The Socioeconomic Factors in Constructing Women Fertility Index: A Malaysian Case Study

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***Abstract*— Women fertility is rated by the average number of children a woman will have during her childbearing years. Malaysia is now facing a population crisis and the fertility rate continues to decline. This situation will have implications for the age structure of the population. Malaysia is expected to reach aging population status by the year 2035. As the aging population has a very long average life expectancy, the government needs to spend a lot on medical costs for senior citizens and need to increase budgets for pensions. The government may be required to increase tax revenues to support the growing older population. The falling fertility rate requires proper control by relevant authorities, especially through planning and implementation of strategic and effective measures. Hence, this paper aims to develop a fertility index using correlation and Shannon's entropy method. There are two main results from this analysis which are the factor rank and fertility index for each state. The three most important factors that influence fertility in Malaysia based on correlation method listed the number of females living in urban areas, number of females employed, and family planning methods while Shannon's entropy method listed female tertiary education attainments, number of divorces, and family planning methods. Next, the fertility index show that Selangor, Johor, and Sarawak are among the states with the highest values. On the other end of the spectrum, Terengganu, W.P. Labuan, and Perlis are ranked in the last positions. As a summary, the weighted calculation based on the correlation and entropy give different results in terms of rank the factors influencing the fertility. However, the results of both methods show that Selangor has the highest fertility index. From this study, the government may design the appropriate policies to mitigate dwindling fertility rates among Malaysian women.**

***Index Terms*—correlation; entropy; fertility; Malaysia**

I. INTRODUCTION

Women fertility is rated by the mean number of children that a woman will have during her childbearing years. Fertility patterns in the world have changed dramatically over the last few decades from 5.04 children per woman in 1965 to around 2.5 children per woman in 2015 [1]. Since the 1970s, a large number of developed countries such as United Kingdom, Canada, Denmark, and Germany have seen their fertility rates below replacement level [1].

As a developing country, Malaysia had experienced fertility declined over the years. Figure 1 shows the total fertility rate (TFR) in Malaysia from 1958 to 2016. Malaysia has recorded a TFR of 6.28 in 1958 and steadily declined to 5.06 in 1969. Afterwards, the TFR had reached 4.09 in 1977 and reduced to 3.13 in 1997. Furthermore, the TFR was at par with the replacement level in 2010 which is only 2.1 children per woman. The lowest TFR ever recorded was in 2016 which is only 1.9 children per woman.

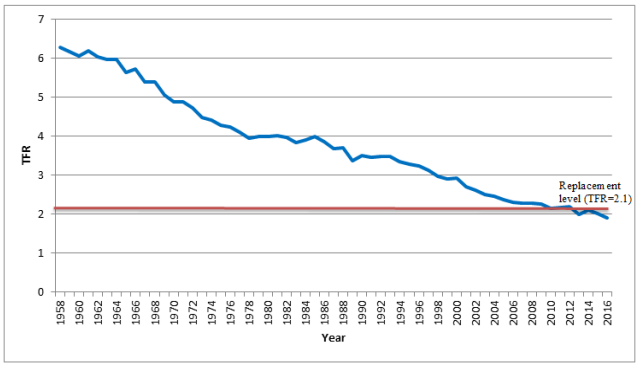

Figure 1: Total fertility rate (TFR) in Malaysia from 1958-2016

The negative influence of low fertility rate is the main cause to further investigate this topic. In society, low level of fertility rate is one of the economic challenges when the population age structure will be affected. In year 2035, Malaysia is projected to reach the status of aging population where percentages of senior citizens are higher than percentages of people aged below 5 years old [2]. This situation presents a major fiscal challenge for the government. Currently, it is a serious problem for governments in terms of what the effects will be on healthcare, care services, and pensions. The increasing age is associated with higher morbidity, higher use of health services i.e. number of visits to doctors and hospitalizations, and greater demand for specialized services. All these factors will lead to an increase in the complexity of health services required and increased the government expenditure. The government needs to spend a lot on medical costs for senior citizens and also needs to increase budgets for pensions. In order to support the growing older population, the government also required to increase the tax revenue that places an increasing burden on the young workers. The falling fertility rate requires proper control by relevant authorities, especially through planning and implementation of strategic and effective measures.

