Using stochastic frontier analysis to measure the satisfactory efficiency of countries

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ABSTRACT

Happiness is a macro-economic standard and a micro-economic measure to reveal an individual's true well-being, which has gained considerable attention from both academics and policymakers. The research adopts the concept of happiness relating to the appraisal of life satisfaction or quality of life, which is measured over a period. The determinants of life satisfaction are searched at both individual-level and country-level, which present a wide spectrum of both socio-economic status and personal traits. The study utilizes data from the World Value Survey (WVS), from which 31 variables are selected to employ in the model. The paper applies Stochastic Frontier Analysis (SFA) to quantify the abstract concept of satisfaction and measure how efficiently countries translate their resource endowments into satisfaction. This model helps to recognize random noises from inefficiency. The results show that absolute economic value does not need to increase efficiency when converting inputs into well-being, but relative financial satisfaction is the main factor driving satisfactory efficiency. In line with previous studies, the quality of social fabric, such as freedom and trust, supports the conversion of other inputs into happiness. The findings also find new determinants of age and location (rural and urban areas), which also influence conversion efficiency.

1. Introduction

Since the time of Aristotle's eudemonia, there has been much discussion on the exact meaning of happiness. Eudemonia, in Aristotle's view, is a result of virtue, health, prosperity, and beauty (Mamatzakis & Tsionas, 2021). In this current scientific era, happiness is a macro-economic standard and micro-economic measure to reveal the true individuals' well-being which has gained considerable attention from both academics and policymakers. Additionally, as contemporary societies have become more secular and democratic, the pursuit of happiness has emerged as a significant subject of public discourse (Jagodzinski, 2010). Nevertheless, the ongoing discussion regarding the definition of happiness and the factors that influence it remains lively.

The happiness concept comprises both objective and subjective indicators, short-term and long-term spectrum. Although terms like happiness, life satisfaction, and subjective well-being are used interchangeably in some research, this is not accurate (Prasoon & Chaturvedi, 2016). Kahneman and Krueger (2006) provided a valid distinction between experience happiness, which pertains to our emotional state in the present moment, and life satisfaction, which refers to our overall evaluation of our existence. While the former describes the current experience and spontaneous feeling, which is not easily measurable, the latter relates to the appraisal of life satisfaction or quality of life from various aspects combined into an overall judgment over a period. In this paper, I adopt the latter concept of happiness and am interested in qualifying satisfaction and measuring satisfaction inefficiency. The aspect of being measured over a period of satisfaction definition, additionally, is consistent with characteristics of the dataset World Value Survey (WVS) that I used in this paper.

When discussing the factors that contribute to life satisfaction, it's crucial to thoroughly examine the intricacies and potential determinants that are involved. The term Quality of Life or Life Satisfaction was introduced in the 1960s (Veenhoven, 1996), in tune with this, new themes of "limits to economic growth" appeared, and values came to shift to post-materialism. The traditional economic criteria were replaced by social indicators stating that money cannot buy happiness (Prasoon & Chaturvedi, 2016). Until now, there are various social-economic variables input in satisfaction or happiness studies. According to Veenhoven (1996), determinants of life satisfaction can be searched for in two aspects: external factors and inner psychological processes. The complex vector of factors can also be named from individual determinants (self-esteem, optimism, personality traits) (Mamatzakis & Tsionas, 2021), to socio-demographic and social factors (gender, age, education, marital status, number of children, trust, social capital) (Mavruk, 2022; Mueller, 2009; Näsman & Nyqvist, 2022; Sudo, 2022), economic (income, unemployment) (Mikucka et al., 2017; Schalembier, 2019; VeČerník & Mysíková, 2015), to institutional political factors (Valgarðsson & Devine, 2022) or geographic location (urban and rural area) (Binder & Broekel, 2012; Sørensen, 2014). In this paper, I employ both individual-level and country-level variables, which present a wide spectrum of both socio-economic status and personal traits. The chosen variables heavily depend on the literature and data available, but the filter and re-selecting by a suitable algorithm are important to ensure prediction accuracy and model interpretability.

