Presented at the DLSU Research Congress 2014
De La Salle University, Manila, Philippines
March 6-8, 2014

Estimating the mortality of the Philippines and some Southeast Asian countries using the Heligman-Pollard Model

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Abstract: In 1980, Heligman and Polard proposed an eight parameter mortality model encompassing the entire lifetime of a human life. The Heligman-Pollard model is given by:

$$\mu(x) = A^{(x+B)^C} + De^{-E(\ln x - \ln F)^2} + GH^x$$

In 2005, Ozeki used this model to fit eighteen Japan Life tables from 1891 to 2000. He then used the results to project the Japan Life Table for 2025. This paper will use the procedure suggested by Ozeki to estimate the parameters of the Philippine life table. Life tables of other Southeast Asian countries, namely Thailand, Malaysia, and Singapore will be used to find estimates for these countries' mortality using the same procedure.

Key Words: mortality models; life table; estimation

1. INTRODUCTION

One of the main problems in Actuarial Science studies is the determination of mortality of a group of lives. Several mortality models have been developed to explain the behaviour of the mortality of human lives. Some of the basic mortality models are the De Moivre's, Gompertz's and Makeham's. However, these basic models do not represent the mortality of lives very well. Over the years, several newer and better models has been formulated. Rodriquez and Wee (2007), used the Carriere's mixture model, with eleven parameters, to estimate Philippine mortality. This mixture consists of the Gompertz, the Inverse Gompertz, the Weibull, and the Inverse Weibull distributions. Furthermore, a bootstrapping technique was used to check the validity of the estimates obtained. De La Cruz, De La Cruz and Jos (2010) applied the Lee-Carter Model to estimate and forecast the mortality of the Baltic States of Estonia, Latvia, and Lithuania. The mortality of several Northern European countries were estimated and forecasted applying a Poisson log-bilinear approach by Chua and De Guzman (2011). Ozeki (2005) proposed several methods of estimating and forecasting mortality. He applied these methods to eighteen Japan Life tables with data from 1891 to 2000. One of the methods suggested by Ozeki is a simulation method. This simulation model was used by Ayusa, Bautista and Jos (2008) to estimate Philippine mortality. Another method suggested by Ozeki uses the Heligman-Pollard model. This is the model that we will use to estimate the mortality of lives in the Philippines, Malaysia, Singapore and Thailand.

2. METHODOLOGY

The eight-parameter, Heligman-Pollard model, developed in 1980 is given by:

$$\mu(x) = A^{(x+B)^C} + De^{-E(\ln x - \ln F)^2} + GH^x,$$

where A, B, C, D, E, F, G, H are parameters, x represents age, and $\mu(x)$ is the force of mortality. This model consists of three components. These components represent early childhood mortality, accidental mortality and senescent mortality, respectively.

The main problem of this research is to find estimates for these parameters. The estimates for these parameters are its values when the square sum,

$$s = \sum_{x=0}^{\omega} \left(\frac{\widehat{q_x}}{q_x} - 1\right)^2$$

is minimize. The notation q_x, represents the probability that a person aged x will die on or before attaining age x+1 for the observed data, , while $\widehat{q_x}$, represents the same probability statement using the model. The limiting age of the table is denoted by ω. The solver add-in of Microsoft Excel will be used to determine these estimates. This procedure requires initial estimates for the parameters. The initial estimates used are the estimates given by Ozeki (2005) for the Japan Life Table of 2000.

This paper will find estimates for the parameters of the Heligman-Pollard model for the mortality experience of the Philippines, Malaysia, Singapore and Thailand. The mortality tables for these countries were obtained from the website of the Actuarial Society of Hong Kong.

3. RESULTS AND DISCUSSION

The Philippine data used is the 1973-1978 Philippine Intercompany Table. The table is a joint table for male and female. The estimates for the parameters are given in Table 1.

Table 1. Estimates for the Philippines

Parameters	Estimates
A	0.00973677
B	1.69787558
C	0.18209364
D	0.00213094
E	0.39060002
F	53.51800418
G	0.00000627
H	1.13148267

A graphical representation of the observed mortality experience in the Philippines against the model results for the entire lifetime is given in Figure 1. This represents the graphs of log qx The value of s at the estimates when it is minimum is 1.39881719.

