CHAPTER THREE

THEORY

3.0 Introduction

This study employs the simplified Grossman Health Capital Model, as suggested by **Lee and Kong (1999)**. They reinvestigated Muurinen's generalized Grossman-type Health Investment Model and also derived a cointegration restriction to examine aggregate US medical care data based on a time series context. The cointegration restriction derived by **Lee and Kong (1999)** is robust under a generalization of the health capital model, which allows a better understanding for explanatory variables in the demand for medical care.

In addition, this simplified generalized version of Grossman model also allows for uncertainty to happen in health and medical care. According to **Lee and Kong (1999)**, consumption and investment are simultaneously considered in the model. Then the preference parameters in the utility function will be estimated and the prediction of the model will be tested to obtain the results consistent with the fact by showing that consumption expenditures and the relative price of medical care are key determinants of the macroeconomic demand for medical care.

In order to overview the theory in chapter three, the consumption model will be discussed in general. This will be followed by the explanation of the basic health care demand model as well as **Grossman's (1972)** Health Capital Model. **Muurinen's (1982)** generalized Grossman-type Health Investment Model will be discussed after Grossman's model. Finally, an explanation of the outline of the model will be given. The conclusion will also be included in the discussion as an ending to this chapter.

3.1 Consumption Model

Generally, the consumption function is formed through the relation between aggregate consumption (sometimes known as aggregate savings) and aggregate income. This consumption function plays an important role in economic thinking, where it is estimated from two kinds of data, the first is the time series data on consumption, savings, income, prices and other similar available variables, whereas, the second type is about budget data on the consumption, savings and income of individuals and families. Both data are used to corroborate Keynes's hypothesis[32].

Keynes (1936) in his '*The General Theory*' has mentioned that current consumption expenditure is the keystone of the theoretical structure in general theory since consumption is a highly dependable and stable function of current income. He termed it as a "fundamental psychological rule of any modern community that, when its real income is increased, it will not increase its consumption by an equal absolute amount. However, albeit the consumption is not increased by an equal amount, but it will

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[32] Refer to Milton Friedman (1957): "A Theory of the Consumption Function," A study by the National Bureau of Economic Research, New York, Princeton University Press, Princeton, stated in pp. 3.

lead a rule by saying that a greater proportion of income is saved as real income increase[33]".

The above statement can be explained in this way; when current consumption expenditure is highly correlated with income, which shows the marginal propensity to consume is less than unity, and the marginal propensity is less than the average propensity to consume, the percentage of income saved would increased with income.

The usual consumption function can be written as the following:

$$c = f(w, i) \tag{1}$$

Where c, is the consumption service for the given price, w, represents the consumer unit's of wealth. While i, is the interest rate and f, is the consumption function. Equation (1) reveals that the effects of wealth and interest rate directly affect consumption. Furthermore, this wealth can be indicated as income because on a theoretical level, income is generally defined as the amount a consumer unit could consume. Thus, consumption is also considered as a function of income.

Now, include the utility function into individuals' consumption decisions and consider an individual lifetime utility for T periods as:

$$U = \sum_{t=1}^{T} u(t), \qquad u'(\cdot) > 0, \; u''(\cdot) < 0 \tag{2}$$

[33] Keynes, J. M. (1936), The General Theory of Employment, Interest and Money (New York and London: Harcourt, Brace and Co.), pp. 96, 97, cited in Milton Friedman (1957): "A Theory of the Consumption Function," A study by the National Bureau of Economic Research, New York, Princeton University Press, Princeton, pp. 3.

Where $u(\cdot)$, is the instantaneous utility function and C_t, is consumption in period t. A_0, is considered as initial wealth for an individual, while $Y_1, Y_2, ..., Y_t$ is labor incomes in the T periods along his or her lifetime. From here, an individual can save or borrow based on exogenous interest rate subject to the constraint that any outstanding debt must be repaid at the end of his or her life.

