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WORK AND THE ECONOMICALLY IDEAL STUDENT

by

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ABSTRACT

What makes an economically ideal student? An individual who has decided to invest in college but has financial problems must work to afford his or her education.

Using the data made available in the U.S., we show that young students with better grades earn more. Then, within the framework of utility maximization model, we try to explain theoretically and empirically the student behavior with respect to the problem of time allocation among employment, education, and leisure.

We estimated in particular a linear version of demand function for number of hours to study. The empirical results identify the variables which determine a college student's commitment to an educational program.

The life styles in Japan seem to be changing. Many will reconcile work and study until retirement rather than attending schools while young and then concentrating on work until around 60. How to allocate time between employment and education is to become an important problem in such a society.

1. *Introduction*

The process of education accumulation over time has been explained by the model of maximization of expected future net income over an individual's lifetime working period.[1] The main concern in human capital literature is to determine what type of

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1) S. Becker, *Human Capital*, Columbia University Press, New York 1965.
Y. Ben-Porath, "The Production of Human Capital and the Life Cycle of Earnings," *Journal of Political Economy*, Vol. 75, 1967.
E. Sheshinski, "On the Individual's Lifetime Allocation Between Education and Work," *Metroeconomica*, 1968 April.
H. Oniki, "On Deriving the Individual's Demand Function for Education Investment," Harverd University, Discussion Paper Number 154, Dec. 1970.

educational investment the individual needs and when this investment must be undertaken. Much of the work, however, takes the length of formal schooling as a datum and does not consider the possibility that the student can work while he stays in school.

This paper deals with students who have already decided to invest in a college education. Students in many universities work and study during their college years. The problem confronting these students is the efficient allocation of time between employment and education. Within a framework of utility maximization model, the paper tries to explain theoretically and empirically the student behavior with respect to the problem of time allocation.

2. *Prior Analysis*

It is known that the number of years attended in school directly affects one's earnings over his lifetime. Among those who attended the same number of years, it is less clear who gets the most earnings. Monetary returns to college education are associated with several variables such as major field, college attended, academic performance, year of graduation, as well as such common variables for all as sex, age, motivation, personality and common sense.

The analysis in this section presents some evidence of the empirical correlations of ability with future earnings and studying hours. Throughout the analysis, the concept of ability is discussed in terms of some index of campus achievement. Although several studies (including the work by R. Bridgman (1930), Walfle and Smith (1956), Hansen, Weisbrod and Scanlon (1970), and Wise (1975)) observe the direct effect of ability on earnings, the following papers should particularly be mentioned here.

Becker (1964), based on data by the Bell Telephone Company in 1956, indicates that rank in college did not have a great impact on starting salaries, but after fifteen years the employees who ranked in the top two-fifths of their college class earned about 20 percent more than those of the bottom two-fifths. In later years the differences grew still greater. Weisbrod and Karpoff (1968), using the same empirical data, find that if the quality of schools is the same, the better able (in terms of class rank) earn more than the less able. Their findings in Table 1 also show that the graduates from the better schools earn more and the quality of schools plays an important role for those

Table 1. Earnings Index Values by College Quality and Class Rank

	College Quality			
Class Rank	Best	Above-Average	Average	Below-Average
Top 10%	118.7	111.6	103.0	102.8
Rest of 1/3	113.0	103.9	99.4	97.6
Middle 1/3	103.5	99.1	94.4	93.7
Lowest 1/3	96.9	95.0	91.0	90.1

An index value of 100 represents earnings equal to the mean earnings of the entire sample.

students who are better able: the earnings of the top 10% of graduates from the best schools are far greater than the rest. Similarly, Daniere and Mechling (1970) find that brighter students earn more for each level of college quality. They use verbal scores on the Scholastic Aptitude Test as measures of student ability.

