THE MONETARY VALUE OF PHYSICAL EXERCISE FROM THE THAI POPULATION'S PERSPECTIVE

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ABSTRACT:

Background: Physical exercise improves physical health, reduces sickness risk and raises work productivity. This study proposes the expected, present value of bequest increment being induced by physical exercise to measure these combined benefits. Bequest summarizes how long, how healthily, and how lucratively a person lives. Because its present value is expressed as today's monetary value, everybody understands how much the combined benefits are.

Methods: Monte Carlo analyses of 5,000 scenarios were performed for Thai females and males, aged 20, 30, 40, 50 and 60 years, to compute the expected, present values of bequests. The analyses incorporated stochastic life-time incomes, expenses, savings and investment returns together with mortality and morbidity data. The monetary value of physical exercise is the difference of the expected, present values of bequests under exercise and sedentary lifestyles.

Results: For all Thai, the monetary value is significant statistically and financially. It is 3,747,336 and 1,661,293 baht for 20-year-old females and males, respectively. It is lower for older people. For 60-year-old female and male, the worth is 67,300 and 302,919 baht.

Conclusion: The money worth of physical exercise is significant. The resulting worth is higher for younger than for older Thai, implying that they benefit more if they start to exercise at a young age. This study recommends that everybody exercises and starts it early in life.

Keywords: Physical exercise, Money worth, Monte Carlo analysis

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INTRODUCTION

It is accepted that physical exercise improves physical health [1]. The study [2] proposes improved earnings a financial metric, to communicate better with people about the benefits to motivate more exercise. The earnings metric underestimates the benefits because it does not consider the reduced risk of medical costs and work-day or productivity losses. The study [3] analyzes combined benefits from the resulting health and earnings and relates them with a person's generational value. But the one metric, that combines all the benefits and is easy to understand, is not proposed. In this study, the researcher extends [3] and proposes the expected, present value of bequest increment being induced by physical exercise to measure the combined benefits. The model in [3] is comprehensive retirement planning, which incorporates stochastic life-time incomes, expenses, savings and investment returns together with mortality and morbidity data. Because bequest is the saving at the age at death, it summarizes how long, how healthily, and how lucratively a person lives. Its present value is in today's money worth. Everybody understands what it means. The model will be applied for the Thai population.

METHODOLOGY

Bequest is the saving at the age at death [3]. Therefore, let's start the analysis from $S^*_{t_0}$—the initial saving of the representative t_0-year-old Thai. The saving level $\tilde{S}_{t_0+j}$ in the next j years when the person turns $t_0 + j$ must equal the previous year's $\tilde{S}_{t_0+j-1}$ plus $\tilde{r}_{t_0+j}$-percent investment return plus income $\tilde{I}_{t_0+j}$ net of personal expenses $\tilde{P}_{t_0+j}$ and medical expenses $\tilde{M}_{t_0+j}$. That is,

$$\tilde{S}_{t_0+j} = \tilde{S}_{t_0+j-1} e^{\{\tilde{r}_{t_0+j}\}} + \tilde{I}_{t_0+j} - \tilde{P}_{t_0+j} - \tilde{M}_{t_0+j} \quad (1)$$

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When $j = 1$, $\tilde{S}_{t_0+j-1} = \tilde{S}_{t_0} = S^*_{t_0}$.

Symbol "$\sim$" labels stochastic variables. The researcher assumes that the investment return $\tilde{r}_{t_0+j}$ is age-specific to reflect the fact that the person may adjust the investment strategies along the glide path [4]. It is a normal variable with a μ_{t_0+j} mean and a σ_{t_0+j} standard deviation when $\tilde{S}_{t_0+j-1} \geq 0$. It is a minus lending rate when $\tilde{S}_{t_0+j-1} < 0$.