Assume the interest rate and the individual's discount rate is equal to zero, so the individual's budget constraint is:

$$\sum_{t=1}^{T} C_t \leq A_0 + \sum_{t=1}^{T} Y_t \qquad (3)$$

Since the marginal utility of consumption is always positive, the individual satisfies the budget constraint with equality. The Lagrangian for individual maximization problem can be written as:

$$£ = \sum_{t=1}^{T} u(C_t) + \lambda(A_0 + \sum_{t=1}^{T} Y_t - \sum_{t=1}^{T} C_t) \qquad (4)$$

Where the first-order condition for C_t is:

$$u'(C_t) = \lambda \qquad (5)$$

Equation (5) is assumed to hold in every period, and the marginal utility of consumption is constant. Therefore consumption is also considered constant since the level of consumption uniquely determines its marginal utility. Substituting $C_1 = C_2 = ... = C_T$ into the budget constraint, would yield the below equation:

$$C_t = \frac{1}{T}(A_0 + \sum_{\tau=1}^{T} Y_\tau) \qquad \text{for all t} \tag{6}$$

$A_0 + \sum_{\tau=1}^{T} Y_\tau$ represents the individual's total lifetime resources. Thus, it can be deduced that an individual allocates his or her lifetime resources equally among each period of life.

3.2 The Basic Health Care Demand Model[34]

The health care utility function is assumed as follows:

$$Utility = U(x, H) \tag{7}$$

Where $H = g(m)$, here H represents the stock of health and health is a function of medical care and other inputs such as time; x, is the used goods purchased from the market.

The health care demand function obtains diminishing returns to scale since it has a downward sloping demand curve. This curve is subject to the budget constraint as:

$$I = P_\tau x + P_m m \tag{8}$$

Where I, is the investment function, p, is a vector of prices in the market, x, is the used goods purchased from the market and m, represents the income. Therefore, the health care demand function is subject to the maximization of the sum of the used goods based on the purchase prices in the market and also the income prices.

[34] Refer to "The Demand for Medical Care: The Demand for Health Capital". http://www.econ.utoledo.edu/faculty/yurgin/courses/4750/lecture6_adobe.pdf

On the other hand, the mortality rate, the morbidity rate and also the quality of life are used to measure the health status. Mortality rate is based on the number of deaths per 100,000 populations. It is considered as a good measure for statistical purposes, but it may be not as good as a health measure because it only takes into account the number of people who are dead or alive without inspecting the reasons behind the causes of deaths and other diseases. The morbidity rate is a measure of the prevalence of a particular disease and it is more suitable to use as a measure of health status. Moreover, it also includes the measure of activities of daily living or number of bed days.

The last element used to measure the health status is the quality of life, which computed the quality adjusted life year (QALY's). It calculates the time spent in a particular illness multiplied by the relative desirability of that particular illness. This quality adjusted life year is often used for resource allocation. For instance, if treatment A gives more QALY than B for a given expenditure, then choose A.

Besides the measure of health status, determinants of health status are also important to influence the health care demand. They are income, education (helps to be more efficient in production of health, sometimes it may be related to rate of time preference), environmental factors (such as pollution), lifestyle (eating, drinking, life expectancies etc.) and also genetic factors (e.g.: genetic discrimination, in this case as the illness becomes more severe, the demand curve is likely to shift further out and become steeper).

Finally, are factors that would cause a shift in the demand function. These factors consist of patent factors (such as the tastes and preferences), individual's health status, demographic characteristics (e.g.: birth, death etc.), economic standing as well as physicians and physician induced demand.

3.3 A General Discussion of Grossman's Model

Michael Grossman (1972) mentioned in his paper, health is considered as a capital good since it lasts for more than one period and depreciates over time. Consumers began to demand for medical care when they became aware of the importance of medical care in health. They spent time on health-improving efforts and also in purchasing medical inputs. Grossman (1972) also recognized that the demand for health has pure consumption and pure investment effects.

