

Including a human happiness index in a social well-being model

Joan C. Micó^a, David Soler^a, María T. Sanz^{b*}, Antonio Caselles^c

^a *Institut Universitari de Matemàtica Multidisciplinar, Universitat Politècnica de València, Camí de Vera s/n, 46022 València, Spain*

^b *Departament de Didàctica de la Matemàtica, Universitat de València, Avda. Tarongers 4, 46022 València. Spain*

^c *Departament de Matemàtica Aplicada, Universitat de València, Dr. Moliner 50, 46100 Burjassot, Spain.*

Abstract

This paper presents a new Happiness Index built through five abstract concepts: development, freedom, solidarity, justice and peace. These five concepts are evaluated through quantitative variables obtained from the Human Development Reports, World Data Bank and Eurostat. To validate the presented index, it is compared with the Overall Life Satisfaction Index, an index used by the *UN*. Moreover, this new Happiness Index is included in a dynamic mathematical model through the demographic rates to study the evolution of the population. The model has been validated for the case of Spain in the 2001-2015 period.

Keywords: *Happiness Index, UNDP, stochastic model, demographic population.*

1. Introduction

Most people believe that happiness is the basis of a meaningful life [1], and for this reason, the intention to measure the happiness is increasing. The literature reflects two different ways to measure this concept. On the one hand, authors who try to measure the happiness of the people. George Gallup created the Gross National Well-Being (GNW), also known as the Gross National Happiness Index (GNH Index). It consists of 7 dimensions: economic, environmental, physical, mental, work, social, and political. The Scale of Life Satisfaction (SWLS) [2] is a short 5-item instrument designed to measure global cognitive judgments of satisfaction with one's life, and the Scale of Subjective Happiness [3] asks four questions to measure the happiness on a scale from 1 to 7. On the other hand, there are authors that try to measure the happiness of a country, as The Happy Planet Index (*HPI*), which captures the degree to which long and happy lives are achieved per unit of environmental impact. It is calculated [4] through life expectancy at birth, well-being and progress in life, and ecological footprint. Finally, in the Overall Life Satisfaction Index, used in [5], subjective well-being questions are involved about health, wealth, and access to basic education.

The index presented here is calculated through the terms studied by Caselles [6]. He considered that human dignity (from now on Happiness Index) could be calculated from five fundamental concepts (see Fig. 1). He also showed a list of variables (qualitative and quantitative) that could be related with them.

This paper has two objectives. First, obtaining a generic formula to measure the happiness of a country/region with quantitative variables. The term “generic” is introduced because this formula could be extrapolated to any country, although in this work this new index has been calculated only for 13 EU countries in 2013, because the information is not available for all countries in the different database. Second, adding this index to a dynamic mathematical model through the demographic rates [7,8].

2. Happiness Index

As mentioned before, we consider happiness as a disaggregation of the five fundamental concepts: Development, Solidarity, Justice, Peace and Freedom, but in order to evaluate it, we must find quantitative variables that allow us to get closer to its meaning.

* Corresponding author. Tel.: +34 963983285.

E-mail addresses: jmico@mat.upv.es (J.C. Micó); dsoler@mat.upv.es (D. Soler); m.teresa.sanz@uv.es (Maria T. Sanz); antonio.caselles@uv.es (A. Caselles)

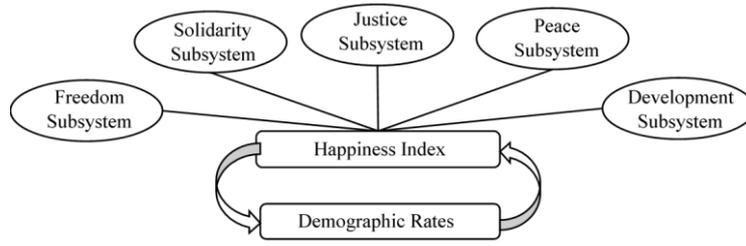


Fig 1. Causal diagram of the Happiness Index.

Our theoretical reference has been [6], and data have been obtained from Eurostat and World Data Bank in the 2001-2015 period. The methodology to obtain the Happiness Index is the one used in UNDP Reports. Minimum and maximum values (values limits) are determined to transform the real variables into variables with values between 0 and 1. In this way, all variables can be used in the same formula because they have the same dimension. Due to the 4-page limitation, it is impossible to show all the equations here. For this reason, the fundamental concepts are only explained and the chosen quantitative variables are presented.

Development: *Options of survival and self-fulfilment. It includes: life/health, social progress (education, culture, etc.) and standard of life (economic resources, comforts, etc.).*

It is related with the Gender Development Index (*GDI*) [5]. Note that the education quality is not computed in *GDI*, therefore it is included through the following four variables: a) primary school teachers trained to teach, b) performance of 15-year-old students in reading, mathematics and science, c) the average number of pupils per teacher in primary education in a given school year and d) public expenditure on education.

Freedom: *Non-restrictions to self-fulfilment. This would be the total freedom that, obviously, in a group must be limited by the dignity of the other members of the group.* The variables used in this subsystem are: a) Net migration rate, b) Stock of immigrants, c) International inbound tourists, d) Mobile phone subscriptions, e) Exports and imports and f) Research and development expenditure.