Another point that should be considered is the measured levels of satisfaction. Rayo and Becker argued that individuals consistently strive to maximize their pleasure based on their personal traits and resource endowments (Rayo & Becker, 2007). In line with this, it is necessary to reach higher values of happiness efficiency and find out the maximization of happiness as the frontier of estimate function (Mamatzakis & Tsionas, 2021). For this reason, and different from other regression models, the paper applies Stochastic Frontier Analysis (SFA) to quantify the abstract concept of satisfaction.

The main contribution of this paper, therefore, is to utilize and develop traditional concepts of happiness to estimate the aggregated satisfactory efficiency measures of countries based on the reported individual satisfaction level. The issue will be addressed by constructing an efficient frontier consisting of the top performers who are able to effectively convert their resources into higher levels of satisfaction. Subsequently, the level of inefficiency of each nation in terms of satisfaction can be quantified by measuring the distance to the boundary.

A second contribution to this study comes from identifying the new determinants of satisfactory efficiency. Instead of employing the available framework or certain factors, the model is first run on a comprehensive set of factors influencing the absolute levels of well-being that have once appeared in previous studies and are present in the WVS dataset. This presents an opportunity to explore new determinants and check their validity.

The paper is organized as follows: In Section 2, I review the relevant literature, particularly on satisfactory efficiency and the use of frontier techniques in satisfactory efficiency measures. Section 3 details the methods applied to measure satisfactory efficiency, along with descriptions of the dataset and variables used in the empirical analysis study. Section 4 reports the main findings: First, I describe the efficiency score and make a country-cross comparison then I decompose total efficiency scores into technical and scale efficiency and interpret determinants' influence on efficient conversion inputs into satisfaction. Finally, the paper ends with some concluding remarks.

2. Theoretical basis

Happiness economics has become popular in the economic literature during the last two decades (Kahneman & Krueger, 2006). Life satisfaction, also known as subjective well-being, has been proposed as an alternative metric for assessing the increasingly complex welfare society beyond the one-dimensional income-based measures (Cordero et al., 2021; Reeskens & Wright, 2011; Sarracino & O'Connor, 2022). Satisfaction has been considered a summarizing measure to evaluate both economic and non-economic aspects; it could also be regarded as input or output to production (DiMaria et al., 2020). The increasing body of literature focuses mainly on addressing two concerns: which determinants contribute to increasing individuals' overall satisfaction levels and how efficiently individuals can achieve their desired degree of satisfaction (Binder & Broekel, 2012). Previous research has identified various elements that significantly impact individuals' satisfaction scores. These aspects include macroeconomic variables, social indicators, and institutional factors. But little is known about how well countries transform their resources and endowments into satisfaction.

The idea of satisfactory efficiency can explain why some people might not be able to reach certain levels of satisfaction despite having equal access to resources. The variation in happiness levels among individuals can be attributed to differences in the efficiency of converting resources into well-being.

Frontier techniques were initially applied in the study of production functions, which aimed to determine the most efficient use of inputs given a set of outputs or the maximum output from a given set of inputs in productive units. This method is commonly used to calculate economic efficiency across sectors, including banking, health care, agriculture, transportation, education, environment, and finance (Liu et al., 2013). The concept that satisfaction can be generated with high or low efficiency and that this efficiency can be quantified is relatively novel. In happiness research, the satisfaction efficiency frontier refers to any deviation from the frontier where individuals deviate from their maximum potential satisfaction and could achieve if they optimally utilize their resources. It involves comparing the utilization of inputs to outputs (Binder & Broekel, 2012; Cordero et al., 2021).

Frontiers can be calculated using different methods, which are often categorized as (i) a non-parametric piecewise-linear convex frontier or Data Envelopment Analysis (DEA) and (ii) a parametric function fitted to the data (Coelli et al., 2005). Few previous studies have mainly applied a nonparametric approach to estimate well-being efficiency measures and advocated this approach for its flexibility (Binder & Broekel, 2012; Sarracino & O'Connor, 2022). Parametric methods, in contrast, are prone to errors since it is difficult to accurately specify the exact functional form (Ravallion, 2003). The research contributes to offering a more neutral view when considering the trade-offs of each method and promotes the advantages of the less preferred method, the parametric approach, according to the characteristics of the research sample. Given the small number of observations, the parametric method is a better alternative, as the nonparametric one demonstrates its limited ability to distinguish patterns in this type of data (Cordero et al., 2021). Another problem with the non-parameter frontier is that "no account is taken of measurement errors and other sources of statistical noise - then all deviations from the frontier are assumed to be the result of technical inefficiency" (Coelli et al., 2005, p. 242). The parametric technique can address this drawback by distinguishing between noise effects and technical inefficiency in inefficient units. Considering the noise effect attributable to omitted variables, it is significant to accurately understand where the deviations from the frontier come from. For these reasons, I suggest using a parametric model known as the stochastic production frontier model (SFA) and show how we can estimate the parameters of the model and also predict the (technical) satisfaction efficiencies.