According to **Grossman (1972)**, in order to construct a model of the demand for the commodity "good health", individuals buy inputs and spend their time to produce services that increase their utility. Consumers produce gross investments in health and the other commodities in the utility function according to a set of household production functions, the home production of utility will be summarized by a composite home good B as:

$$\begin{aligned} I &= I(M, TH, E) \\ B &= B(X, TB, E) \qquad (9) \end{aligned}$$

Where *I*, is the investment in health stock. The inputs to this investment are time spent in improving health (*TH*), and health care inputs from the market (*M*), as well as the individual's education level (*E*). Likewise, to produce home goods and services (*B*), the inputs to this composite home good are the individual spends time in home production (*TB*), and the used goods purchased in the market (*X*), as well as the individual's education level (*E*). Here, *I* and *B* increase with increases in their inputs and *E* is an efficiency measure that varies from person to person and would be related to an individual's education level.

Nonetheless, Grossman also discussed the problem of a time allocation where the individual must choose how to allocate his or her total time (*T*) among time improving health (*TH*), time spent producing home goods (*TB*), time lost due to illness (*TL*) and time devoted to work (*TW*). This is employed as a labor leisure tradeoffs or simple labor-leisure tradeoffs. In addition, health consists of both investment and consumption aspects, which can obviously be seen from the whole lifespan based on one period model.

Furthermore, Grossman also indicates health as a productive good that produces healthy days. However, because of the law of diminishing returns, as the health stock increase, the number of healthy days will also increase, but at a diminishing rate. Whereas, if the health stock falls below H_{min}, then the person will have zero healthy days and will be dead. Therefore, an individual must choose how to allocate resources between health and consumption.

The production possibilities curve shows that if health gives no psychic benefits, the optimal allocation of resource will occur at point C, and the indifference curve is vertical. Conversely, if an individual receives utility from being healthy, then the indifference curve is downward sloping and there is a tradeoff between health and consumption. Thus, when "feeling healthy," adds to utility, the consumer will consume more health than when health is just an investment.

In conclusion, health is a capital good with pure investment and pure consumption aspects. The consumer purchases health inputs and uses them to produce health.

3.3.1 Grossman Health Capital Model (In Mathematical Form)

Michael Grossman (1972)[35] has developed a health capital model also known as Grossman's Intertemporal Health Consumption Model to investigate the demand for the commodity "good health". He was a pioneer in constructing the demand for health capital model. The essential assertion of this model considered health as a durable capital stock, which produces as output of healthy time. In other words, he assumed health as an output while medical care as one of the inputs avail in health production.

Besides, Grossman also argued that what distinguishes health capital from other forms of human capital is from the aspect of justification, namely a person's stock of knowledge contributes to his productivity, while a person's stock of health helps in time

[35] Refer to Grossman, M. (1972), On the Concept of Health Capital and the Demand for Health, Journal of Political Economy 80, pp. 223-255.

managing to produce many earnings and commodities. From here, Grossman tried to differentiate the fundamental objects of choice-called "commodities"-and market goods[36].

Since goods and services appeared to be the inputs of the commodities production, therefore the demand for these goods and services became a derived demand. However, traditional demand theory entered consumers' utility functions in their goods and services purchased. Consequently, Grossman directly entered the preference functions as well as sick days (as a source of disutility) in his model to represent the commodity consumption by consumers demand for health. Moreover, the consumers demand for health is also concerned with the commodity investment, which attributes as a time determinant throughout for market and nonmarket activities.

Therein, Grossman perceived that health is a choice variable because it is a source of utility (satisfaction) and helps in determining the income as well as wealth levels. Thus, the definition of health is widened to comprise longevity and illness-free days in a given year.