Table 2. Academic Performance and One's Earnings for College Graduates in 1965 or 1966

Age Group	Category	Sample Size	Average Age	Average Starting Salary	Average Current Salary in 1975
All	GPA ≧ 3.00	39	36.8	9,441	25,525
	GPA < 3.00	82	34.9	7,787	22,067
31 to 35	GPA ≧ 3.00	22	32.7	8,380	26,025
	GPA < 3.00	56	33.0	7,441	22,660

Table 3. Academic Performance and Study Hours

Category	Sample Size	Studying hours/week
GPA ≧ 3.00	103	17
GPA < 3.00	166	13

Our small survey in Tables 2 and 3 also indicates the followings: (1) The students with the same degree but with better grades than others can get a higher future income[2), (2) More earnings are expected when students graduate at younger age, and (3) students who take more time to study get better grades. Table 2 presents how grade point average (GPA) during years in college, an index to measure the quality of educational output, affects the earnings after graduation. Though sample size is relatively small, the data are highly homogeneous as they are taken from male graduates of one college who graduated in 1965, and majored in engineering or business.[3) Table 3 presents the relation between grade average and studying hours. It shows that grade is positively related to time allocated for study. Those students who have a GPA equal to or greater than three report more studying hours than those with a GPA less than three.

According to Tables 2 and 3 it appears that monetary return to college education depends upon a good academic performance which could be achieved by allocating time efficiently between work and school.

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2) Studies which conclude no relation between college grades and job performance (or indirectly, earnings) are summarized in D.P. Hoyt, "The Relationship Between College Grades and Adult Achievement: A Review of the literature," American College's Testing Program Res. Rep. No. 7, Sept. 1965.

3) Question on studying hours were asked in the survey but response was too poor to use here. Therefore it was replaced by a questionnaire handed out to daytime students of a university in Ohio.

3. *The Model-Analytical Approach*

In this model, it is assumed that there exists the periods of joint education and schooling. That is, a student receives education while working in the market place. So, we consider that the student desires to maximize his utility from activities both at school and in the market over the years in college life.

In the following model, the student is considered to have a preference ordering that can be denoted by the utility function

$$U = \int_0^t U(C, L)\, e^{-i\tau} d\tau + U(W)e^{-it} \tag{1}$$

where C presents the level of consumption, L the time spent on leisure and t the number of years to finish the college. W presents wealth after graduation or present value of future earnings at t. Utility for the student in college years is derived by summing up the flow of utility over the planning period under consideration. Here, future utilities are discounted with discount rate, i.

For simplicity, we assume that the utility function is separable, and C, as well as L, is constant in the interval (0, t). On this assumption, we rewrite the utility function (1) as

$$U = \left\{ U_1(C) + U_2(L) \right\} \frac{1 - e^{-it}}{i} + U_3(W)\, e^{-it} \tag{2}$$

Let R be the required total credit hours. Then, credit hours earned per unit of period, D, is obtained as

$$D = \frac{R}{t} \tag{3}$$

The student faces a budget constraint which states that expenditures on consumption and education cannot exceed income. Let P be the price of market goods, α the education cost per hour of credit hour, a the wage rate of the student in college years, and F the financial aid. Assuming that the student has no saving, his income constraint is given by

$$PC = aM + F - \alpha D \tag{4}$$

where M presents the time spent on market work.

The student also faces a time constraint which states that a summation of the time spent in school, in market work and on leisure must be equal to the total time available per unit of period. It is presented as

$$S + M + L = T \qquad \begin{array}{l} 0 < M < T \\ 0 < S < T \\ 0 < L < T \end{array} \tag{5}$$

where T is the total time available. Schooling, work and leisure coexist with restriction of S, M, L greater than zero.