In equation (2.1), because income $\tilde{I}_{t_0+j}$ is age-specific and rising with inflation for j years from its starting level $I^*_{t_0}$ in the current year, the income must be inflation-adjusted. In addition, it must be scaled to reflect the actual working days in the year. Finally, it must be adjusted downward or upward for falling or rising productivity from sickness or physical exercise.

$$\tilde{I}_{t_0+j} = I^*_{t_0} e^{\left\{\sum_{h=1}^{j} \tilde{\pi}^I_h\right\}} \times \left(1 - \frac{\sum_{d=1}^{4} L_d \tilde{\gamma}_{d,t_0+j}}{252}\right) \times \left(1 + \tilde{F}_{t_0+j}\right), \quad (2.1)$$

where $\tilde{\pi}^I_h$ is the stochastic inflation rate for income in year h. It is assumed the income inflation is mean-reverting with respect to the Bank of Thailand's inflation targeting policy [5].

$$\tilde{\pi}^I_h = \theta\left(\bar{\pi} - \pi^I_{h-1}\right) + \tilde{\varepsilon}^I_h. \quad (2.2)$$

Θ is the convergence rate, $\bar{\pi}$ is the long-run mean and $\tilde{\varepsilon}^I_h$ is the normally-distributed error of $\tilde{\pi}^I_h$.

L_d is lost working days resulting from disease d. $\tilde{\gamma}_{d,t_0+j}$ is the disease-d indicator variable. $\tilde{\gamma}_{d,t_0+j}$ = 1 if the person experiences disease d at age $t_0 + j$. Otherwise, it is zero. The researcher follows the study [3] to limit the interest to only four important non-communicable diseases (NCDs)—namely (1) diabetes, (2) heart, (3) stroke and (4) cancer, because these four NCDs are chronic and costly and are leading causes of death worldwide [6]. Chronic NCDs imply $\tilde{\gamma}_{d,t_0+j}$ = 1 if $\tilde{\gamma}_{d,t_0+j-1}$ = 1. But if $\tilde{\gamma}_{d,t_0+j-1}$ = 0, $\tilde{\gamma}_{d,t_0+j}$ is a (1, 0)-Bernoulli with probability of the disease-d incidence rate. The incidence rate corresponds with age and sex. The term $1 - \frac{\sum_{d=1}^{4} L_d \tilde{\gamma}_{d,t_0+j}}{252}$ scales the income proportionately with actual working days in the year.

$\tilde{F}_{t_0+j}$ is the productivity adjustment variable. It equals exercise-induced productivity increment rate if the person exercises and equals zero if he does not exercise. However, in any case, $\tilde{F}_{t_0+j}$ necessarily equals the NCD-induced productivity loss rate if $\tilde{\gamma}_{d,t_0+j}$ = 1.

The researcher assumes the personal expense $\tilde{P}_{t_0+j}$ depends on the subsistence level and income level as in equations (3.1) and (3.2).

$$\tilde{P}_{t_0+j} = Max\left[P^*_{t_0} e^{\left\{\sum_{h=1}^{j} \tilde{\pi}^P_h\right\}}, 0.75\, \tilde{I}_{t_0+j+1}\right], \quad (3.1)$$

$$\tilde{\pi}^P_h = \theta\left(\bar{\pi} - \pi^P_{h-1}\right) + \tilde{\varepsilon}^P_h. \quad (3.2)$$

$P^*_{t_0}$ is the subsistence personal expenses for the t_0-year-old person in the current year. Therefore, it must rise with the inflation, constituting a level of $P^*_{t_0} e^{\left\{\sum_{h=1}^{j} \tilde{\pi}^P_h\right\}}$ when the person turns $t_0 + j$. If the person earns more, he naturally spends more. Following the recommendation [7], the researcher assumes the person spends 75% of his income. The actual spending is the maximum of the two sums.

$\tilde{\pi}^I_h$ and $\tilde{\pi}^P_h$ share the same θ and $\bar{\pi}$ parameters because they track the country's general inflation. But their errors $\tilde{\varepsilon}^I_h$ and $\tilde{\varepsilon}^P_h$ are uncorrelated because incomes and expenses of Thai households have low correlation [8].