Additionally, prior studies rely on the available framework, notably the World Happiness Reports (WHRs) framework, which is constituted by six factors: GDP per capita, health life expectancy at birth, social support, freedom to make life choices, generosity, and perceptions of corruption. This WHR framework serves as a definitive and reliable point of reference. These indicators play a high role in measuring the absolute level of well-being; however, they leave around three-quarters of the variation in subjective well-being around the world unexplained (Cordero et al., 2021; Sarracino & O'Connor, 2022). Another contribution of this work is to explore a new set of variables. This allows us to examine new determinants and explain how well they are translating into the maximum output of satisfaction.

3. Methodology

The research uses Stochastic Frontier Analysis (SFA) to explore the ability of countries to reach the maximum levels of satisfaction given a certain level of resources while accounting for the probabilistic handling of inefficiency and noise in stochastic models.

The SFA model was introduced by Aigner et al. (1977). The basic idea is the introduction of an additive disturbance term, which is summed of a purely random (usually normal) error term and a stochastic inefficiency term with a specific random distribution (e.g., the half-normal) (Behr, 2010). Efficiency analysis, then, will be the comparison of an observed output and an estimated output resulting if inputs are used efficiently.

Since the previous research on well-being efficiency mainly used an arbitrarily chosen function to envelop the data point (the DEA method), this time satisfaction efficiency is calculated by a stochastic production frontier model that is constructed based on a Cobb-Douglas production function, in which the logarithm of output is determined by a non-negative random error that indicates technical inefficiency, and a symmetric random error that accounts for noise (Coelli et al., 2005).

$$\ln q_i = x'_i\beta + v_i - u_i \tag{1}$$

Where q_i represents the output as satisfactory efficiency of each country i; x_i is a vector containing the logarithms of inputs or available endowments and resources; β is a vector of unknown parameters; v presents random errors attributed by variables other than x_i; and u_i is a non-negative random variable related to technical inefficiency, interpreted as the percentage shortfall in pursuit well-being relative to the maximum possible satisfaction.

The stochastic frontier production function is named as such because the output values are bounded from above by the stochastic variable $\exp(x_i'\beta + v_i)$. The v_i term takes care of the stochastic nature of the production process and possible measurement errors of the inputs and output, and the u_i term is the possible inefficiency of the firm. The random error v_i can exhibit both positive and negative values, resulting in variations in the stochastic frontier outputs around the deterministic component of the model, $\exp(x_i'\beta)$. If $u_i = 0$, it means 100% efficient, and, if $u_i > 0$, then there is some inefficiency.

With these features, the Cobb-Douglas stochastic frontier model takes the form:

$$lnq_i = \beta_o + \beta_1 lnx_i + v_i - u_i \tag{2}$$

$$\text{or } q_i = \underbrace{\exp(\beta_0 + \beta_1 lnx_i)}_{\text{Deterministic component}} \times \underbrace{\exp(v_i)}_{\text{noise}} \times \underbrace{\exp(-u_i)}_{\text{inefficiency}} \tag{3}$$

Within this framework, countries that exhibit the highest level of efficiency are situated on a frontier and serve as a benchmark. The efficiency scores are determined by the distance to the country with similar resources and obtaining the similar degree of satisfaction. The inefficiency will be interpreted as waste in the current use of resources (Binder & Broekel, 2012; Nikolova & Popova, 2021).

So, the prediction of the inefficiency effects is the ratio of observed output to the corresponding stochastic frontier output:

$$TE_i = \frac{q_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i) \tag{4}$$

This metric of technical efficiency ranges from zero to one. The measure quantifies the i_{th} output in comparison to the output that gains full efficiency and could be generated with the same input vector. When considering life satisfaction estimate under production function, it is assumed that life satisfaction should be non-decreasing, the expected value of satisfaction is non-decreasing in efficiency index and, therefore, is maximized when efficiency equal 1.