Substituting the equations (3) and (5) into the equation (4) and normalizing prices by P = 1, we get

$$C = a(T - S - L) + F - \alpha \frac{R}{t} \tag{6}$$

In addition to these equations, the student's wealth after graduation, W, is assumed to depend on the level of student's ability at graduation, A. Here, the student's ability is considered to be dependent upon the time spent in school, the years he undertook education and the native intelligence, I, being reflected on his productivity at school. Then, W is presented as

$$W = W(A) = W(s, t, I) \tag{7}$$

The prior analysis implies that young students with higher ability get more earnings. If so, the equation (7) would imply that

$$\frac{\partial W}{\partial S} > 0, \frac{\partial W}{\partial t} < 0, \frac{\partial W}{\partial I} > 0 \tag{8}$$

Equations (2), (6) and (7) provide a well-defined maximization problem. Multiplying $i/(1 - e^{-it})$ to equation (2), we get

$$V \equiv \frac{i}{1 - e^{-it}} U = U_1(C) + U_2(L) + U_3(W) \frac{i}{e^{it} - 1} \tag{9}$$

Maximizing U with respect to S and L is equivalent to maximizing V with respect to the same variables. The first order condition for the maximization is written as

$$V_S = -aU_1' + \frac{i}{e^{it} - 1} U_3' W_S = 0 \tag{10}$$

$$V_L = -aU_1' + U_2' = 0 \tag{11}$$

Demand functions for S and L can be derived from the necessary conditions (10) and (11) and presented as a function of α, a, t, i, I, F and parameters of utility, wealth and ability functions.

In order to find changes in L and S in response to changes in α, a, t, i, I and F, equations (10) and (11) are totally differentiated. While detailed analysis of this model are provided in the appendix, the following relations are inferred from the model.

(1) The sign of $\frac{dS}{d\alpha}$ and $\frac{dL}{d\alpha}$ may be negative. If the education cost goes up, it reduces both the studying hours and leisure. The student would work more to afford education.

(2) The sign of $\frac{dS}{da}$ and $\frac{dL}{da}$ may be either positive or negative. Assume that the degree of diminishing marginal utility of consumption is relatively small. Then, if the

wage rate is increased, it reduces both hours of study and leisure because of the increase in foregone earnings. The student allocates more hours to work, strengthening the preference toward the consumer goods.

When the marginal utility of consumption declines fast, however, the wage increase will have the effect of increasing hours of study and leisure. Since the desire to consume more may not be so strong anymore, the student would tend to work less.

Therefore, the net result will depend upon the size of the diminishing marginal utility of consumption and must be verified by the empirical analysis.

(3) The sign of $\frac{dS}{dt}$ and $\frac{dL}{dt}$ can not be predicted a priori. It depends on the second derivatives of the utility function. When the marginal utilities of consumption and wealth decline slowly, the student will reduce the studying hours on the one hand and increase the leisure on the other, if years in college is increased. In this case, the reduction in the studying hours surpasses the increase in the leisure and the hours of work are increased.

When the marginal utilities of consumption and wealth decline at fast speed, years spent in college may be positively related to the hours of study. Increase in the number of years in college causes the reduction in wealth. Accordingly, to reduce this direct effect on wealth, the studying hours must be increased. Further, if the reduction in wealth is on a large scale, hours of leisure will be reduced. With more years in college, the student would also reduce the working hours.

(4) The sign of $\frac{dS}{di}$ may be negative, but the sign of $\frac{dL}{di}$ may be positive. When the discount rate of future value increases, the current consumption becomes relatively more important. With this effect of i, the student would tend to increase leisure and work hours and allocate less hours of study for a given total time available.

(5) We expect the sign of $\frac{dS}{dI}$ to be negative and the sign of $\frac{dL}{dI}$ to be positive. The higher the level of the native intelligence is, the more hours of leisure and work with less hours of study are realized.

(6) The sign of $\frac{dS}{dF}$ and $\frac{dL}{dF}$ may be positive. If financial aid increases, the student would study more, or enjoy leisure, and work less.

4. *Empirical Results*

In this section a linear version of demand function for number of hours to study is estimated. Data used in the analysis were obtained from a sample of young men based on the National Longitudinal Surveys.[4] The Sample consists of men who are single and in college while working.