The medical expenses $\tilde{M}_{t_0+j}$ are the sum of disease-d expenses as in equation (4).

$$\tilde{M}_{t_0+j} = \sum_{d=1}^{4} M^*_{d,t_0}\, e^{\left\{\sum_{h=1}^{j} \tilde{\pi}^d_h\right\}} \times \tilde{\gamma}_{d,t_0+j}, \quad (4)$$

where M^*_{d,t_0} is the medical expenses for disease d for the t_0-year-old person in the current year. M^*_{d,t_0} is adjusted randomly upward by the inflation $e^{\left\{\sum_{h=1}^{j} \tilde{\pi}^d_h\right\}}$ to reflect rising costs. $\tilde{\pi}^d_h = \mu_D + \sigma_D \tilde{z}^d_h$, where μ_D and σ_D are the expected general price increase and the standard deviation. $\tilde{z}^d_h$ is a standard normal variable. It is independent for a disease from for the others. The expense structure in equation (4) suggests that medical expenses share the same nature but do not necessarily rise or fall together systematically. The indicator variable $\tilde{\gamma}_{d,t_0+j}$ ensures these medical expenses are incurred only by the sick one.

By definition, bequest is the saving $\tilde{S}_{\tilde{T}}$ at age $\tilde{T}$ at death. The researcher identifies age $\tilde{T}$ at death based on the fact that death is an absorbing state and the person may die at age $t_0 + j$ with probability of the age-, sex-and-disease specific mortality rate. Consider disease-specific death indicator variable $\tilde{x}^d_{t_0+j}$ for disease d. $\tilde{x}^d_{t_0+j}$ is a (1, 0) Bernoulli with probability of the disease-d specific mortality rate. And consider another (1, 0) Bernoulli $\tilde{x}_{t_0+j}$ with probability of the general, NCD-free mortality rate. If the researcher sets the variable $\tilde{X}_{t_0+j} = \tilde{x}_{t_0+j} \times \left\{1 - Max\left(\tilde{\gamma}_{1,t_0+j}, .., \tilde{\gamma}_{4,t_0+j}\right)\right\} + \sum_{d=1}^{4} \tilde{x}^d_{t_0+j} \tilde{\gamma}_{d,t_0+j}$, he can identify age $\tilde{T}$ at death by $Min\left\{t_0 + j \leq 100 \mid \tilde{X}_{t_0+j} > 0\right\}$. The condition $t_0 + j \leq 100$ is imposed with respect to the 100-year maximum age

Table 1 Age specific data

Panel 1.1 Female

Age	Annual Income[1]	Mortality Rates[a]					Incidence Rates				Investment Returns[7,b]	
		General[2]	Diabetes[3]	Heart[3]	Stroke[3]	Cancer[4]	Diabetes[5]	Heart[5]	Stroke[5]	Cancer[6]	Mean	S.D.
21	100,872.01	0.08%	1.96%	3.89%	6.20%	4.43%	0.10%	0.01%	0.01%	0.02%	8.57%	12.82%
31	145,831.68	0.09%	1.96%	3.89%	6.20%	4.45%	0.10%	0.01%	0.01%	0.06%	8.57%	12.82%
41	167,360.52	0.15%	1.82%	4.55%	7.70%	4.50%	0.63%	0.03%	0.03%	0.18%	8.57%	12.82%
51	248,671.20	0.30%	2.85%	5.09%	8.90%	4.64%	1.43%	0.10%	0.08%	0.29%	6.68%	7.40%
61	81,840.37	0.98%	9.89%	13.05%	18.73%	5.29%	2.12%	0.36%	0.27%	0.40%	4.53%	2.98%
71	62,462.15	3.06%	9.89%	13.05%	18.73%	7.28%	2.12%	0.36%	0.27%	0.52%	4.53%	2.98%
81	54,119.65	7.03%	9.89%	13.05%	18.73%	11.08%	2.12%	0.36%	0.27%	0.52%	4.53%	2.98%
91	6,000.00	19.30%	19.30%	19.30%	19.30%	22.82%	2.12%	0.36%	0.27%	0.52%	4.53%	2.98%
100	6,000.00	100.00%	100.00%	100.00%	100.00%	100.00%	2.12%	0.36%	0.27%	0.52%	4.53%	2.98%