To estimate the SFA model, we determine the values of the unknown parameters $\beta, \sigma_v^2, \sigma_u^2$ using the maximum likelihood principle.

The estimation methods rely on assumptions regarding these two random variables: The variable v_i is distributed independently of each variable u_i, and both errors are uncorrelated with the explanatory variables in x_i (Coelli et al., 2005).

In addition, $v_i s$ are independently and identically distributed normal random variables and $u_i s$ are independently and identically distributed half-normal random variables.

$$v_i \sim iiN(0, \sigma_v^2)$$

$$\text{and } u_i \sim iidN^* (0, \sigma_u^2)$$

With all these assumptions, Aigner et al. (1977) obtained Maximum Likelihood estimates. Using the parameterization, the log-likelihood function for this half-normal model in term of $\sigma^2 = \sigma_v^2 + \sigma_u^2 \; and \; \lambda^2 = \frac{\sigma_u^2}{\sigma_v^2} \geq 0$ is:

$$\ln L(y|\beta, \sigma, \lambda) = -\frac{1}{2}\ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{l} ln\Phi\left(-\frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{l} \varepsilon_i^2 \tag{5}$$

However, the first-order conditions with respect to the unknown parameters are highly nonlinear and cannot be solved analytically for β, σ, λ. Thus, an iterative optimization procedure must be adopted to maximize the likelihood function numerically to obtain the maximum likelihood estimates of the parameters.

Using this SFA model allows us to calculate deviations (additive error term) ϵ from the estimated production frontier and distinguish the variances σ_v^2 from σ_u^2. This means it is possible to define the unexplained variation in national average levels of well-being that are still left in other frameworks, for instance the WHRs framework. At the same time, it enables to detect the measurement errors from stochastic omitted variables v which other flexible framework of nonparametric methods can't do.

4. Data and variables

4.1. The world value survey dataset

The paper employs the data from the World Value Survey (WVS), which is a longitudinal research program, the largest non-commercial, cross-national, time series investigation of human beliefs and values ever executed, the only academic study covering the full range of global variations, from very poor to very rich countries, in all the world's major cultural zones. The survey covered a variety of subjects, such as economic growth, democratization, religion, gender equality, social capital, and subjective well-being. The data collected from this survey has been used in various studies.

In particular, the researcher used the WVS Wave 7 (WVS-7) - the most recent wave of WVS started in mid-2017 and, following a 1-year postponement due to the Covid-19 pandemic, was finally closed on December 31, 2021. WVS-7 questionnaire was structured along 14 thematic sub-sections, including some new topics: justice, moral principles, corruption, accountability and risk, migration, national security, and global governance.

The survey was mainly conducted by face-to-face interview at the respondent's home or place of residence. In other cases, interview modes could include postal surveys, self-administered online surveys, and telephone interviews. The samples are indicative of the entire population aged 18 and above who live in private households in each country.

In terms of the sample, the outcome (life satisfaction) comes from the individuals' responses to the question ***"All things considered, how satisfied are you with your life as a whole these days?"***. The output takes the value of 1 which means that the underlying individual is completely dissatisfied, where 7 would indicate the maximum level of life satisfaction or completely satisfied. Based on previous studies on life satisfaction and the available features in the dataset, I have included a wide range of features from WVS in the study model. The selected variables are listed in Appendix A.2 Table 1 (online version).

4.2. Data manipulation and variable selection

There are some steps of data manipulation that should be done before building a model. The extracted data will be checked for duplicates and missing data. The original including 94,278 observations is shrunk to 93,279 observations after cleaning data.

For this first screening step, we included as many variables as possible. All variables that have been examined in previous studies on the topic of happiness and appear in the WVS dataset will be collected. For the cross-country regression, the individual-level data will be aggregated for the mean values of the country level. This prior dataset is completed by merging with GDP per capita and unemployment rate from the World Bank. This variable set includes just three out of six variables of the WHRs framework relating to GDP per capita, perception of corruption, and freedom. However, they cover all main thematic sub-sections of economic status, social capital, institution, and demography.

