Journal of Social Science Humanities and Literature, Vol. 9, Issue 10, (Oct) **2026**
ISSN 2277-842X
DOI: 10.66069/ojspub.22771006

An Attempt to Construct a Happiness Equation from the Perspectives of Financial Cost Theory and Actuarial Mathematics

Huan Zhang

Financial Department, Jianghan University, Wuhan 430056, Hubei, China

Abstract: ***This paper starts with an analysis of the definitions and core logics of two very famous Happiness Equations, and further analyzes their advantages and disadvantages when people apply them in real life. Then, the thesis give some adives for application. Based on these studies, the author presents his two attempts of construction of Hapiness Equation: one comes from a "three-dimension cube" by use financial cost theory; and the other comes form the idea of "total variance minimization" which derived from Actuary Mathematics' risk perspective. After demonstrate the definitions and logic of the two Happiness Equation, the author present and analysize typical examples. Finally, the pros and cons of the two equations were discussed.***

Keywords: Happiness Equation; Feeling of happiness; Financial cost; Actuarial Risk.

1. INTRODUCTION

The Happiness Equation is a model built in different methods to explain the source of happiness and measure the degree of happiness. The most famous ones are the psychological equation of happiness (**H = S + C + V**) and Paul Samuelson's Happiness Equation: Happiness = Utility/Desire. Since then, scholars around the world have constructed all kinds of Happiness Equations. Some of them, structured by using AHP (analytic hierarchy process) or structured formula and so on. They all have function in real world. Based on his financial professional knowledge and understanding of real life, the author attempt to construct two Happiness Equations from the perspectives of financial cost and actuarial risk respectively, hoping to give some help to everyone.

2. EXISTING HAPPINESS EQUATIONS AND THE EVALUATION OF THEIR ROLES

2.1 A Happiness Equation Based on Psychology

2.1.1 Basic definitions and descriptions

Positive psychology Happiness Equation (H = S + C + V). It was proposed by positive psychologists Sheldon, Lyubomirsky, and Scott. The core of it is to break down happiness into three parts (Set-point, Circumstance, and Voluntary activities), and the proportions of each part are approximate ratios derived from relevant research, not absolute values, as shown in Table 1 below:

Table 1: Proportion of Elements in Psychological Happiness Equation

Elements	Proportion	Contents
Set-point(S)	50%	The inherent ability to perceive happiness is determined by genes and personality traits and is relatively stable, like a baseline of happiness. People's sense of happiness fluctuates around this baseline
Circumstances(C)	10%	This includes objective facts that cannot be changed, such as race and gender; there are also aspects that can be changed, such as marital status, type of work, health and wealth
Voluntary activities(V)	40%	The short-term and long-term choices that individuals make to obtain happiness, such as developing hobbies, building close relationships, practicing gratitude, and pursuing the flow experience

2.1.2 Main merits

1) Clear framework, easy to understand and apply

It breaks down happiness into genetic Settings (S, about 50%), living conditions (C, about 10%), voluntary activities (V, about 40%), and conveys the core idea by using common formulas, that "Happiness is not entirely

determined by nature or environment, and 40% can be controlled through activechoices". Thus, it lowering the threshold for public understanding and practice. It aligns with the goal of positive psychology to increase happiness from level 0 to 5.

2) Promote disciplinary development and practical transformation

Provide research frameworks for happiness economics and positive psychology, explain phenomena such as the Easterlin paradox (the disconnection between income growth and happiness improvement), and generate actionable happiness intervention methods such as gratitude, mindfulness, and goal setting to facilitate the implementation of happiness enhancement projects for individuals and organizations.

3) Empower individuals and enhance subjective initiative

Emphasizing the leading role of V(voluntary activities), encouraging people to enhance happiness by changing their thinking patterns and behavioral habits, meeting the psychological need that "destiny is in one's own hands", alleviating environmental anxiety, and stimulating the motivation for active growth.