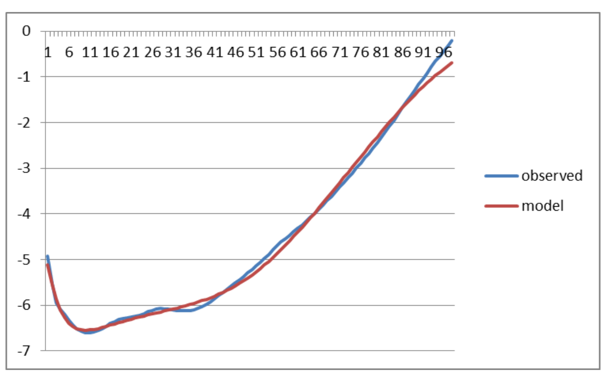

Fig. 1: Philippine mortality.

The data for Malaysia used is the 1983-1988 life table. There is are two tables, one for male and another for female. The estimates are given in Table 2.

Table 2: Estimates for Malaysia

Parameters	Malaysia(male)	Malaysia(female)
A	0.047110038	0.03881709
B	33.95225417	40.9754080
C	0.22324201	0.19577097
D	0.000495	0.00038448
E	19.25954257	26.12857615
F	21.88441654	24.92547888
G	0.00002954	0.00001896
H	1.10397049	1.10618413

The graphs of log qx given by the model and the observed data for Malaysia's male and female are given in Fig. 2 and Fig. 3 respectively. The minimum values of s are 1.03803237 and 1.17734828 for male and female respectively.

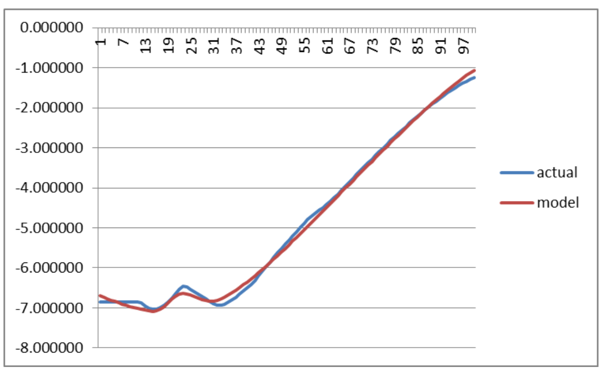

Fig. 2: Malaysia (male) mortality

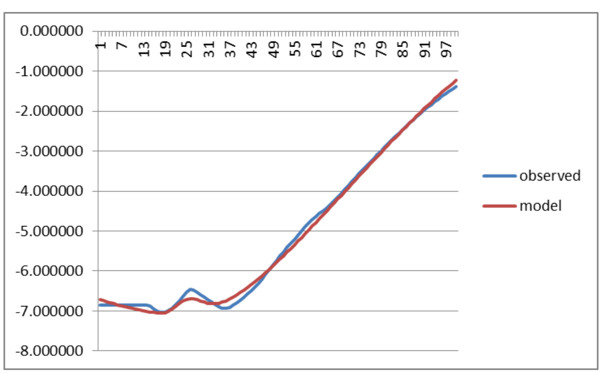

Fig. 3 : Malaysia (female) mortality

The data for Singapore is also split into male and female life tables. The data is from 1997 to 2002. The results are in Table 3.

Table 3: Estimates for Singapore

Parameters	Singapore(male)	Singapore(female)
A	0.00015711	0.00015445
B	0.20872659	0.17611851
C	0.00589027	0
D	0.00031119	0.00038450
E	22.90054835	6.50105779
F	22.27656037	54.68470743
G	0.00000813	0.00000144
H	1.11569343	1.13513807

The graphs of log qx given by the model and the observed data for Singapore's male and female are given in Fig. 4 and Fig. 5 respectively. The minimum values of s are 0.23722477 and 0.22898870 for male and female respectively.