In the end, the dataset includes observations representative of 64 countries and 31 variables. The dimension of the dataset likely causes the overfitting. Additionally, there are some groups of variables which share the same domain and potentially highly correlated (i.e., important in life: politics, satisfaction with the political system performance, national pride, etc.). That requires more steps of checking correlation and selecting variables which can be considered a significant step for an appropriate model building.

After checking the correlation of some variable groups, I have detected a high correlation between the importance of religion (*imp_religion*) and attending religious activities (*attend_reli*) (correlation coefficient is 0.86), and decide to reject the *attend_reli* variables. The variables group relating to politics does not show multicollinearity (Appendix A.1. Figure 2) (online version). The rest of the correlation coefficients are all smaller than 0.7.

The robustness is checked, but the coefficient and statistical significance are not reduced, so I suggest keeping all the variables for now. For the reason of prediction accuracy and model interpretability, the model selection (variables selection) is still necessary. In this paper, I use the subset selection to identify a subset of predictors that I believe to be related to the response. The hybrid approach of forward and backward stepwise is applied. This method involves sequentially adding variables to the model (forward selection). However, after adding a new variable, any variables may be removed (backward selection) if they no longer contribute to the improvement of the model (James et al., 2013). After all, the best six-variable model is identified by stepwise selection (Appendix A.2 Table 2) (online version). The chosen variables include GDP per capita, age, freedom (free choice and control over their lives), satisfaction in finance, trust (most people can be trusted), and urban rural areas.

5. Result and discussion

The research calculates the aggregate data at the country level for a single year, accordingly, can measure the nations' satisfactory efficiency and explore the potential influence of countries characteristics on their average well-being.

5.1. Ordinary Least Squares (OLS) regression

The descriptive statistics of variables are presented in Table 1 below. The average age is 42.70 when the maximum value is 56.26, and the minimum one is 30.57 (they are the mean values of each country after aggregating from individual-level data). GDP per capita is highest at 100,172.08 USD and lowest at 897.05 USD; the average is 18,764.46 USD. Freedom, satisfaction with financial status, and satisfaction with life ranged from 1 to 10, with the average values being 7.17, 6.13, and 7.04, respectively. Finally, trust and settlement types are indicated by binary variables. A value of one for trust signifies that "most people can be trusted," while a value of two means "one needs to be very careful." For settlement type, a value of one represents an urban area, while a value of two indicates a rural area. The average trust value among the population is 1.76. The mean of settlement types is 1.32, showing that more people reside in urban areas.

Table 1

Descriptive Statistics

	age	freedom	GDP_per_ capita	satis_ finance	satis_life	trust	urbrural
Mean	42.70	7.17	18,764.46	6.13	7.04	1.76	1.32
Std.Dev	6.05	0.70	22,062.79	0.83	0.87	0.17	0.21
Min	30.57	5.84	897.05	3.64	4.46	1.26	1.00
Median	42.80	7.24	8,368.67	6.25	7.07	1.81	1.27
Max	56.26	10.00	100,172.08	8.00	10.00	2.00	1.77
N.Valid	64	64	64	64	64	64	64
Pct.Valid	100.00	100.00	100.00	100.00	100.00	100.00	100.00

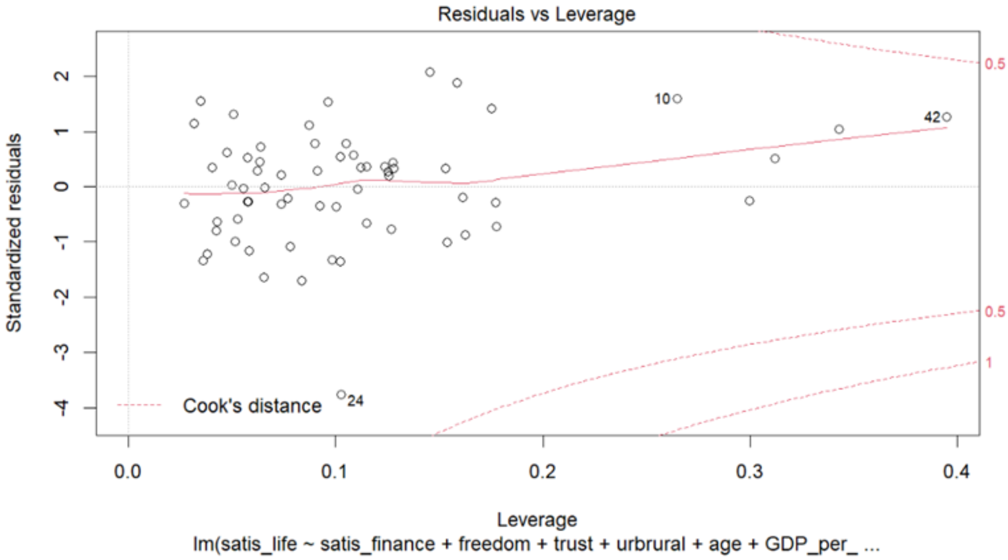
Note. Author's work
Source. Data analysis result of the research