2.1.3. Major weaknesses

1) Solidifying Proportion, ignoring individual and contextual differences

50%/10%/40% is an interpretation of variance ratio based on Western samples,not a universal constant. The influence of C (circumstances) increases significantly insituations such as extreme poverty, war, and serious illness; The weights of S, C, and V may also change in different personality and cultural contexts, and the formula may not fit all scenarios.

2) Dimension is too simple, ignoring complex interactions

It is difficult to fully explain the complexity of happiness without considering the interaction between three elements; S, C, V (such as genes influencing environmental selection, environment shaping behavioral patterns), and without covering deep dimensions such as spiritual beliefs, meaning of life, and post-traumatic growth.

3) Quantification is ambiguous and lacks precise measurement standards

The formula is only a qualitative model, and there is no unified quantification units or measurement tools for S, C, and V, making it impossible to accurately calculate individual happiness values; And the definition of "happiness" is biased towards lasting satisfaction, and it is difficult to cover multiple experiences such as instantaneous pleasure and sense of meaning.

4) It is prone to cause bias in responsibility attribution

Overemphasizing the controllability of V may lead to a "happiness accountability" interpretation of vulnerable groups, ignoring external constraints such as social structure and resource allocation, and weakening the necessity of public policy for improving C (circumstances such as healthcare, education, social security).

5) Inadequate fit for people with mental disorders

The formula does not fully take into account the Particularity of psychological problems such as depression and post-traumatic stress disorder, where S maybe abnormal and V has limited room for adjustment. Simply applying the formula may increase the psychological burden.

2.1.4 Application Suggestions

Use it as a "happiness guide" rather than a "computational tool", adjust the weights according to your own context, and incorporate the Samuelson happiness Equation (see Section 2.2), the PERMA model, etc., to balance utility and desire and construct a sense of meaning, to form a more comprehensive happiness enhancement plan.

2.2 A Happiness Equation Based on Economics

2.2.1 Basic definitions and descriptions

The equation was proposed by Paul Samuelson as follows:
Happiness = Utility/Desire
This is a classic model for interpreting happiness from an economic perspective, derived from his work "Economics". See Table 2 below:

Table 2: Elements of the Economic-Based Happiness Equation

Elements	Contamination
Happiness	The subjective satisfaction of an individual towards life is a psychological feeling without an absolute quantitative standard. It is determined by the ratio of utility to desire
Utility	In microeconomics, it refers to the subjective satisfaction that goods, services or living conditions bring to individuals, such as the satisfaction derived from income, health, interpersonal relationships, etc.
Desire	The expectations and desires of individuals for life, encompassing various aspects such as material and spiritual needs and goals

2.2.2 Core Logic and ways to improve

1) Logical relationships

Happiness is proportional to utility and inversely proportional to desire. When desires are fixed, the higher the utility, the stronger the happiness; When utility is fixed, the lower the desire, the stronger the happiness. For example, when two people have the same income, the one with lower desiresis more likely to feel happy.

2) Two paths to increase happiness

a) Increase utility (numerator)

Increase real satisfaction in life by working hard to boost income, improve health, expand social connections, etc.

b) Control your desires (denominator)

Rationally adjust expectations for material possessions, social status, etc., avoid excessive expansion of desires, and reduce the psychological gap caused by overly high expectations.

c) Key extension

The formula reveals the relativity of happiness or feelings of happiness doesnot simply depend on how much one has, but on the balance of needs and gains. When desires expand infinitely, happiness may stagnate or even decline, even if utility grows in tandem.

2.2.3. Main benefits

Samuelson's equation of happiness provides a core framework for understanding happiness in modern society from an economic perspective, profoundly influencing individual decision-making, economic research, public policy, and social culture. Here are the specific dimensions of influence:

1) Guide personal life and decision-making

a) Balance material pursuits with desire management The formula reveals the reality that "an increase in income doesnot necessarily lead to an increase in happiness", prompting people to actively control their desires beyond "productive" behaviors such as increasing income and improving life, such as practicing minimalism, reducing material comparisons, and reducing anxiety caused by the expansion of desires, in line with the life wisdom of "contentment brings happiness".

b) Optimize resource allocation Guide individuals to invest their resources in high-efficiency areas such as health, intimate relationships, self-growth, etc., rather than simply pursuing material consumption to enhance the cost-effectiveness of life satisfaction. For example, reduce impulse spending and increase investment in education, health check-ups, etc., to enhance utility levels in the long term.