Peace: *Absence of violence, coercion and fear.* The corresponding quantitative variables to measure this concept are the prison population and the homicide rate.

Solidarity: *It is considered synonymous of brotherhood, that is, mutual aid.* The information to create the Solidarity Index are a) at-risk-of-poverty rate, b) share of total population living in a dwelling, and c) material deprivation rate.

Justice: *Mechanisms of prevention, protection and compensation for individuals or groups face to possible damages or benefits*”. The variables considered in this case are, a) the police officers, b) the professional judges, c) the prison population. and d) crimes and violence.

Finally, the Happiness Index (*HAIN*) is calculated through Eq. (1). The geometric mean is used because it is considered the best option to calculate indices [5].

$$HAIN(t) = \sqrt[5]{development * freedom * peace * solidarity * justice} \quad (1)$$

To validate this new index, we have compared it with the Overall Life Satisfaction Index (Fig. 2), calculated in the Human Development Reports [5].

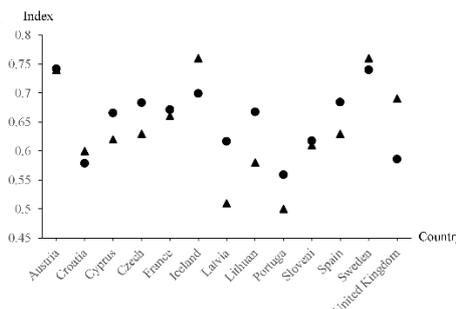


Fig 2. Happiness Index (circle) and Overall Life Satisfaction Index (triangle) in 2013 year. $R^2=0.5027$.

3. Demographic Model

The starting point of the demographic model is the model presented by [9] without age structure where all variables depend on time $t \in [t_0, \infty[$, $i=1$ refers to male and $i=2$ refers to female,

$$\frac{dPOPL_i(t)}{dt} = RFER_i(t) \cdot POPL_2(t) - RDEF_i(t) \cdot POPL_i(t) + (RINM_i(t) - REMM_i(t)) \cdot POPL_i(t) \quad (2)$$

where, $POPL_i$ is the total population, $RFER_i$ is the birth rate, $RDEF_i$ is the death rate, $RINM_i$ and $REMM_i$ are, respectively, the immigration and emigration rates.

In previous studies, birth and death rates depended on the well-being variables [7,10] or the environmental variables [8]. A goal of this paper is to introduce the Happiness Index in all demographic rates: birth, death and migration rates (emigration and immigration). The model, with this change, would be the following,

$$\begin{aligned} \frac{dPOPL_i(t)}{dt} = & RFER_i(xhdi, equi, hain) \cdot POPL_2(t) - \\ & RDEF_i(xhdi, equi, hain) \cdot POPL_i(t) + (RINM_i(xhdi, equi, hain) - REMM_i(xhdi, equi, hain)) \cdot \\ & POPL_i(t) \end{aligned} \quad (3)$$

Where, HDI , $EQUI$ and $HAIN$ are, respectively, the Human Development Index [11], the Environmental Quality Index [11] and the Happiness Index.

To do this, the input variables of the Happiness Index must be fitted by the time through a software (*Regint*) [12,13]. Regarding the Environmental Index, an extension of the temporal period is made, since in [8] the construction is for a time series from 2000 to 2007 and is needed until 2015. Finally, the Human Development Index is defined by the UN Human Development Reports [11] and there is a time series 2010-2014. In [5] there are values since 1980 but every 5 years. To have the time series analogous to the previous ones, the temporal trend is observed and it is fitted as a logistic function with a determination coefficient, $R^2 = 0.99964$.

The mathematical structure considered for the demographic rates are described as functions of the *three indices* as follows:

$$a0 + \frac{b0}{1 + \text{Exp}\left[\left(-b1 + \frac{xhdi \cdot hain}{equi}\right)/b2\right]} + \frac{c0}{1 + \text{Exp}\left[\left(-c1 + \frac{xhdi \cdot hain}{equi}\right)/c2\right]} \quad (4)$$

Logistic functions have the property that they can be interpreted in saturation of resources, and their use in demography has been proved to be very useful [14]. To introduce the Happiness Index in the fertility and mortality rates [8], the rates tendency with the new index is observed and it reveals direct relation. In the migration rates case, they are fitted with the same independent variable and with the same mathematical structure. Finally, the specific structures have been found by a trial and error process with the fitter tool *Regint* [12,13]. The fitted process is considered successful for three reasons: the R^2 are very high: female fertility rate $R^2=0.683692$, male fertility rate $R^2=0.705732$, female mortality rate $R^2=0.61328$, male mortality rate $R^2=0.809224$, female emigration rate $R^2=0.86737$, male emigration rate $R^2=0.887952$, female immigration rate $R^2=0.888557$ and male immigration rate $R^2=0.899601$. The randomness of the residuals has been verified and the Kolmogorov-Smirnov test is chosen to prove the data normality.