First, I use the OLS regression to model people's life satisfaction. This model will include 06 variables selected by the stepwise method in the previous step. The results from Appendix A.1 Figure 3 (online version) show that all variables are statistically significant. The p-value of *satis_finance* and *freedom* are smaller than 0.001; the p-value of *urbrural* and *age* is smaller than 0.01, and that of trust and *GDP_per_capita* is smaller than 0.05. The multiple R-squared is 0.8837 and the adjusted R-squared is 0.8714. However, the regression plot reveals evidence of a nonlinear relationship. Additionally, the result shows an abnormal negative correlation between GDP per capita and satisfaction level. This motivates a non-linear transformation of regression. Then, a polynomial term of GDP per capita updates the model. We successfully exclude the inverse relationship between well-being and economic value while simultaneously improving the R-adjusted square (Appendix A.1 Figure 4) (online version).

The OLS estimation assumes that deviations are symmetrically distributed around zero and follow a normal distribution. This can also be observed from the plot of this regression model in Figure 1 below. The estimated function in the figure lies in the middle of all the observations. The model has a clear interpretation: it is a production function; the estimated function seems to be in accordance with the observations and the relevant parameters. And it seems that we have a good model. There is an issue with some of the observations being above the estimated production function, which goes against the definition of a production function that is meant to maximize the satisfaction level. This is the reason I employ the SFA model to shift the estimated OLS regression outwards by the maximal deviation between observed output y and fitted regression values.

Figure 1

Linear Regression Plot



Source. Author' work

Based on the result of OLS regression, the chosen dependent variables in the model will be employed as the inputs of the satisfaction frontier model below.

5.2. SFA model

5.2.1. Efficiency scores and decomposing inefficient units

According to the SFA model result, the mean efficiency is quite high at 0.946; the lowest score is 0.76, and the highest one is 0.99 (Appendix A.1, Figure 7) (online version). The individual efficiency index is extracted for comparison across countries. Since the model employs the most statistically significant variables that are highly related to absolute life satisfaction level, the satisfactory efficiency scores from the SFA model are all quite high and are not strongly discrepant. The countries with the highest efficiency scores are China, Lebanon, Serbia, Ecuador, and Argentina, which are at least 98% efficient. Iraq ranks as the least efficient country on our list with a score of 0.76, followed by Iran with a score of 0.88. These countries with poor efficiency levels should thoroughly evaluate their utilization of resources.

The two-step approach: first, choosing inputs from OLS regression, then computing the efficiency score using the SFA model, has proven the globally acceptable inputs that could be transformed for rather equally satisfactory efficiency across countries. However, this input set shows the drawback of not being able to undertake a cross-country comparison. And with this new set of inputs, the result is not in line with previous studies when explaining the cross-country pattern. For instance, the research of Cordero et al. (2021), which used the same data source but a different variable set, has found heterogeneous contexts; certain European nations, in addition to those in Latin America, rank among the most efficient nations in terms of wellbeing. The other research concluded that the most satisfactory efficiency is found in northern and central European countries, whereas the less efficient countries in attaining happiness tend to be in Asian transitional economies (Cordero et al., 2017). This result reveals that satisfactory efficiency may be driven by other important inputs than those employed in this model that are not directly related to satisfaction level. This statement is further reinforced by the correlation between the satisfactory efficiency score and the satisfaction level gained from the interview, which is just 0.44. The efficiency score of each country does not need to directly correspond to its absolute degree of life satisfaction.