2) It has promoted the development of economics research and disciplines

a) Promoting the rise of the economics of happiness

The formula broke the traditional economics' single perception of "wealth = happiness", prompting economics to incorporate subjective well-being into its research scope, giving rise to the branch of "economics of happiness", focusing on the connections between income, employment, social security, etc. and well-being, and explaining phenomena such as the "Eastlin paradox".

b) Expand the boundaries of utility theory

Push the concept of utility from mere material satisfaction to non-material dimensions such as health, emotion, and social relationships to provide a theoretical basis for subsequent studies, such as the analysis of preferences and decision biases in behavioral economics.

3) It has contributed to public policy-making and social governance

a) Shift towards a policy orientation of maximizing utility

Instead of focusing solely on GDP, the government aims to enhance people's well-being by improving the utility of public services such as healthcare, elderly care, education, and ecological governance. For example, policies such as the downward allocation of medical resources, community elderly care services, and the supply of ecological products have reduced the cost of living for residents, enhanced public utility, and indirectly increased happiness.

b) Curb the expansion of irrational desires

By guiding rational consumption through policies such as setting cooling-off periods for live-streaming e-commerce and incorporating labor educationin to compulsory courses to help the public build reasonable expectations and avoid excessive desires caused by social competition, stabilizing happiness from the "denominator side".

4) Contribute to the shaping of social culture and values —Reflect on consumerist culture

The formula reveals that the infinite desires generated by consumerism will dilute the happiness brought about by the growth of wealth and promote the formation of a cultural atmosphere in society that emphasizes rational consumption and spiritual satisfaction, such as the popularity of ideas like "declastivism" and "anti-involution".

5) Balancing individual and social well-being

Guide society from "competition for personal wealth" to "enhancement of common utility", emphasize the role of public interest and mutual assistance in overall well-being, promote social equity and harmony, and reduce psychological. imbalance caused by the wealth gap.

2.2.4 Limitations and Supplements

The formula focuses on the economic perspective and provides insufficient explanations for non-utility factors such as spirit and belief. It needs to be combined with positive psychology models such as H=S+C+V(see section 2.1.1) to understand happiness from multiple dimensions such as genes, living conditions, and voluntary activities, achieving a dual balance of material and spirit.

3. TWO ATTEMPTS BY THE AUTHORS IN CONSTRUCTING HAPPINESS EQUATION

3.1 Based on the Financial Cost Perspective

Happiness Eequation come from Three-dimensional Cube

3.1.1 Definition and its calculation steps

Happiness is a psychological feeling comes from the actual total costs which below the expected total costs when people buy something or do something. That is to say, happiness comes from actual paid is less than expected payments from financial cost theory.

Step 1:

Extract three factors—money (represents price), energy (represents human power or efforts), and time (represents working time) from all the cost factors which affects the Happiness, and fix them to gauge the outcome because happiness always comes from less costs (costs represent sacrifice). Then, used them as 3 dimensions and geometrically construct a cube, and the cube's volume (means total costs) can be calculated by multiplying the length of each dimension.

Step 2

Build up an expected costs cube and an actual costs cube separately before we gauge the Happiness. The volume of the former is calculated by the expected values of the three dimensions: money, time, and energy; the volume of the latter is calculated by actual values Of the same three dimensions.

Step 3

Happiness = difference of volumes between expected cube and actual cube = expected time × expected money × expected manpower - actual time × actual money × actual manpower.

If the difference is positive, happiness produced; if not unhappy produced.