The dependent variable is defined as the number of hours studied per week (S). Although this is not directly available on the tape, the complement of the number of hours worked per week (M) is taken as the dependent variable. On the basis of the fixed amount of total time available per week (T), the dependent variable was measured

4) The surveys are carried out by the Ohio State University, Center for Human Resource Research. The data based on a five-year longitudinal study is updated to 1970.

as total time, T minus hours worked per week, i.e., S = T − M, where T is taken as 96 hours per week. It is assumed that 2/3 of the hours of each day can be available for either working or studying on a 6 days per week basis.[5] The independent variables are; hourly rate of pay at current job; planned years in college; IQ as a proxy for student's native intelligence to learn; quality of school where a student is attending, measured by per full-time student expenditure (average college tuition), as an education variable; and each full-time student expenditure to go to college as a main portion of educational cost. To estimate the demand equation for studying hours, some additional variables are also introduced. To measure the effect of a student's socioeconomic background on S, father's occupation and socioeconomic index are included in the equation.[6]

Another important factor affecting the student's hours for study is his motivation. To capture this effect, we used a variable indicating whether or not the student had received father's encouragement. The variable was coded "1" if the student had received the encouragement and "0" if he had not. As an additional proxy to reflect the student's motivation, another variable was added to the equation. The variable took on the value "1" if the student had any financial aid such as scholarship, fellowship, assistantship, loan and the like, and "0" if he had not. Finally, the age variable is included in the equation to reflect the student's behavior on campus more accurately. The expanded equation is, therefore

$$\begin{aligned} S_j &= a_0 + a_1 w_j + a_2 A_j + a_3 Q_j + a_4 EC_j + a_5 O_j \\ &+ a_6 SI_j + a_7 EG_j + a_8 AGE_j + a_9 M_{1j} \\ &+ a_{10} M_{2j} + E_j \end{aligned} \tag{12}$$

where w, A, Q, EC, O, SI, EG and AGE stand for the wage rate, native intelligence, quality of school, educational cost, father's occupation index, socioeconomic index, number of years spent in college and age of student respectively, and M_1 and M_2 stand for father's encouragement and financial-aid dummies. E is a stochastic error term.

Results of fitted regression equation, by ordinary least squares, are shown in the Table 4.

The table shows that the motivation variables (M_1 and M_2) were consistently the most significant variable and had correct sign in all cases. Availability of financial aid and father's encouragement, therefore, seem to affect the student commitment to school

5) 1/3 of the hours of each day and Sunday are considered to be spent for sleeping, and/or for pure leisure.

6) Duncan index is used for father's occupation. It assigns a two-digit status score to each three-digit occupation code in the classification scheme of the U.S. Bureau of Census. The index of Socio-economic level of parental family is constructed by combining the five elements. They are (1) fathers education, (2) mother's education, (3) occupational status of the father (or of the head of the household) when the respondent was 14 years of age, (4) educational attainment of the respondent's oldest older sibling and (5) availability of reading material in the home when the respondent was 14 years of age. See the National Longitudinal Surveys, Survey of men 14-24, (Notebook Supplement 69A, Center for Human Resources Research, the Ohio State Univ.

Table 4. Regressions on Demand for Schooling Hours Model[a]