To the best of the authors' knowledge, the official report on the Malaysian women fertility index has not yet been studied. Therefore, in this study, we present the mathematical development for measuring fertility index to discover the ranking of the women population ability to have children. The women fertility index is perform to demonstrate the rank of each state in Malaysia. The fertility index plays an important role to explain the fertility level for each state in Malaysia from "high fertility" to "low fertility", as it may help the government to design appropriate policies aimed at increasing fertility rates among the Malaysian women.

For the development of women fertility index, there are several factors that potentially related to the fertility behavior can be employed in developing the women fertility index based on previous researchers findings. In details, there are seven factors that were used in this study as a potential determinant in fertility behavior which are place of living (urban or rural), age at first marriage, female tertiary education attainment, number of divorces, female participation in labor force, family planning methods, and female income.

In this study, the total number of children ever born (CEB) per woman was used as a measure of fertility. CEB is regularly used as proxy for fertility in various studies [3-5].

The rest of the paper is structured as follows. The next section defines the methodology which includes the data standardization, weight calculation and index development of the woman fertility for each state. To close the paper, we present the results, and conclusion of the study.

II. METHODOLOGY

The development of a fertility index requires three main steps; the first involves identification of factors related to fertility from comprehensive literature review, the second requires calculation of weighting factor, which involves application of correlation and Shannon's entropy method, and the final involves building of fertility index using methods of linear combination or weighted arithmetic average [6].

In this study, the data has been obtained from the Fifth Malaysian Population and Family Survey by the National Population and Family Development Board. The data standardization is performed since the measurement units and scales of seven factors differ. The standardization is used to transform different scales and units among various factors into common measurable units to allow for multi factor comparisons [7].

A. Data Standardization

Let $X = [x_{ij}]$ and $Z = [z_{ij}]$ being the elements of data matrix of number of children ever born (CEB) and standardized data matrix, respectively across all factors. Table 1 provides further information regarding the factors.

Table 1
Description of the Factors

No.	Factors	Description of factors
1	URBAN	Number of females living in urban areas by state
2	AGE	Female age at first marriage (years)
3	EDU	Number of females tertiary education attainments by state
4	DIVORCE	Number of divorces by state
5	EMPLOYED	Number of females employed by state ('000)
6	PLAN	Number of married couples using family planning methods by state
7	INCOME	Median monthly female income by state (RM)

In this study, to eliminate anomalies of measurements units and data scales, the data standardization is performed before calculate their weights [7]

$$z_{ij} = \frac{x_{ij}}{\sum_{j=1}^{k} x_{ij}} \quad (1)$$

B. Weight Calculation

In Table 2, the structure of the matrix is constructed with n number of location (state), i against k fertility factors, j and w_j is the weight of fertility factors j.

Table 2
Structure of the Matrix

	Factor 1	**Factor 2**	…	**Factor *k***
Location 1	x_{11}	x_{12}	…	x_{1k}
Location 2	x_{21}	x_{22}	…	x_{2k}
⋮	⋮	⋮		⋮
Location *n*	x_{n1}	x_{n2}	…	x_{nk}
	w_1	w_2	…	w_k

Since different factors have different meaning, it is not appropriate to assume that they all have equal weights. Methods for finding weights for each factor can be classified into two groups which are subjective and objective weights [7]. Subjective weights are determined only according to the preference off decision makers such as rank- based method, pair wise comparison method [8], Analytic Hierarchy Process (AHP) method, weighted least squares method, and Delphi method [9]. The objective methods determine weights for each factor by solving mathematical models without any consideration of the decision maker's preferences. The examples of objective weights are correlation method, entropy method, multiple objective programming, and principle element analysis [7]. Subjective weighting may be preferable in the most real problems, since the decision maker's expertise and judgments are taken into account. However, the use of objective weights is practical when obtaining such reliable subjective weights is difficult [7]. In this study, we proposed to implement correlation and Shannon's entropy methods for determining the weighting factor.