3.1.2 Equation logic

1) Reasons for builing this model and one example.

First, due to information asymmetry, a man/woman have a mental expectation of costs such as price, time, and physical effort before he/she shopping or take on a work. Quantifying this expectation into three dimensions: time, money, and human effort can simply help calculate the volume of the expected cube as a budget before purchasing. After that, one person go shopping or taking up his/her work, the final actual costs in those three dimensions will produced, so the happiness can brought about by calculating the difference between the two cubes' volume.

The feeling of happiness is produced by saving momey, time and energy; the unhappiness feeling comes from the senses of expensive, fatigue and the purchang time is agonizing.

This thesis only assumes that one article is purchased, and regardless of how the cost composition changes, the utility of the product to the customer remains unchanged. Since the assumption is that only one article is purchased, there is no need to consider the situation where marginal utility may decrease when purchasing more items. (diminishing marginal utility theory)

2) One example

Here, we mock two scenarios of actual costs fluctuation and compare them with the expected costs for calculating the values of Happiness, as shown in Table 3:

Table 3: Happiness Computation

	Total costs in three dimensions			Volume	Happiness/unhappiness
	X:time	Y: price	Z: Energy	X·Y·Z	Expect volume-actual volume
Expect costs	48hours	$100	80	384000	—
Favorable actual costs	24hours	$80	60	115200	268800
Unfavorable actual costs	72hours	$120	100	864000	-480000

Above sheet generates three cubes as below, they are Figure 1, Figure 2, And Figure 3.

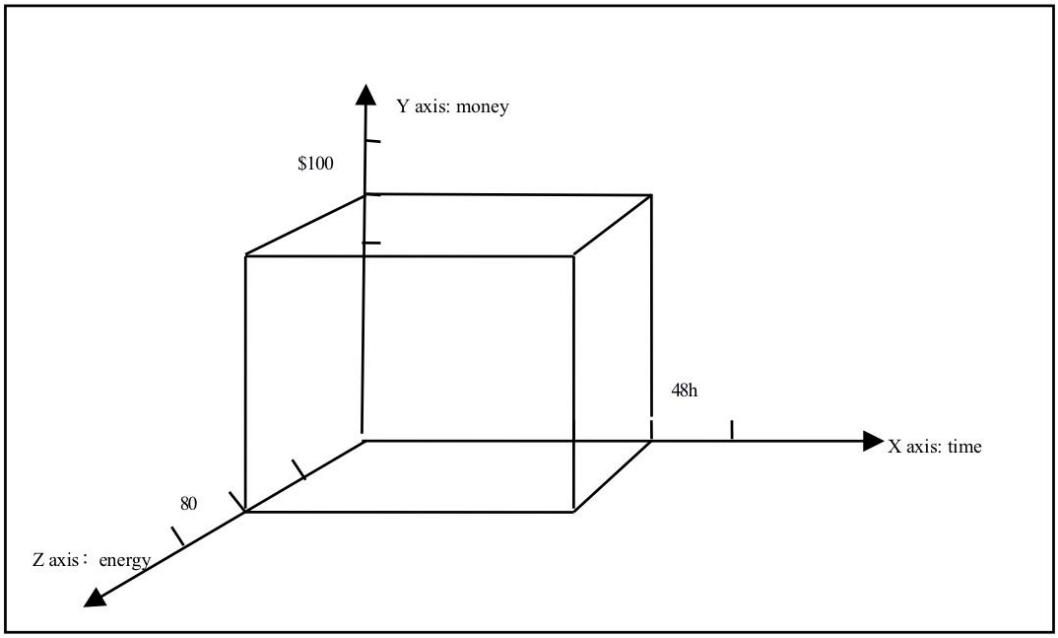


Figure 1: Expected costs cube

As show above, the volume of cube=48×100×80=384000.