	Model Number									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	−0.648	14.48	3.933	23.21	31.40	−3.565	27.06	−6.777	5.053	21.00
	(−0.04)	(0.78)	(0.20)	(1.21)	(1.66)	(−0.163)	(1.22)	(−0.32)	(1.18)	(0.73)
w	0.053	0.060	0.073	0.079[b]		0.089	0.076[c]	0.074	0.138[c]	1.116[b]
	(1.12)	(1.29)	(1.51)	(1.72)		(1.55)	(1.40)	(1.31)	(2.04)	(1.74)
A			−0.136	−0.148	−0.1238	−0.186	−0.238[c]		−0.330[c]	−0.354[c]
			(−1.22)	(−1.148)	(−1.241)	(−1.44)	(−1.96)		(−2.04)	(−2.24)
Q			0.0006			−0.003	0.003		0.00004	0.0003
			(0.62)			(−0.92)	(−0.36)		(0.04)	(0.13)
EC									0.003[b]	0.003
									(1.75)	(1.22)
O						0.012	0.021			
						(0.14)	(0.26)			
SI	0.058	0.090	0.051	0.082		0.038	0.107	0.032	0.076	0.067
	(0.95)	(1.497)	(0.78)	(1.31)		(0.32)	(0.96)	(0.39)	(0.83)	(0.76)
EG	2.527[c]	3.097[c]	3.245[c]	4.122[c]	4.083[c]	3.838[c]	4.595[c]	2.876[c]	5.184[c]	6.127[c]
	(2.30)	(2.84)	(2.610)	(3.42)	(3.38)	(2.58)	(3.27)	(2.16)	(2.61)	(3.06)
AGE		−1.274[c]		−1.558[c]	1.450[c]		−1.963[c]			−1.302[c]
		(−2.907)		(−3.36)	(−3.13)		(−3.67)			(−1.81)
M_1	8.835[c]	8.397[c]	5.332	4.839	5.699[b]	9.159[c]	9.498[c]	8.854[c]		
	(2.85)	(2.78)	(1.64)	(1.55)	(1.84)	(2.02)	(2.24)	(1.96)		
M_2	8.672	7.459[c]	8.145[c]	6.610[c]	6.357[c]	10.60[c]	8.788[c]	10.85[c]		
	(2.92)	(2.55)	(2.70)	(2.27)	(2.17)	(2.72)	(2.39)	(2.84)		
R^2	0.18	0.23	0.17	0.25	0.22	0.22	0.33	0.20	0.26	0.32
T ratio	6.17[d]	6.83[d]	3.41[d]	5.29[d]	6.44[d]	3.11[d]	4.7[d]	4.48[d]	2.40[d]	2.64[c]
Sample size	145	145	122	122	122	95	95	95	48	48

a. The figures in parentheses are t-ratios and all tests are two-tailed t-tests.
b. Denotes significance at the 10 percent level.
c. Denotes significance at the 5 percent level.
d. Denotes significance at the 1 percent level.

positively. Coefficients of the number of years spent in college (EG) were also significant in all cases with positive signs. The coefficients of the age (AGE) were significant in 4 of 5 cases at 5 percent level and in all 5 cases at the 10 percent level. This indicates that the older the student is, the fewer is the number of hours studied. Although this variable may not be independent of EG and or M_2, the inclusion of this variable into the regression increases the explanatory power of the model. The coefficients of our proxy variable for the native intelligence had the negative sign in all cases where it appeared, but were significant in only 3 of the 7 cases at 5 percent level. Our results, however, do not imply that the native intelligence is not an important explanatory variable for the demand for studying hours. The use of IQ may be a poor measurement of native intelligence. The coefficients of wage rate, one of the basic variables in the model, indicate that there exists a positive income effect of wages on the hours studied, while these coefficients were significant in only 3 of 9 cases. Concerning socioeconomic background, it is expected that students from relatively blessed families can devote more time on school work and possibly enjoy higher benefits from the same amount of education than is otherwise the case. Although it has the expected positive sign, socioeconomic index is not significant in any models. The effect of father's occupation on the student behavior was also tested in the model 6 and 7, but, neither of them appears significant. The effect of quality of school on the hours studied is small in magnitude with either positive or negative coefficient and is also nonsignificant. The coefficients of educational cost (EC) in the models 9 and 10 have an unexpected positive sign and are significant in one of them at 10 percent level.

While R^2 in the equations are relatively low, they are statistically sifnificant. Several factors cause the relatively low R^2. The students in the sample are too young to settle into some behavioral pattern toward work and study. The full impact of many variables, therefore, does not seem to appear clearly; the number of hours studied during the survey week was used as dependent variable. An appropriate variable, however, might be an average value over weeks to eliminate transitory factors such as job changes; the relation between the dependent variable and the independent variables may not be linear. In addition to these, we might have omitted some variables which also influence the dependent variable. It must be pointed out, however, that the absence of quantitatively reliable measurement of some of the independent variables in the model has caused measurement error to estimate their effects on the number of hours for study. To get more precise estimate it will be necessary to develop better variables using a larger sample.