Grossman (1972) assumed the intertemporal utility function of a typical consumer to be:

$$U = U(\phi_0 H_0, ..., \phi_n H_n, Z_0, ..., Z_n) \quad (10)$$

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[36] It serves as the point of departure of Michael Grossman's Health Capital Model. The approach showing that consumers produce commodities with inputs of market goods and their own time in Grossman (1999). "The Human Capital Model of the Demand for Health," NBER Working Paper Series 7078, pp. 2.

Where H_i, represents the stock of health in the ith time period, ϕ_i, is the service flow per unit stock, while $h_i = \phi_i H_i$ is total consumption of "health services" and Z_i, is total consumption of another commodity in the ith period. As noted H_0, is considered as the inherited stock of health in the initial period, however, the stock of health at any other age is endogenous, this includes the length of life as of the planning date (n).

Since death takes place when $H_i \leq H_{min}$, so the length of life is determined by the quantities of health capital, which maximize utility subject to production and resource constraints. The following is the equation of net investment where net investment in the stock of health equals gross investment minus depreciation:

$$H_{i+1} - H_i = I_i - \delta_i H_i \qquad (11)$$

The above equation shows that the rate of depreciation is assumed to be exogenous but depends on age. I_i, is gross investment and δ_i, is the rate of depreciation during the ith period. According to a set of household production function, consumers can produce gross investments in health and the other commodities in the utility function:

$$I_i = I_i(M_i, TH_i; E_i)$$
$$Z_i = Z_i(X_i, T_i; E_i) \qquad (12)$$

Here, M_i, is medical care, X_i, is the goods input in the production of the commodity Z_i. Whereas, TH_i and T_i are time inputs and E_i, is the consumer's stock of knowledge or human capital exclusive of health capital, which is assumed to be exogenous or predetermined. The semicolon in between is used to differentiate between the stock of human capital and the endogenous goods and time inputs. It is assumed that a shift in human capital will change the efficiency of the nonmarket production. Furthermore, it is also assumed that all production functions are homogenous of degree 1 in the goods and time inputs. Thus, the gross investment production function yields:

$$I_i = M_i g(t_i; E_i) \qquad (13)$$

Where $t_i = TH_i / M_i$ and the marginal products of time and medical care in the production of gross investment in health are:

$$\frac{\partial I_i}{\partial TH_i} = \frac{\partial g}{\partial t_i} = g'$$

$$\frac{\partial I_i}{\partial M_i} = g - t_i g' \qquad (14)$$

Nonetheless, **Grossman (1972)** has mentioned that from the point of view of the individual, both market goods and own time are scarce resources and he obtained:

$$\sum \frac{P_i M_i + V_i X_i}{(1+r)^i} = \sum \frac{W_i TW_i}{(1+r)^i} + A_0 \qquad (15)$$

Equation (15) demonstrates that the goods budget constraint equates the present value of outlays on goods to the present value of earnings income over the life cycle plus initial assets (discounted property income). Where P_i and V_i are the prices of M_i and X_i, while W_i, is the wage rate, TW_i, is hours of work. A_0, is discounted property income and r, is the interest rate. However, the time constraint requires that the total amount of time available in any period, which represented by Ω, must be exhausted by all possible uses:

$$TW_i + TL_i + TH_i + T_i = \Omega \qquad (16)$$

TL_t, is time lost from market and nonmarket activities due to illness or injury. Despite, TL_t can be written as:

$$TL_t = \Omega - h_t \tag{17}$$

Where h_t, is the total number of healthy hours in a given year.

By substituting for hours of work (TW_t) from equation (16) into equation (15) would yield the single "full wealth" constraint as:

$$\sum \frac{P_t M_t + V_t X_t + W_t (TL_t + TH_t + T_t)}{(1+r)^t} = \sum \frac{W_t \Omega}{(1+r)^t} + A_0 = R \tag{18}$$

According to equation (18), full wealth equals initial assets plus the present value of the earnings an individual can obtain if he spent all of his time at work. From here, the wealth is allocated to be spending on market goods, nonmarket production time and part of it lost for illness.