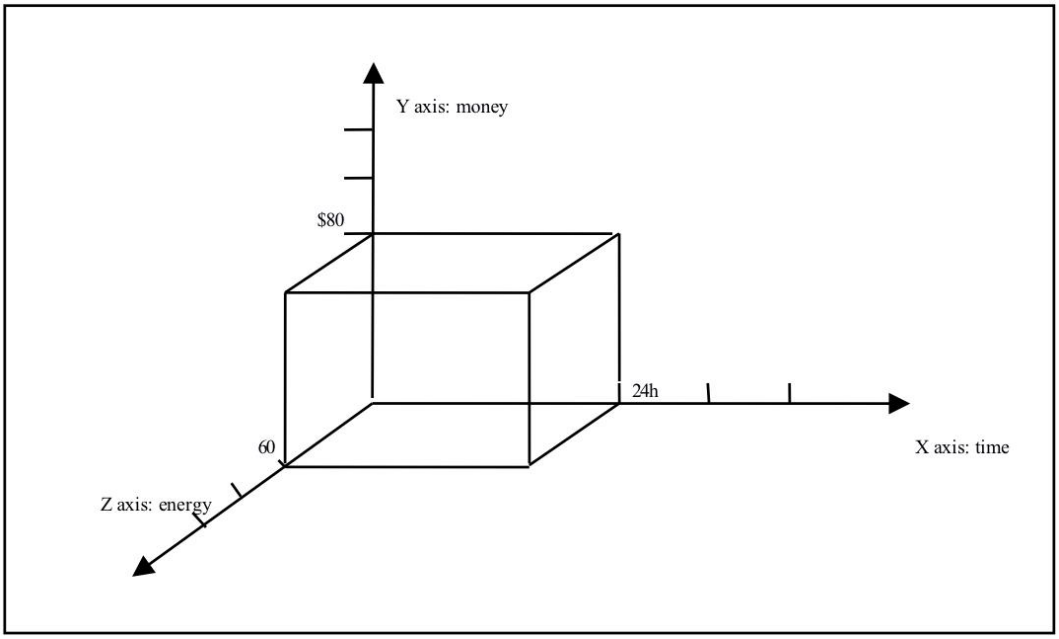


Figure 2: actual costs cube: Favorable case

As shown above, the actual cost in the favorable case is the volume of the cube = 24×80×60 = 115200

So, the saved costs is 384,000-115200 = 268,800, and happiness generated.