Panel 1.2 Male

Age	Annual Income[1]	Mortality Rates[a]					Incidence Rates				Investment Returns[7,b]	
		General[2]	Diabetes[3]	Heart[3]	Stroke[3]	Cancer[4]	Diabetes[5]	Heart[5]	Stroke[5]	Cancer[6]	Mean	S.D.
21	124,737.84	0.23%	3.25%	5.02%	7.68%	4.57%	0.07%	0.01%	0.01%	0.02%	8.57%	12.82%
31	151,328.88	0.26%	3.25%	5.02%	7.68%	4.60%	0.07%	0.01%	0.01%	0.04%	8.57%	12.82%
41	165,066.84	0.37%	3.65%	4.97%	8.98%	4.71%	0.43%	0.04%	0.05%	0.10%	8.57%	12.82%
51	210,959.76	0.68%	4.84%	6.30%	9.48%	5.01%	1.02%	0.14%	0.13%	0.26%	6.68%	7.40%
61	180,646.68	1.66%	12.43%	13.92%	17.62%	5.94%	1.61%	0.41%	0.37%	0.52%	4.53%	2.98%
71	79,634.28	4.31%	12.43%	13.92%	17.62%	8.48%	1.61%	0.41%	0.37%	0.81%	4.53%	2.98%
81	6,000.00	10.18%	12.43%	13.92%	17.62%	14.09%	1.61%	0.41%	0.37%	0.85%	4.53%	2.98%
91	6,000.00	20.46%	20.46%	20.46%	20.46%	23.92%	1.61%	0.41%	0.37%	0.85%	4.53%	2.98%
100	6,000.00	100.00%	100.00%	100.00%	100.00%	100.00%	1.61%	0.41%	0.37%	0.85%	4.53%	2.98%

Note: [a] = The researcher adjusts the disease-specific mortality rates to their corresponding general mortality rates if the disease-specific rates are lower than the general rates. [b] = The return for negative saving is -20%—the lending rate for clean loans in 2014.

Data Sources: [1] = The National Statistical Office's labor force survey data for quarter 1, 2013. The researcher adjusts the income of those over 60 years old to 6,000 baht equaling the annual old-age pension paid by the government, if the surveyed income is lower than 6,000 baht. [2] = 2008 Mortality Table for General Population by the Office of Insurance Commission, [3] = Computed using 2013 case fatality data from the Bureau of Epidemiology, [4] = Computed based on the formula in [9], using the mortality rate for general population from the Office of Insurance Commission, together with the average cancer mortality rates from 2008 to 2012 reported by the Bureau of Epidemiology, [5] = Computed using the 2013 new patients data of the Bureau of Epidemiology, together with the 2011-2012 average population data from the National Statistical Office, [6] = [10], [7] = Computed based on investment strategies on the glide path being used by Government Pension Fund members [4].

Table 2 Disease-specific data

Disease	Medical expenses				Lost work days[1]		Productivity loss (%)[3]
	Level (Baht)[1]		Annual growth (%)[2]		Female	Male	
	Female	Male	Average	S.D.			
Diabetes	53,434.00	53,434.00	6.02	2.69	10.82	11.75	11.00
Heart	38,236.00	38,236.00			6.23	5.90	
Stroke	48,001.00	48,001.00			10.96	10.66	
Cancer	31,903.00	28,446.00			8.85	9.37	

Data Sources: [1] = [11], [2] = Computed using the 2002 to 2011 national accounts data from the Office of the National Economic and Social Development Board, [3] = [12].