Correlation Method

The weighting factor based on correlation method was introduced by [10] and is also known as Hellwig method. The method states that the greater the correlation coefficient, the greater the weight for the factors.

After data standardization, correlation test is performed to test whether the correlations are significant among the factors. If correlations between factors are significant, the size of correlation between factors is taken into account in calculating the weights. The weighted value of a factor, which is estimated by this procedure, is equivalent to the absolute value of the normalized correlation for all factors, namely

$$w_j = \frac{r_j}{\sum_j r_j}, \quad r_j = \sum_l |r_{ij}| \tag{2}$$

where r_{ij} is the correlation coefficient between the i^{th} and the j^{th} factor.

Entropy Method

The concept of entropy was introduced by [11] in communications theory and the concept is now widely used in many different fields. The concept put forward by Shannon entropy is based on statistical theory. The method of entropy can be used in identifying objective weight which is based on the degree of uncertainty of the information as employed in probability theory [8, 12]. The entropy measure for the j^{th} factor is given by the following formula:

$$E_j = -\frac{1}{\ln n} \sum_{i=1}^{n} z_{ij} \ln(z_{ij}) \tag{3}$$

Entropy measures the size of uncertainty information contained in a decision characteristics, i.e. the larger the size, the lower the condition. The weight for the j^{th} factor is:

$$w_j = \frac{1 - E_j}{\sum_{j=1}^{k} 1 - E_j} \tag{4}$$

C. Index Development

This step is also known as aggregation method, which involves the process of combining a set of values into a single value. In this study, a linear combination method or weighted arithmetic average is used.

Mathematically, the fertility index (FI) can be written as follows:

$$FI_i = w_j z_{ij} + w_j z_{ij} + \ldots + w_j z_{ij} = \sum_j w_j z_{ij}, \quad \sum_j w_j = 1, \quad w_j \geq 0 \tag{5}$$

where,

FI_i = Fertility index for location i.

w_j = weight for factor $j, j = 1, 2, 3, \ldots, k$.

z_{ij} = normalized value of location $i, i = 1, 2, 3, \ldots, n,$ with respect to factor j.

III. RESULTS AND DISCUSSIONS

Correlation matrix of the factors affecting fertility is presented in Table 3. The correlations coefficients indicate that EMPLOYED, PLAN, DIVORCE, URBAN, and EDU have positive relationship with CEB. Meanwhile, the relationship between INCOME and CEB are negatively correlated, where high income has less number of children ever born, and vice versa. The increasing in age at first marriage also contributed to low number of children ever born.

Since correlations between variables are significant, the correlation size is taken into account in the weighting factor, and the weighted value is calculated using Equation 2. The resulted weights are shown in Table 4 and the women fertility index for each state in Malaysia are listed in Table 5.

The factors of URBAN, EMPLOYED, and PLAN which have highest weight, can be considered as important factors in explain fertility behavior among Malaysian women, followed by DIVORCE, EDU, INCOME, and AGE.

Table 3
Correlation matrix among factors

	URBAN	AGE	EDU	DIVORCE	EMPLOYED	PLAN	INCOME	CEB
URBAN	1	0.1915	0.8860	0.8259	0.9407	0.8800	-0.2414	0.9068
AGE	0.1915	1	0.4367	-0.1565	0.0014	-0.1043	0.2931	-0.1192
EDU	0.8860	0.4367	1	0.5884	0.7630	0.6448	-0.0789	0.6652
DIVORCE	0.8259	-0.1565	0.5884	1	0.8971	0.9132	-0.1804	0.9228
EMPLOYED	0.9407	0.0014	0.7630	0.8971	1	0.9674	-0.3148	0.9729
PLAN	0.8800	-0.1043	0.6448	0.9132	0.9674	1	-0.3393	0.9689
INCOME	-0.2414	0.2931	-0.0789	-0.1804	-0.3148	-0.3393	1	-0.4077
CEB	0.9068	-0.1192	0.6652	0.9228	0.9729	0.9689	-0.4077	1

Table 4
Initial value, weighted value, and factor rank for fertility using correlation method

Criteria	Initial value, r_j	Weighted value, w_j	Factor rank
URBAN	5.8723	0.1766	1
AGE	2.3027	0.0692	7
EDU	5.0631	0.1523	5
DIVORCE	5.4842	0.1649	4
EMPLOYED	5.8573	0.1761	2
PLAN	5.8178	0.1750	3
INCOME	2.8556	0.0859	6
	$\sum w_j = 1.0000$		

After the $FI_i, i = 1, 2, 3, \ldots, n$ are calculated, the state can be ranked from the highest index to the lowest index. Based on the results in Table 5, the state with the highest values of index presents better conditions for childbirth and childbearing.

