eq.(A10) and (A11) are the theoretic model of this study.

Appendix.2. The proofs of proposition 1 and proposition 2

1. Proof for proposition 1

In Eq. (A10) , if $\gamma > 0$, i.e. enjoyment leisure time has positive externality; its growth could accelerate the growth of economy, which is the result of "Learning by Leisure". However, such effect is dependent on the pattern of economy growth. For instance, when economy grows along balanced path[①] as it is shown in Eq. (A8) the balanced growth rate is a constant. Given the growth rate of the variable x is marked as g_x, in the present framework , when economy grows along balanced path, it implies $g = g_y = g_h$, then Eq. (A10) can be reformulated as

$$\beta g + \gamma g_{l3} + \beta n = 0$$

$$\Rightarrow \frac{\dot{Y}}{Y} = g + n = -\frac{\gamma}{\beta} g_{l3} \qquad \text{(A12)}$$

Where, g_{l3} and n are estrogenic. The above formula indicates that people should reduce suitable enjoyment leisure time, namely $g_{l3} < 0$ to guarantee a positive growth rate of economy

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[①] Economy growth theory calls it as "balanced growth path" when the capital、output、technology level grow at constant rate.

along balanced growth path.

2. Proof for proposition 2

The relationship between education time (l_1) and human capital growth is positive, which is essential for the Lucas' externality theory of human capital (Lucas, 1988). Meanwhile, Eq. (A10) reflects that enjoyment leisure has direct effect on economic growth. When the activities are active and healthy and leisure is normal goods, namely $\psi_3 > 0$ and $\gamma > 0$, enjoyment leisure time (l_3) would promote the economic growth at the speed of $(\psi_3 + \gamma)$.