5. *Conclusion*

In the United States, the better the GPA of the student is, the higher his (or her) earnings become. The good grade seems to indicate the valuable and productive human resources. Therefore, an individual who has decided to invest in college but has financial problems must allocate his time in the best possible way to get a better grade: he is engaged in a series of complex decisions to allocate time between studying, leisure and working in the labor market. The present results at least indicate that student's attitude toward schooling particularly depends upon student's age, availability of financial aid, father's encouragement, and planned years to stay in college. The model tentatively supports the proposition that the financial aid is more important than opportunities in job market to encourage students to spend more hours at school.

Due to the availability of the data, the study is undertaken for the students in the U.S. However, the research related to this paper should be quite relevant to us. The number of students who stay more than four years in college is increasing in Japan. More people have started to seek education while working. Time allocation between employment and education will become an important problem in such a society.

APPENDIX

[A] In order to examine the effects of changes in the parameters on L and S, we take total differentiation of equations (10) and (11), and get

$$\begin{bmatrix} V_{SS} & V_{SL} \\ V_{LS} & V_{LL} \end{bmatrix} \begin{bmatrix} dS \\ dL \end{bmatrix} = \begin{bmatrix} -V_{S\alpha}d\alpha - V_{Sa}da - V_{St}dt - V_{Si}di - V_{SI}dI - V_{SF}dF \\ -V_{L\alpha}d\alpha - V_{La}da - V_{Lt}dt - V_{Li}di - V_{LI}dI - V_{LF}dF \end{bmatrix} \quad (A.1)$$

where

$$V_{SS} = a^2U_1'' + \frac{i}{e^{it}-1} U_3''w_S^2$$

$$V_{SL} = V_{LS} = a^2U_1''$$

$$V_{LL} = a^2U_1'' + U_2''$$

$$V_{S\alpha} = V_{L\alpha} = \frac{aR}{t} U_1''$$

$$V_{Sa} = V_{La} = -\left\{U_1' + a(T-S-L)U_1''\right\}$$

$$V_{St} = -\frac{a\alpha R}{t^2}U_1'' - \frac{i^2 e^{it}}{(e^{it}-1)^2} U_3' w_S + \frac{i}{e^{it}-1} U_3'' w_S w_t$$

$$V_{Lt} = -\frac{a\alpha R}{t^2} U_1''$$

$$V_{Si} = \frac{e^{it}-1-ite^{it}}{(e^{it}-1)^2} U_3' W_S$$

$$V_{Li} = 0$$

$$V_{SI} = \frac{i}{e^{it}-1} U_3''W_SW_I$$

$$V_{LI} = 0$$

$$V_{SF} = -aU_1''$$

$$V_{LF} = -aU_1''$$

(Here, we assume that $W_{SS} = 0$, $W_{St} = 0$ and $W_{SI} = 0$ for simplicity)

Let us represent the Jacobian matrix in the left-hand side of equation (A.1) by H, and its determinant by $|H|$. Then, we have

$$|H| = V_{SS}V_{LL} - V_{SL}V_{LS} = U_2''\left(a^2U_1'' + \frac{i}{e^{it}-1} U_3''W_S\right) + a^2U_1'' \frac{i}{e^{it}-1} U_3''W_S > 0$$

Taking this into account, we can examine the effects of changes in parameters by solving equation (A.1) for each parameter.

(i) The effects of changes in α

By solving equation (A.1) for a change in α, we get

$$\frac{dS}{d\alpha} = \frac{I}{|H|} \begin{vmatrix} -\frac{aR}{t}U_1'' & a^2U_1'' \\ -\frac{aR}{t}U_1'' & a^2U_1'' + U_2'' \end{vmatrix} = -\frac{I}{|H|}\frac{aR}{t} U_1''U_2'' < 0$$

$$\frac{dL}{d\alpha} = \frac{I}{|H|} \begin{vmatrix} a^2U_1'' + \frac{i}{e^{it}-1} U_3''W_S^2 & -\frac{aR}{t} U_1'' \\ a^2U_1'' & -\frac{aR}{t} U_1'' \end{vmatrix} = -\frac{I}{|H|}\frac{i}{e^{it}-1}\frac{aR}{t} U_1''U_3''W_S^2 < 0$$

Similarly, we can compute dS and dL when we change a, t, i and I.