Table 3 Benefits from exercise

Risk reduction (%)		Productivity gain (%)[5]	
		Female	Male
Diabetes	58.00[1]	10.00	6.00
Heart disease	50.00[2]		
Stroke	20.00[3]		
Cancer	16.00[4]		

Data sources: [1] = [13], [2] = [14], [3] = [15], [4] = [16], [5] = [17].

in the Office of Insurance Commission's 2008 mortality table.

Let β be the discount factor. The present value of the bequest is $\widetilde{W}(\epsilon) = \beta^{(\tilde{T}-t_0)}\tilde{S}_{\tilde{T}}$. The researcher writes $\widetilde{W}(\epsilon)$ as a function of ϵ--the exercise indicator, in order to make it clear that bequest is affected by the exercise $(\epsilon = 1)$ or sedentary $(\epsilon = 0)$ lifestyle. The researcher proposes to measure the money worth of physical exercise by the difference ΔW of the expected, present values $E\{\widetilde{W}(\epsilon = 1)\}$ and $E\{\widetilde{W}(\epsilon = 0)\}$ of the bequests conditioned on the lifestyles.

$$\Delta W = E\{\widetilde{W}(\epsilon = 1)\} - E\{\widetilde{W}(\epsilon = 0)\}. \qquad (5)$$

It is difficult to solve for ΔW analytically. Therefore, the researcher obtains ΔW numerically, using a Monte Carlo analysis. The researcher simulates variables based on the specification described above for the person in 5,000 scenarios. The interesting variables are age $\tilde{T}$ at death and bequest $\tilde{S}_{\tilde{T}}$. $E\{\widetilde{W}(\epsilon)\}$ is the average $\widetilde{W}(\epsilon)$. Because the generated random numbers are kept fixed, the interesting variables in the exercise and sedentary lifestyles are matched. Statistical significance of the money worth ΔW can be tested by a paired-difference procedure.

THE DATA

The researcher collects the data for the Thai population from various sources. Table 1 reports the age-specific data and their sources. It is an extract. Readers may obtain the full table from the researcher upon request. From the table, female earn less than male. Also, female's general and disease-specific mortality rates, except for stroke, are smaller than male's ones. As for the NCD risk, the diabetes-incidence rate is higher for female. For heart disease, stroke and cancer, on the contrary, the incidence is higher for male. The researcher assumes the same glide path for female and male. Therefore, the expected returns and standard deviations are the same in both panels.

Table 2 reports the disease-specific data consisting of medical expenses, lost work days and productivity loss rate. The medical expenses are the same for female and male for all the NCDs, except for cancer where the expenses for female is about 12% higher. If they are sick, their net incomes are adversely affected from loss of work days and productivity.

Table 3 reports the health and financial benefits male and female can gain if they exercises regularly. Note that physical exercise can reduce the risk of diabetes and heart disease by 58% and 50%. As for stroke and cancer, the reduction is 20% and 16%. The risk reduction benefits health and longevity. Exercise also lessens contingent medical expenses, work-day and productivity losses from imminent NCDs. Moreover, exercise raises productivity by 10 and 6 percent for female and male, hence leading to higher income and saving.

The subsistence personal expenses are 108,000 baht a year or 9,000 baht a month. This level is the national minimum wage rate. The researcher follows previous studies, e.g. [18], to assume zero initial savings. The researcher uses maximum likelihood

Table 4 Present values of bequests and money worths of physical exercise

Panel 4.1 Female

Statistics	20Y		30Y		40Y		50Y		60Y	
	Exercise	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**
Average	-101,701	-3,849,037	431,382	-1,551,521	-517,081	-1,323,046	-858,101	-1,613,259	-8,823,072	-8,890,372
S.D.	33,959,566	65,841,345	12,310,898	39,415,917	19,419,846	15,504,155	3,055,880	4,835,125	14,278,628	14,945,461
Skewness	-25	-33	-29	-49	-50	-41	-8	-9	-3	-4
Kurtosis	725	1,441	1,058	2,853	2,827	2,174	96	130	15	18
Median	1,777,104	1,013,824	1,319,677	889,839	569,891	275,695	-63,114	-287,036	-3,372,477	-3,172,297
M. Worth	3,747,336		1,982903		805,996		755,158		67,300	