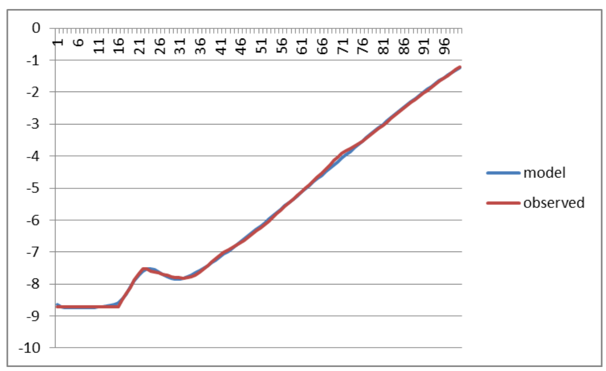

Fig. 4 : Singapore (male) mortality.

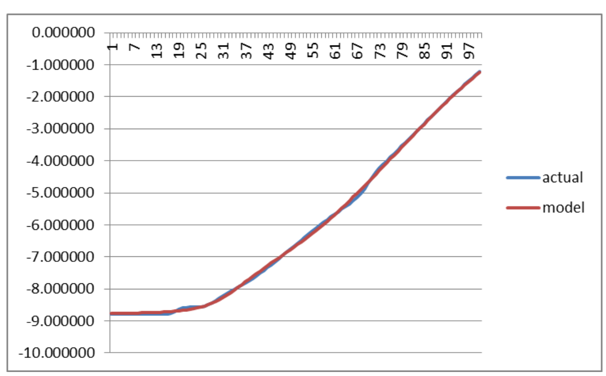

Fig. 5 : Singapore(female) mortality

The Thailand data is the 1997 Life table with separate tables for males and females. The estimates for the parameters are given in Table 4.

Table 4: Estimates for Thailand

Parameters	Thailand(male)	Thailand(female)
A	0.01212872	0.00413395
B	2.04539856	1.23475907
C	0.26649487	0.16199822
D	0.00490440	0.00081598
E	4.30046852	3.94815287
F	25.11473468	25.28382653
G	0.00014397	0.00004236
H	1.08803431	1.10055469

The graphs of log qx given by the model and the observed data for Thailand's male and female are given in Fig. 6 and Fig. 7 respectively. The values 0.20491924 and 0.15031391 are the minimum values for male and female respectively

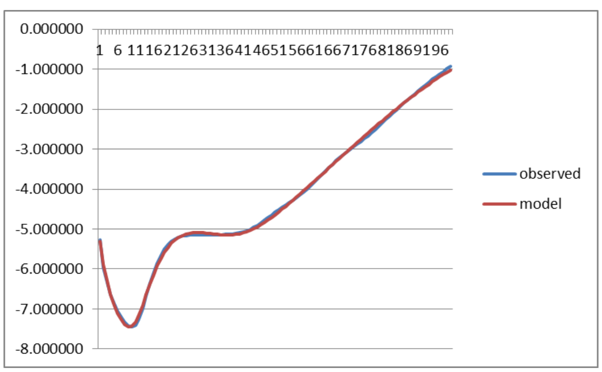

Fig. 6 : Thailand (male) mortality

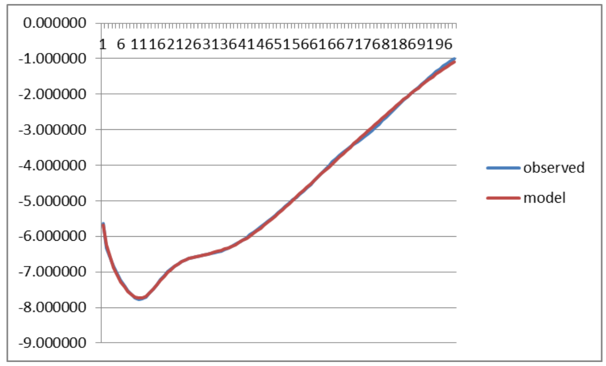

Fig.7 : Thailand (female) mortality.

4. CONCLUSIONS

The estimates for the parameters of Heligman-Pollard were obtained. We can see from the graphs, as well as from the minimum values of e that the Heligman-Pollard models fits very well with the Singapore and Thailand mortality experience for both male and female. However, there is still a need to establish the significance of these estimates. Furthermore, statistical tests has still to be applied to check the appropriateness of the model in fitting the mortality experience of the countries included in this study.

5. REFERENCES

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