The equilibrium quantities of H_t and Z_t can be found by maximizing the utility function given by equation (10) with respect to the constraints given by equation (11), (12) and (18). Based on the given inherited stock of health and also the depreciation rates, the optimal quantities of gross investment can determine the optimal quantities of health capital.

According to **Grossman (1972)**, the human capital parameter in the consumption demand function for health is:

$$\hat{H} = \rho\eta_H + (\rho_H - \rho_Z)(1-\theta)\sigma_{HZ} \qquad (19)$$

Where ρ_Z, is the percentage increase in the marginal product of the Z commodity's goods or time input caused by a one-unit increase in E (the negative of the percentage reduction in the marginal or average cost of Z), while η_H, is the wealth elasticity of demand for health, and $\rho = \theta\rho_H + (1-\theta)\rho_Z$ is the percentage increase in real wealth as E rises with money full wealth and the wage rate held constant. The first term on the right-hand side of equation (19) reflects the wealth effect and the second term reflects the substitution effect. If E's productivity effect in the gross investment production function is the same as in the Z production function, then $\rho_H = \rho_Z$ and $\hat{H}$ reflects the wealth effect alone. In this case, a shift in human capital is "commodity-neutral" (measured by years of formal schooling completed or education). If $\rho_H > \rho_Z$, E is "biased" toward health, its relative price falls, and the wealth and substitution effects will operate in the same direction. As a result, an increase in E surely increases the demand for health. Conversely, if $\rho_H < \rho_Z$, E is biased away from health, its relative price rises, and the wealth and substitution effects will operate in opposite directions.

In addition, **Grossman (1972)** stated the human capital parameter in the consumption demand curve for medical care as:

$$\hat{M} = \rho(\eta_H - 1) + (\rho_H - \rho_Z)[(1-\theta)\sigma_{HZ} - 1] \qquad (20)$$

If shifts in E are commodity-neutral, medical care and education are negatively correlated unless $\eta_H \geq 1$. On the other hand, unless the wealth and price elasticities both exceed one, if there is a bias in favor of health, medical care and education will still tend to be negatively correlated.

3.4 *Generalized Grossman-type Health Investment Model*

Jaana-Marja Muurinen (1982) developed a new approach in which he constructed a generalized version of Grossman's model for the demand of health and medical care. This model, however, does not rely on the acceptance of household production theory and time prices.

In order to restore this deficiency, **Muurinen (1982)**[37] tried to indicate some assumptions in his model such as direct increases in utility, known as investment benefits of health, which is considered as consumption benefits of health and increase in healthy time.

On the other hand, Muurinen argued that health stock is not sufficient for service producing; whereas, it also need to involve consumer's stock of skill and knowledge as well as their stock of wealth in his mathematical model. To achieve the above approach, Muurinen emphasized the concept of use-related deterioration of health, which allowed for changes exist between behavior and life style. This can be obtained by defining the

[37] Refer to Muurinen, J. (1982), Demand for Health: A Generalized Grossman Model, Journal of Health Economics 1, pp. 5-28.

rate of depreciation of health as a function for the stock of age and also the intensity of use.

Murinnen also perceived that the involvement of environmental variables in gross investment is inefficient in explaining the health model with the reason if the beneficial inputs are not utilized, the environmental external effect would not be operative.

According to **Muurinen (1982)**, each individual consumer is assumed to maximize his expected lifetime utility. Utility is a function of a composite consumption good, $Z(t)$, at each time t, and of the services of the stock of health[38]. This intertemporal utility function can be expressed as:

$$\int_0^T \alpha(t)U[Z(t), s(t)]dt \qquad (21)$$

Where $\alpha(t)$, is a time discount factor, the services of health are considered as reduced illness through less sick time, $s(t)$. The first partial of utility with respect to $Z(t)$, is assumed to be positive while with respect to $s(t)$, is negative (i.e. $Uz > 0$ and $Us < 0$). Therefore, sick time is 'produced' from the stock of health, $K^h(t)$, and this equation indicate as:

$$s(t) = \phi[K^h(t)], \qquad \phi' < 0, \ \phi'' > 0. \qquad (22)$$

Where ϕ, represents the service flow per unit stock. Equation (22) shows that as the stock grows, the reductions in sick time will be smaller with the raised stock of health.