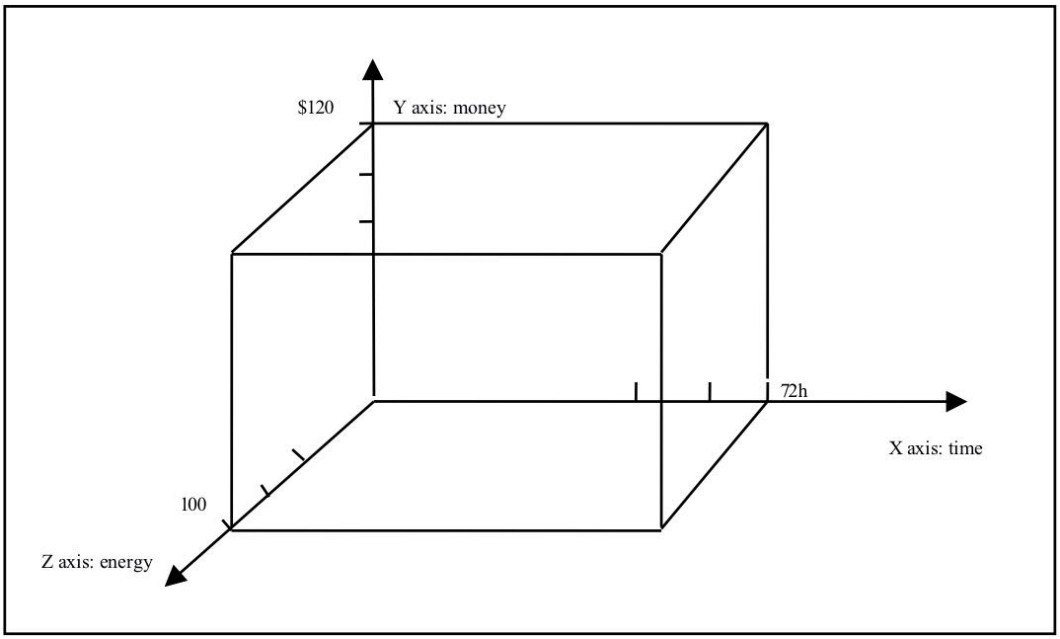


Figure 3: Actual costs cube: unfavorable case

As shown above, he actual cost in the unfavorable case is the volume of the cube=72×120×100=864000.

Because the actual cost is greater than the expected cost = 864,000-384,000 =480,000, and unhappiness generated.

3.1.3 Further explanation of equation's assumption

From a one-dimension perspective, buyers can simply consider only the psychological price and the actual price. Similarly, buyers can also make a comparison based on two dimensions. For instance, they can compare the psychological price and the expected spending time with the actual price and the actual spending time. If only the price is considered, the actual payment price is lower than the highest price that consumers are willing to pay. This is very similar to the concept of consumer surplus in economics. But happiness is usually the result of a combination of various factors

Moreover, in these three dimensions, the money dimension can be changed into the other two—energy and time. This is because money/currency is backed by the credit of governments so it can be regarded as a option with flexibility. Sometimes, when this option is executive, time and energy can be bought by money. But in other cases, you cannot buy time and energy of other people because you must do something by yourself. From the economic perspective, this phenomenon can be explained by the Marginal Rate of Technical Substitution: the ratio at which one production factor can be substituted for another while keeping the output constant. For instance, the most important production factors are often classified as capital and labor. But sometimes, when there is a shortage of labor, capital (money) can be used to purchase labor.

3.1.4 Self-assessment of equation's strengths

1) Straightforward

Reducing all the factors that affect happiness to the three factors that the author considers most important, simplifies the complex problem as far as possible.

2) Intuitive and easy to calculate

The different values of the three axes form cubes of different volume, which are easy to calculate and compare. Someone might ask: Why draw a three-dimensional cube instead of a triangle to represent the three dimensions? Then, calculate the difference between the expected and actual areas of the two triangles to determine the level of happiness? Because for three line segments to form a triangle, there are certain conditions: the sum of the lengths of any two sides must be greater than the length of the third side. Therefore, when the values in certain dimensions

are random, it is possible that the corresponding triangle cannot be drawn.

3) Flexibility

When one or two of the three elements—time, money and energy are missing, the model can easily be transformed into a comparison of area orlength. To compare one factor, one can use the length of a line segment. To compare two factors, they can be multiplied together, i.e., to compare the area of a rectangle, one can use the formula: length times width.

3.1.5 Self-assessment of shortcomings

1) The three elements are too simplistic

When this model is used, it should be stated that it is a comparison of people's pre-event psychological expectations with the actual results after the event took place under information asymmetry. However, sometimes, information asymmetry leads to the difference between the expected costs and the actual costs is very big, which will lead to the outcome is useless to evaluate.

2) It is not easy to prove that one of the three elements is more important than the others

For example, money can buy somebody else's time and energy to do his/her own things. On the other hand, time is irreversible, and it combined with space, especially sometimes the person must be present in person. Moreover, energy/manpower involves the application of different professional emotions, skills and knowledge, so most of time, the money cannot buy them in the same level from person to person.

3) The calculation of volume is the multiplication of three elements, which contains the assumption in probability theory that the three dimensions are independent of each other.

Inreality, the three elements may not be always independent of each other. For example, as time goes by, people will become more mentally exhausted and more amount of money needed to compensate the people's fatigue. It is difficult to find a unit of measurement for human labor. Most of the time, labor hours are used for measurement, but using the calorie unit (a measure of energy) is not very appropriate.