(ii) The effects of changes in a

$$\frac{dS}{da} = \frac{I}{|H|} U_2'' \left\{ U_1' + a(T - S - L) U_1'' \right\}$$

$$\frac{dL}{da} = \frac{I}{|H|} \frac{i}{e^{it} - 1} U_3'' W_S^2 \left\{ U_1' + a(T - S - L) U_1'' \right\}$$

if U_1'' is small, $\frac{dS}{da} < 0$, $\frac{dL}{da} < 0$

if U_1'' is large, $\frac{dS}{da} > 0$, $\frac{dS}{da} > 0$

(iii) The effects of changes in t

$$\frac{dS}{dt} = \frac{I}{|H|} \left\{ a^2 U_1'' \left[\frac{i^2 e^{it}}{(e^{it}-1)^2} U_3' W_S - \frac{i}{e^{it}-1} U_3'' W_S W_t \right] + U_2'' \left[\frac{i^2 e^{it}}{(e^{it}-1)^2} U_3' W_S - \frac{i}{e^{it}-1} U_3'' W_S W_t + \frac{a\alpha R}{t^2} U_1'' \right] \right\}$$

if U_1'' and U_3'' are of small value, $\frac{dS}{dt} < 0$

if U_1'' and U_3'' are of large value, $\frac{dS}{dt} > 0$

$$\frac{dL}{dt} = \frac{I}{|H|} \left\{ U_3'' \left[\frac{i}{e^{it}-1} W_S^2 \frac{a\alpha R}{t^2} + \frac{1}{e^{it}-1} W_S W_t a^2 \right] - \frac{i^2 e^{it}}{(e^{it}-1)^2} U_3' W_S a^2 \right] \right\}$$

if U_3'' and $|W_t|$ are small, $\frac{dL}{dt} > 0$

if U_3'' and $|W_t|$ are large, $\frac{dL}{dt} < 0$

(iv) The effects of changes in i

$$\frac{dS}{di} = -\frac{I}{|H|} \frac{e^{it} - 1 - ite^{it}}{(e^{it}-1)^2} U_3' W_S (a^2 U_1'' + U_2'') < 0$$

$$\frac{dL}{di} = \frac{I}{|H|} a^2 U_1'' \frac{e^{it} - 1 - ite^{it}}{(e^{it}-1)^2} U_3' W_S > 0$$

(v) The effects of changes in I

$$\frac{dS}{dI} = -\frac{I}{|H|} \frac{i}{e^{it}-1} U_3'' W_S W_I (a^2 U_1'' + U_2'') < 0$$

$$\frac{dL}{dI} = \frac{I}{|H|} a^2 U_1'' \frac{i}{e^{it}-1} U_3'' W_S W_I > 0$$

(vi) The effects of changes in F

$$\frac{dS}{dF} = \frac{I}{|H|} a U_1'' U_2'' > 0$$

$$\frac{dL}{dI} = \frac{I}{|H|} a U_1'' \frac{i}{e^{it}-1} U_3'' W_S^2 > 0$$

[B] Time allocation among S, L and M, in response to changes in α, a, t, i, I and F, will be altered as follows.

	S	L	M
α ↗	↙	↙	↗
a ↗	U_1''が小さい時		
	↙	↙	↗
	U_1''が大きい時		
	↗	↗	↙
t ↗	U_1'', U_3''が小さい時		
	↙	↗	↗
	U_1'', U_3''が大きい時		
	↗	↙	↙
i ↗	↙	↗	↗
I ↗	↙	↗	↗
F ↗	↗	↗	↙

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