[38] The explanation for the Generalized Grossman Model is referring to Muurinen, J. (1982), Demand for Health: A Generalized Grossman Model, Journal of Health Economics 1, pp. 5-28

Albeit T, the time of death in this context is not fixed, however, it is still defined by the stock of health as below:

$$T = \min\left\{t : K^h(t) \leq \bar{K}^h\right\} \tag{23}$$

Where $\bar{K}^h$, is a given positive constant, the 'death stock' of health.

When gross investment in health does not equal the deterioration of the stock, the health stock would change overtime and it can be defined by

$$\dot{K}^h(t) = f(t)M(t) - \delta[t, X(t)]K^h(t) \tag{24}$$

Here, $f(t)M(t)$, is the new health produced by the use of medical care, $M(t)$, while the input coefficient of medical care, $f(t)$, is assumed positive as:

$$f(t) > 0 \qquad \text{for all t} \tag{25}$$

From equation (24), $\delta[\cdot]$, the rate of depreciation on health is an explicit function of age and a function of vector, $X(t)$, which include all other relevant exogenous variables. Thus, the environmental variables are introduced into the model.

Nonetheless, the change in the stock of wealth, $K^w(t)$, is another dynamic constraint of the model and it is written in the equivalent of the static budget constraint as the following:

$$\dot{K}^w(t) = rK^w(t) + Y[s(t), M(t), R(t)] - [P^Z(t)Z(t) + P^M(t)M(t)] \tag{26}$$

Where r, is a constant rate of interest, Y, is earned income, which is considered as a function of sick time and the use of medical care and other relevant variables, $R(t)$. Whereas:

$$\partial Y / \partial s = Y_s \leqq 0 \tag{27}$$

$$\partial Y / \partial M = Y_M \leqq 0 \tag{28}$$

Equation (26) illustrates that $P^Z(t)$ and $P^M(t)$ are the exogenous prices respectively for $Z(t)$ and $M(t)$. From here, being ill or engaged in seeking for medical care cannot directly increase income.

If the use of medical care were positive, the following equality condition for marginal benefits and costs of health would be held for maximization:

$$[U_s / \lambda + Y_s]\phi' = \left\{\delta[t, X(t)] + r - \dot{C}'(t) / C'(t)\right\} C'(t) \tag{29}$$

$[U_s / \lambda]\phi'$ is the consumption benefit of health at the margin, λ, reflecting the marginal utility of initial wealth and $Y_s\phi'$, is the marginal production benefit of health. The sum of the left hand side must equal the user cost of health capital on the right hand side. Here, the 'effective marginal cost of new health investment' displays as $C'(t)$, equals the sum of the money price of care and the opportunity cost of care (in the form of lost income), divided by the marginal productivity of medical care in producing new health.

3.5 Outline of the Model

Lee and Kong (1999)[39] have reinvestigated Muurinen's generalized Grossman-type Health Investment Model and derived a cointegration restriction. In order to examine the restriction, they employed aggregate US data for medical care in a time series context. Based on this model, they derived the cointegration relationship among the log of medical care expenditure, the log of consumption, and the log of relative price of medical care (cited in Lee and Kong, 1999; pp. 325, line 15, 16). From here, Lee and Kong obtained results consistent with the prediction of the model, which shows that these three series are cointegrated in difference-stationary. By using the US National Income and Product Accounts (NIPA) data, they predict the preference parameters in the utility function and realize that cointegration restriction postulate a better scenario for the long run relation.