3.2 Constructing Happiness Equation by Using Actuarial Mathematics

3.2.1 Introduction of Conditional Variance formula in Actuary Science

It is also called the total variance formula, and its exact expression is:

$$Var(X) = E[Var(X|I)] + Var[E(X|I)]$$

Here, X is a random variable of information set used for conditioning.

3.2.2 Formula meaning and breakdown

The total variance of X can be broke down as the sum of two parts:

Part 1: Expectation of conditional variance: $E[Var(X|I)]$

It represents the mean of the variance of X given I(I: condition for triggering or grouping), reflecting the variance brought about by random fluctuations.

Part 2: Variance of conditional expectations: $Var[E(X|I)]$

It represents the extent to which the conditional expectation of X itself fluctuates, reflecting the variance resulting from grouping differences.

3.2.3 Basis for derivation

The core is based on the duality of expectations:

$$E(X) = E[E(X|I)]$$

And links to the definition of variance

$$Var(X) = E(X^2) - [E(X)]^2$$

Derivation:

$$\begin{aligned} Var(X) &= E(X^2) - [E(X)]^2 \\ &= E[E(X^2|I)] - \left[E\big(E(X|I)\big)\right]^2 \\ &= E\left[Var(X|I) + \big(E(X|I)\big)^2\right] - \left[E\big(E(X|I)\big)\right]^2 \\ &= E\left[Var(X|I) + E\left[\big(E(X|I)\big)^2\right]\right] - \left[E\big(E(X|I)\big)\right]^2 \\ &= E[Var(X|I)] + Var[E(X|I)] \end{aligned}$$

3.2.4 Simple example

Suppose X represents the student's test score and I represents which class the student is in.

$Var(X|I)$ is the variance of scores within each class; $E[Var(X|I)]$ is the average variance of all classes.

$E(X|I)$ is the average score of each class;

$Var[E(X|I)]$ is the variance between the average scores of different classes.

The total variance: $Var(X)$. It is the sum of the "score fluctuations within a class" and the "average score fluctuations between classes". The greater the fluctuation, the greater the risk, and therefore the less happy/safe.

3.2.5 Implications for the author's construction of the Happiness Equation

Any sense of happiness is an expectation of future favorable changes after having expectations in mind. After the good event took place, there is a magnitude or interval of change reflecting the extent to benefit. When the final good thing doesnot happen and the bad thing does happen, even if the adverse extent of the change exceeds the psychological defense of the person, the feeling of unhappiness arises. From a financial principle perspective, both uncertainty and risk bring about the feeling of unhappiness. And a risk is an uncertainty with a certain probability.

So, the happiness equation may combine risk avoidance with the conditional variance formula and end up as:

MAX Happiness =min unhappy=MIN (risk) =MIN[adverse changes (Total variance)]=MIN (expectation of changes/variance + changes/variance of expectation).

Mathematically, it is:

happiness = MIN{E[Var(X|I)]+Var[E(X| I)]}

In summary, minimize the total/conditional variance as a Happiness Equation is based on whether the expected changes occurs and its extent.

Sometimes, the first part of the formula, Var[E(X|I)], can be simply calculated using the Bernoulli distribution shortcut if there are only two value outcome or only two groups for categorizing.

The second part of the formula, E[Var(X|I)], is calculated based on the different distributions of events' traits, which is investigated, such as uniform distribution or exponential distribution etc.

3.2.6 One example

Here is an example of applying the equation to a stock investment. To test the extend of calculation results, a CV

(coefficient of variation) is added to judge the quality of the outcome of conditional variance.

Example 3-1: The price range of a certain stock is [0,1500], in US dollars. The probability that the stock price is less than $500 is 0.8. It is known that the stock price follows a uniform distribution (generally, the stock price always follows a lognormal distribution or a geometric Boolean distribution, etc. In order to simplify calculation, this example assuming that the stock price follows a uniform distribution with intervals of (0,500] and (500,1500). Requires:

(1) what is the value of total/conditional variance? (2) What is CV(Coefficient of Variation)?