Panel 4.2 Male

Statistics	20Y		30Y		40Y		50Y		60Y	
	Exercise	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**	**Exercise**	**Sedentary**
Average	1,203,177	-458,116	1,490,672	773,314	794,451	410,086	333,367	55,485	-237,536	-540,455
S.D.	18,964,911	27,800,076	4,149,037	10,377,604	1,822,478	2,306,685	1,579,991	1,828,263	1,471,838	1,886,402
Skewness	-39	-25	-43	-41	-17	-11	-20	-14	-22	-16
Kurtosis	1,647	680	2,203	2,042	413	185	522	308	788	402
Median	1,850,119	1,328,994	1,672,629	1,370,407	1,047,866	828,747	559,599	397,705	26,704	-70,328
M. Worth	1,661,293		717,358		384,365		277,882		302,919	

estimation to estimate the convergence rate Θ, the long-run mean $\overline{\pi}$ and the standard deviation of inflation errors from the annual headline-inflation data from 2001 to 2014. The inflation data are from the Bureau of Trade and Economic Indices, Ministry of Commerce. The resulting statistics are 0.76, 2.56% and 1.33%, respectively. Following [19, 20], the study sets the discount factor equal to 0.96. Finally, it converts all the financial variables to their 2014 values using headline inflation rates.

RESULTS

The researcher estimates the model for Thai female and male of ages 20 years (20Y), 30Y, 40Y, 50Y and 60Y, who have zero savings in the current year 2014. The resulting present values of the bequests and money worths of physical exercise are reported in Table 4.

DISCUSSION

The expected, present values of bequests for exercise lifestyle are higher than those for sedentary one for both male and female of all ages. These results are expected. Those who exercise have lower risk of sickness, medical costs and sick leaves, while they have higher work productivity. They earn more and spend less, hence leading to larger savings and bequests. Those who do not exercise tend to experience the contrary. The expected, present values of bequests are higher for male than for female principally due to the higher income for male than for female.

The average bequests for female are negative for almost all the cases. But this result should not be alarming. The distributions of the bequests are extremely negatively skewed and fat-tailed so that the averages are influenced by a few large negative values. The median bequests are positive for those female of 40 years old or younger. The median bequests for those 50Y and over female are still negative, however.

As for male, the distributions of the bequests are also extremely negatively skewed and fat-tailed. But the average bequests are positive for all the cases except for the 60Y old. The corresponding median bequests are much higher than the average.

The money worths of physical exercise are measured by the difference of expected, present values of the bequests, conditioned on exercise and sedentary lifestyles. Because bequest is saving at the age at death, it is wealth. To a rational person, more wealth is preferred to less wealth. The worths are statistically significant at a 99% confident level for all the cases. They are higher for female than for male and they are falling when a person ages. It turns out that the worths are very high of 3,747,336 baht for 20Y female and 1,661,293 baht for male. They fall to 755,158 and 277,882 baht for 50Y female and male, respectively. It is important to acknowledge that all the money worths are significant financially, when they are compared with the annual incomes, averaged across all ages from 21 to 100 years, for female and male in 2014 of 104,392 and 139,817 baht.

CONCLUSION

Physical exercise improves health, reduces sickness risk and raises work productivity. It leads to lower medical costs and higher wage incomes. Therefore, it has money worth. This study estimates the money worth by the increment to the expected, present value of bequest being induced physical exercise. For the Thai population, the money worth is significant both statistically and financially. It is larger if a person chooses an exercise lifestyle early in life. The study recommends both female and male Thais of all ages do exercise and start it as early in their lives as possible.

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