The SFA allows us to separate inefficiency from noise. For the first SFA model, I input six selected variables (to avoid the collinearities in inputs, just a square of GDP per capita is employed while GDP per capita is not) and did not include the ineffective factors. To estimate the SFA model, that is, to determine the values of the unknown parameters $\beta, \sigma_v^2, \sigma_u^2$ using the maximum likelihood principle. The estimated lambda (λ) - the ratio of the variance of the inefficiency term to the variance of the stochastic term (random noise) called efficiency variance is 4.8. It means that the total error variance is mainly due to inefficiency. The estimated variance for the variation in efficiency is σ_u^2 = 0.005, which is considerably larger than the variation due to random errors σ_v^2 = 0.0002. And the proportion of output explained by the inefficiency term (*gammaVar*) is 0.89. The whole result is shown in Appendix A.1 Figure 5 (online version).

The second SFA model adds one variable more: the Unemployment rate as the inefficient factor. This increases the mean efficiency to 0.96. Percentage of inefficiency variation to total variation $\lambda = 0.79$ (Appendix A.1 Figure 6) (online version). If more variables as inefficient factors are added (for instance, the Importance of democracy and Protecting the environment vs. Economic growth), the mean of satisfactory efficiency is even higher at 0.97. This again proves the outweigh of variables that we selected for satisfactory efficiency out of the others.

A likelihood ratio test, then, is employed to test the hypothesis. If the null hypothesis is true, the stochastic frontier model is reduced to an OLS model with normal errors. According to the output shown in Figure 7 (Appendix A.1) (online version), the p-value is 0.00006 (< 0.05). Therefore, the null hypothesis is rejected as it is statistically significant. The paper also compares the OLS and the SFA estimates of the parameters in the model (Appendix A.1 Figure 8) (online version). The estimates are observed differently. However, except for the intercept, the differences are rather small. The intercept of OLS is -0.64, and that of SFA is -0.22, which means SFA has been shifted much above the OLS regression.

5.2.2. The determinants of satisfactory efficiency

According to the estimated outcome of SFA calculated using MLE, it appears that most variables, including financial satisfaction, freedom, trust, and age, have a positive correlation with satisfactory efficiency. The positive coefficient estimates suggest enhancements in efficiency whereas negative ones signify declines in efficiency.

Out of those, the satisfaction of the household's financial status has the most significant impact on relative satisfaction level, with a coefficient of 0.67. Satisfaction with finance is an economically relative value that is understandably closely related to the satisfaction of the whole life. On the other side, the result interestingly states that GDP per capita, when having a positive correlation with life satisfaction level, shows a negative relationship with satisfactory efficiency. GDP per capita, which is averagely aggregated for each country, can partly describe economic growth but may not be translated well into life satisfaction. As Mikucka et al. (2017) in their study stated that the positive relationship between economic growth and satisfaction is conditional on increasing social trust and declining income inequality, the result of a negative correlation in this paper could be influenced by these two conditions, and/or other constraints of whether they are developed, developing, or transition countries. Veenhoven (1996) stated that economic growth adds to life satisfaction in poor countries, but not in rich ones. Since financial satisfaction and GDP per capita are both economic criteria, just the relative value of financial satisfaction shows the positive, statistically significant coefficient estimates for the relative level of life satisfaction. The absolute value of GDP per capita has a marginal coefficient, suggesting that it does not impact much on satisfactory efficiency. The level of freedom of choice and control over lives and social trust all contribute to increasing the satisfactory efficiency of countries. They can be considered a good institutional environment to convert input into satisfaction. This result aligns with the research of Nikolova and Popova (2021). In fact, freedom of choice refers to the ability of individuals to live their lives according to their own values and is the primary factor in deciding how efficiently they utilize resources. The institutions facilitate individuals to invest in their human capital and ensure their investments yield relatively high levels of well-being. Formal institutions play a crucial role in shaping the overall quality of social structure, networks, and functioning, which are the necessary conditions for individuals to fully utilize the resources available to them. This finding resonates with the finding that institutions are also important drivers of absolute satisfaction levels (Bartolini, 2014; Helliwell et al., 2023; Mikucka et al., 2017). This means promoting freedom and trust in society not only increases absolute satisfaction but also diminishes satisfactory inefficiencies. However, compared to freedom, trust plays a less important role since its coefficient estimate is only marginally statistically significant.