Solution: (1) Let X be the stock price, and we set the conditions that the stock price is less than 500 and the stock price is greater than 500. Let I = 0 if the stock price follows a uniform distribution in the range of (0,500]; let I = 1 if (500,1500].

$E(X)=E[E(X|I)]=0.8\times[(0+500)\div2]+0.2\times[(500+1500)\div2]=400$

$E[Var(X|I)]=0.8\times[(500-0)^2/12]+0.2\times[(1500-500)^2/12]=33,333.33$

$Var[E(X|I)]=0.8\times0.2\times(1000-250)^2=90,000$

$Var(X)=E[Var(X|I)]+Var[E(X|I)]= 33,333.33+90,000=123,333.33$

2) CV=Var(X)^0.5/E(X)=(123,333.33)0.5÷400=0.8780

Explanation of outcome: According to mature data of present Share markets, for a single stock, a CV between 20% and 30% is considered low risk, while a CV above 50% is considered high risk. After calculating VAR(X) in this question, we further calculated CV to consider the degree of risk, which is 0.8780. It is significantly greater than 50%, so the risk of this shareholder is very high. Thus, the unhappiness is also high.

3.2.7 Self-assessment of strengths

1) From an actuarial science perspective, make the calculation more precise and the logic more rigorous.

2) Summarize happiness as risk minimization, that is, minimizing adverse differences and changes. This can guide people to avoid risks in his/her life, control them when they occur, or reduce them to an acceptable low level.

3) It is more intuitive to measure whether the size of the compound variance is dangerous by calculating the coefficient of variation and comparing the value of the coefficient of variation with empirical data.

3.2.8 Self-assessment of shortcomings

1) If an event that is bound to occur, such as buying commodities, we just focus on two elements: the price: P and the quantity N, where N is independent to P (namely, the increase or decrease in the purchase quantity is not affected by the change in price, vice versa. If a customer buys only one item, theoretically the independence of P and N does not need to be considered). Let X be the revenue of seller, so $X=N\cdot P$. In this case, another total variance formula should be changed as follow:

$Var(X)=Var(N)\cdot E^2(P)+E^2(N)\cdot Var(P)+ Var(N)\cdot Var(P)$

2) Overly precise calculation results may not be very necessary. The result of having or not having happiness is more important than the happiness extent.

3) Use CV (coefficient of variation) to measure the value of total variance by comparing it with common empirical data is too realistic. More often than not, there is no empirical data and existing KPI to use. So the calculated CV cannot generates wide-accepted conclusion to describe total variance's quality.

3.3 Conclusions

1) The Happiness Equation can be constructed in various ways, including structured equations by using Analytic Hierarchy Process and so on, in addition to those introduced above in this article.

2) The equations proposed by psychologists Sheldon, Lyubomirsky, and Scott are straightforward. Because happiness itself is a psychological feeling, the ability to regulate the emotions is crucial.

3) Paul Samuelson, the master of economics, replaced addition with division. The most fundamental economic principles such as diminishing marginal utility theory are hidden in the entanglement of utility and desire.

4) The author 's first cube equation, simple and intuitive, evokes the idea of simplifying the complex and initiating further discussion. From three-dimensional to two-dimensional and then to one-dimensional, it demonstrates the flexibility of the model.

5) The author's second equation of total variance minimization, which embodies the idea that happiness is life's risk aversion and also includes measurements or actuarial risk, is an attempt to construct the Happiness Equation from new perspective.

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Author Profile

Huan Zhang Male, Title: Senior Accountant (associate senior) Employer: Jianghan University, Contact information: Contact Address: Room B309, Teacher and Student Service Center, Jianghan University, No. 8 Sanjiaohu Road, Economic and Technological Development Zone (Hannan District), Wuhan City, Hubei Province. Postcode: 430056 Tel: 027-84225206, Mobile: 15972985272 Fax: None E-mail: 22646710@qq.com Additional information: Member of the Chinese Accounting Society, non-practicing CPA, FCCA