They make a concluding remark by saying that consumption expenditures and the relative price of medical care are the key determinants of the macroeconomic demand for medical care to support the useful insight and theoretical justification of the microeconomic foundation. In contrast to Grossman's certainty model, Lee and Kong (1999) allowed for uncertainty to appear in both the level of health and the effectiveness of medical care. Furthermore, they also considered both the consumption and the investment aspects in the model to examine the demand for health.

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[39] The argument is found from Lee, H. K. and Kong, M. K. (1999), Demand for Medical Care, Consumption and Cointegration, Economics Letters, 62, pp. 325-330.

Lee and Kong (1999) assumed a representative consumer maximizes his/her expected lifetime utility as below[40]:

$$V = E_0\left[\sum_{t=0}^{\infty}(1+\rho)^{-t}U(C(t),H(t))\right] \tag{30}$$

If net consumption expenditure is a numerator, the consumer faces the following lifetime budget constraints as:

$$\sum_{t=0}^{\infty}(1+r)^{-t}[C(t)+P_M(t)M(t)] = A(0)+\sum_{t=0}^{\infty}(1+r)^{-t}Y(H(t)) \tag{31}$$

Where

E_0 = the expectation conditioned on information set available at time zero.

$C(t)$ = net consumption expenditures after less medical care expenditures.

$H(t)$ = the consumer's health stock at time t.

ρ = the subjective rate of time preference.

$A(0)$ = the initial interest real asset.

r = the real interest rate.

$P_M(t)$ = the relative price of medical care (the ratio of implicit deflators).

$M(t)$ = medical care demand.

$Y(H(t))$ = the (labor) income-generating function at time t which is an increasing and differentiable function of health stock.

Here, $H(t)$, plays two complementary roles, it generates the direct utility and also serves as an investment to increase the labor earnings.

[40] The model employed in this study is followed the model, which have been proved by Lee and Kong (1999) in their journal "Demand for Medical Care, Consumption and Cointegration" to apply in Singapore and Malaysia situation.

For comparison, **Muurinen (1982)** represents that the health stock develops according to the following relationship:

$$H(t+1) = (1-\delta(t))H(t) + f(t)M(t) \tag{32}$$

where $f(t)$ = the input coefficient of medical care.

$\delta(t)$ = the depreciation rate of health stock.

Both $f(t)$ and $\delta(t)$ are assumed to be stationary random variables and positive for all period t, therefore they allowed for the uncertainty in the effectiveness of medical care and in the level of health.

Lee and Kong (1999) assumed the intraperiod utility function in the addilog form as:

$$U(C(t), H(t)) + \frac{C(t)^{1-\alpha}}{1-\alpha} + \sigma(t)\frac{H(t)^{1-\gamma}}{1-\gamma} \tag{33}$$

where α and γ = the coefficients of risk aversion (with positive sign).

$\sigma(t)$ = a trend-stationary preference shock associated with the health sector

The first-order condition for the intratemporal optimization problem at period t is derived as:

$$P_M(t) - \sum_{s=1}^{\infty}(1+r)^{-s}Y'(H(t+s))f(t+s-1)$$
$$= \frac{E_t\left[\sum_{s=1}^{\infty}(1+\rho)^{-s}\left(\prod_{k=1}^{s}(1-\delta(t+k))\right)\sigma(t+s)f(t+s)H(t+s)^{-\gamma}\right]}{C(t)^{-\alpha}} \tag{34}$$

From equation (32) if $M(t+1)/M(t)$ is stationary, $H(t+s)/M(t)$ is also stationary for any s. Dividing both sides of equation (34) by $\sigma(t)C(t)^{\alpha}M(t)^{-\gamma}$ gives:

$$\frac{\left[P_{M}(t)-\sum_{s=1}^{\infty}(1+r)^{-s}Y'(H(t+s))f(t+s-1)\right]}{\sigma(t)C'(t)^{\alpha}M(t)^{-\gamma}} = E_t\left[\sum_{s=1}^{\infty}(1+\rho)^{-s}\left(\prod_{k=1}^{s}(1-\delta(t+k))\right)\left(\frac{\sigma(t+s)}{\sigma(t)}\right)f(t+s)\left(\frac{H(t+s)^{-\gamma}}{M(t)}\right)\right] \tag{35}$$