Besides social values and relative economic growth, there are two more determinants that help to improve relative satisfaction and help countries reach a high level of well-being, which are not often mentioned in the topic of satisfactory efficiency. Age also has a positive relationship with satisfactory efficiency. The older people are, the more efficiently they can convert their endowment into satisfaction. Additionally, people are more likely to be satisfied when living in urban areas than in rural areas since the coefficient of this variable is -0.187. This result can be interpreted as indicating that people in cities have better conditions to transfer their resources and attain higher levels of satisfaction. This is quite opposite to the research on absolute well-being, which was convinced in Sørensen's research (2014) that rural dwellers were found to have significantly higher life satisfaction than city dwellers. The difference can be explained by some factors considered as control variables. Another research has found that in richer countries, rural dwellers were observed to have higher subjective well-being, but people were less satisfied if they lived in rural areas in poorer countries (Shucksmith et al., 2009). The point is also laid on how urban and rural areas are defined. So, settlement type has a relation to life satisfaction; however, it can also be examined as an objective background, including many objective and subjective sub-variables: security, sense of control, life aspirations, sense of community feeling, preferred type of area, living close to nature, etc. To fully explain the correlation between settlement type and satisfaction, these factors should be taken into account. Further research can be conducted to identify which factors determine the different conditions among regions (rural and urban areas) for the discrepancy in satisfactory efficiency.

6. Conclusions and recommendations

Researchers have directed their attention toward determining factors that contribute to absolute happiness. Nevertheless, considering the upper bounds of happiness measures and the potential for diminishing returns on happiness resources, we argue that it is crucial to assess the efficiency by which individuals transform their resources into happiness. Further insights are necessary when examining the distribution of efficiency scores in relation to the frontier. Moreover, in accordance with the "beyond GDP" movement, non-economic factors are being scrutinized, which compels us to adopt a more comprehensive understanding of quality of life.

The paper contributes to the emerging field of satisfaction and well-being measurement by calculating satisfactory efficiency scores at the country level for 64 countries representing all the continents in the world. The SFA model in this paper enables the measurement of satisfaction efficiency with the goal of maximizing satisfaction values. This innovative approach considers the possibility of noise effects resulting from omitted variables or cultural bias. Using a set of resources chosen in accordance with the absolute level of satisfaction, the model identifies inefficiencies in the way nations attain satisfaction. The variable set is not based on any available framework but is selected from an OLS regression of absolute satisfaction level. The paper has chosen six significant variables from the original 31 ones. They are all statistically significant in the SFA model. These inputs differ from other research but cover enough indicators of economic conditions, social or institutional factors, location, and individual characteristics. This allows us to explore new determinants affecting the conversion of given resources into the satisfaction of countries. This brings especially policy implications as it explores the factors that enhance or impede satisfactory efficiency among countries and, at the same time, identifies what kind of interventions assist nations in improving or sustaining their satisfactory efficiency.

Most of them have a positive relation with life satisfaction, except the GDP per capita and the settlement type of rural area. The results suggest that promoting freedom and trust would increase satisfactory efficiency. They are considered the most important social supports, which ensure translating inputs into happiness efficiently. While the absolute economic value of GDP per capita is not necessarily equipped to transform resources into well-being, the relative economic factor of financial satisfaction supports converting resources into happiness the most. We recognize that satisfactory efficiency cannot be easily accounted for by a simple reversal of causality between life satisfaction and factors such as location, quality of social fabric, or economic growth.

Although the SFA model can detect random noise based on cultural bias or omitted variables, the paper has not yet defined certain noises. Therefore, further research could explore more personality and cultural differences as the ability of individuals to adjust and overcome severe problems. This may help to explain why some countries with poor socioeconomic conditions and less resource endowment could be ranked as top performers in terms of satisfactory efficiency. Additionally, although using this new variable set could not find the difference in converting inputs into well-being on the scale of continents, the urban and rural variable is an interesting proxy to explore spatial variation with satisfactory efficiency. This factor inherently embeds multiple variables that need more investigation to dissection.

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