4. Validation

The historical data used in this article to fit the model have been obtained from the Spanish National Statistics Institute database [15] in 2001-2015 period. The software tool used for the model verification is *SIGEM* [13].

The validation is considered successful for three reasons: the visual evaluation of the graphic overlapping of the historical data and the calculated data is satisfactory, the determination coefficients, R^2 , are very high and the randomness of the residuals is verified by the maximum relative error, which do not exceed the 5%. As an example, Fig. 3 shows the female mortality and the male immigration.

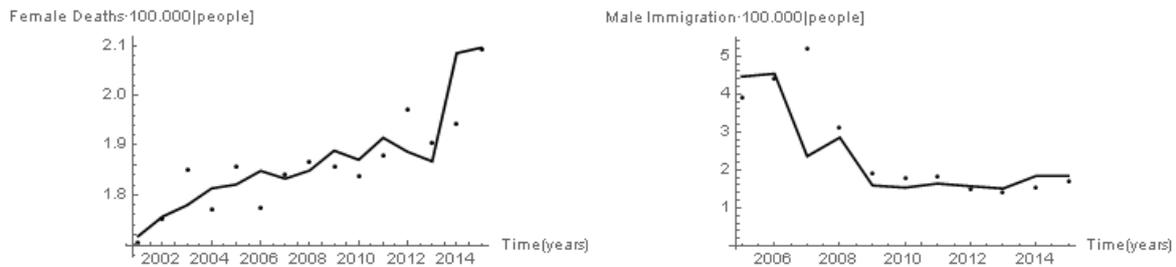


Figure 3. Left: Spanish Female Mortality, $R^2= 0.70961$. Right: Spanish Male Immigration, $R^2= 0.55873$. Real data (points), Fitted data (line), in 2001-2015 period.

5. Conclusion

A dynamic demographic model by sex has been presented where the birth, death and migration rates are calculated through variables related with well-being, environmental and happiness. The well-being and environmental variables have been presented in previous works [7,8] but the happiness variables are built in this work. A general formula is obtained from a Happiness Index. It is calculated through five fundamental concepts: solidarity, development, justice, peace and freedom. This formula provides similar values to those obtained with the Overall Life Satisfaction Index [5] in the case of 13 countries in 2013. The mathematical structures of the demographic rates are logistic function with a specific dependent variable ($\frac{x_{hdi-hain}}{equi}$). Finally, the study has been performed with a deterministic model and has been fitted and verified with the corresponding criteria and real data from Spain in the 2001-2015 period. Nowadays we are working on the design of the different strategies and scenarios to obtain a demographic sustainability with this model.

References

- [1] N. Extremera, P. Fernández-Berrocal, The Subjective Happiness Scale: Translation and preliminary psychometric evaluation of a Spanish version, *Soc Indicators Res.* 119(1) (2014) 473-81
- [2] E. Diener, R.A. Emmons, R.J. Larsen, S. Griffin, The Satisfaction with Life Scale, *J. Pers. Assess.*, 49 (1985) 71-75.
- [3] S. Lyubomirsky, H. Lepper, A Measure of Subjective Happiness: Preliminary Reliability and Construct Validation. *SOCI*, 46 (1999) 137-155.
- [4] <http://www.gallup.com/home.aspx> (accessed 24.03.2017)
- [5] UNDP, Human Development Report 2014. Oxford University Press. New York, Oxford, 2014.
- [6] A. Caselles, Trying to evaluate the human dignity in a social group. In: 9th Congress of the European Union of Systems (UES-EUS). Valencia (Spain), 2014.
- [7] M.T. Sanz, J.C. Micó, A. Caselles, D. Soler, A stochastic model for population and well-being dynamics. *J. Math. Sociol.*, 38 (2) (2014) 75-94.
- [8] M.T. Sanz, A. Caselles, J.C. Micó, D. Soler, Including an environmental quality index in a demographic model, *Int. J. Glob. Warm.*, 9(3) (2016) 362-396.
- [9] J.C. Micó, A. Caselles, D. Soler, Age-Structured Human Population Dynamics, *J. Math. Sociol.*, 30 (2006) 1-31.
- [10] A. Caselles, D. Soler, M.T. Sanz, J.C. Micó, Simulating Demography and Human Development Dynamics, *Cybernet. Syst.*, 45 (6) (2014) 465-485.
- [11] UNDP, Human Development Report. New York: Oxford University Press, 2010.
- [12] A. Caselles, A tool for discovery by complex function fitting. In *Cybernetics and Systems Research'98*. R. Trappl (ed.), Austrian Society for Cybernetic Studies, (1998) 787-792.
- [13] A. Caselles, Modelización y simulación de sistemas complejos (Modeling and simulation of complex systems). Valencia (Spain). Ed. Universitat de València, 2008. (Available in <http://www.uv.es/caselles> (accessed 24.03.2017) as well as SIGEM).
- [14] C. Marchetti, P. S. Meyer, J. H. Ausubel, Human Population Dynamics Revisited with the Logistic Model: How Much Can Be Modeled and Predicted? *Technological Forecast. Soc. Chang.*, 52 (1996) 1-30.
- [15] <http://www.ine.es/> (accessed 24.03.2017)