Since $\delta(t)$, $\sigma(t+s)/\sigma(t)$, $f(t)$ and $H(t+s)/M(t)$ from the above equation are stationary by assumption, following this, both sides of equation (35) will also become stationary. By taking a log transformation for both sides of equation (35) and using a Taylor series expansion, the numerator on the left hand side of equation (35) can be rewritten as:

$$\ln\left[P_{M}(t)-\sum_{s=1}^{\infty}(1+r)^{-s}Y'(H(t+s))f(t+s-1)\right] \approx \ln P_{M}(t) - \sum_{s=1}^{\infty}(1+r)^{-s}\frac{Y'(H(t+s))f(t+s-1)}{P_{M}(t)} - \frac{1}{2}\left[\sum_{s=1}^{\infty}(1+r)^{-s}\frac{Y'(H(t+s))f(t+s-1)}{P_{M}(t)}\right]^2 \tag{36}$$

Thus, the log transformation of equation (35) is reduced to static relationship among three variables, namely, $\ln P_{M}(t)$, $\ln C'(t)$ and $\ln M(t)$.

According to **Lee and Kong (1999)**, when only the 'pure consumption' in Grossman's model is considered (i.e., $Y'(\cdot)=0$), the first-order condition of equation (34) will support $\ln P_{M}(t)-\alpha\ln C'(t)+\gamma\ln M(t)$ to be trend-stationary. As a result if these three series are difference-stationary, they are stochastically cointegrated with the cointegrating vector $(1,\ -\alpha,\ \gamma)$. Conversely, if both the consumption and the investment aspects are considered (i.e., $Y'(\cdot)>0$), the cointegration restriction abide valid as long as $Y'(H(t+s))/P_{M}(t)$ is stationary for any s. Perversely 'heteroscedastic cointegration' among these three series will occur if $Y'(H(t+s))f(t)/P_M(t)$ is nonstationary because $Y'(H(t+s))f(t)/P_M(t)$ comprise a bi-integrated error process in the cointegrating regression.

The explanation for the medical care expenditure function with the expected signs expressed is as follows:

$$M = f\left(\overset{+}{C}, \overset{-}{P_M}\right) \tag{37}$$

The signs above the series indicate as the expected hypothesized sign of the respective regression coefficient in a linear medical care expenditure function. Based on the estimated equation, medical care expenditure is found to be positively related to net consumption expenditure. In contrast, the relative price of medical care has expected negative relationship with medical care expenditure.

The reason behind the positive relationship is mainly because medical care is a necessary good, which depicts that when a person's, particularly ageing people, demand for medical care has increased, the consumption for medical care services would also increase. In contrast, the negative relationship exists between the relative price and medical care due to the fact of diminishing marginal productivity of health capital, which causes a downward sloping curve between relative price and medical care demand.

3.6 Conclusion

The model draws upon the key arguments in **Grossman (1972)** model. However, owing to the deficiency in Grossman Health Capital Model, **Lee and Kong (1999)** tried to modify the Muurinen's generalized Grossman-type Health Investment Model. They simplified this model to make the health capital model more applicable. The differences between Lee and Kong's (1999) model from both Grossman's (1972) model and Muurinen's (1982) model can be seen from two aspects. First, in contrast to Grossman's certainty model, Lee and Kong allows for uncertainty to appear in both the level of health and the effectiveness of medical care. Second, Lee and Kong implied that both the consumption and the investment aspects of the demand for health care are simultaneously considered in the model, which have not obviously been mentioned in Muurinen's model.