Table 5
Fertility index by state using correlation method

Index	Rank	State
0.1311	1	Selangor
0.1202	2	Johor
0.1035	3	Sarawak
0.0758	4	W.P Kuala Lumpur
0.0714	5	Sabah
0.0656	6	Kedah
0.0588	7	Perak
0.0583	8	Pahang
0.0581	9	Melaka
0.0490	10	Negeri Sembilan
0.0486	11	Kelantan
0.0425	12	Pulau Pinang
0.0339	13	W.P Putrajaya
0.0304	14	Terengganu
0.0284	15	W.P Labuan
0.0245	16	Perlis

The results in Table 5 show that the state with the highest fertility index is Selangor, followed by Johor, Sarawak, W.P Kuala Lumpur, and Sabah. On the other end of the spectrum, Pulau Pinang, W.P Putrajaya, Terengganu, W.P. Labuan, and Perlis are ranked in the last positions according to the fertility index.

The entropy value, weighted value and rank of each factor are displayed in Table 6. In terms of rank the factors influencing the fertility, the weighted calculation based on Shannon's entropy method give different results from the previous method. The factors of EDU, DIVORCE, and PLAN, which have the highest weight, can be considered as important factors of fertility, followed by URBAN, EMPLOYED, INCOME, and AGE. Then, the fertility index for each state is calculated by using the weighted value in Table 6.

Table 6
Entropy value, weighted value, and factor rank for fertility using entropy method

Criteria	Entropy value, E_j	Weighted value, w_j	Factor rank
URBAN	0.9347	0.1802	4
AGE	0.9996	0.0012	7
EDU	0.9156	0.2328	1
DIVORCE	0.9327	0.1857	2
EMPLOYED	0.9401	0.1652	5
PLAN	0.9338	0.1825	3
INCOME	0.9810	0.0524	6
	$\sum w_j = 1.0000$		

The ranking of fertility index using Shannon's entropy method is almost similar to the index obtained by the correlation method. The results in Table 7 show that the state with the highest fertility index is Selangor, followed by Johor, Sarawak, W.P Kuala Lumpur, and Sabah. On the contrary, Pulau Pinang, W.P Putrajaya, Terengganu, W.P. Labuan, and Perlis are ranked in the last positions according to the fertility index.

Table 7
Fertility index by state using entropy method

Index	Rank	State
0.1444	1	Selangor
0.1268	2	Johor
0.1051	3	Sarawak
0.0779	4	W.P Kuala Lumpur
0.0701	5	Sabah
0.0651	6	Kedah
0.0587	7	Perak
0.0585	8	Pahang
0.0576	9	Melaka
0.0480	10	Kelantan
0.0476	11	Negeri Sembilan
0.0407	12	Pulau Pinang
0.0297	13	W.P Putrajaya
0.0266	14	Terengganu
0.0235	15	W.P Labuan
0.0197	16	Perlis

IV. CONCLUSION

The weighted calculation based on the correlation and entropy give different results in terms of rank the factors influencing the fertility. Correlation method listed the number of females living in urban areas, number of females employed, and family planning methods as the three most important factors that influence fertility in Malaysia. This is very different for the weights obtained through the entropy method in which the weight concentrated on female tertiary education attainments, number of divorces, and family planning methods. We cannot say that one of this weighted calculation methods is the best because it has their own specialty.

However, the results of the fertility index based on correlation and entropy method as proposed in this study show that Selangor has the highest fertility index. The reason for the high index in Selangor might be because the state government offer schemes to alleviate lower fertility amongst Selangor women [13]. These schemes includes allocation of RM1500 for newborn babies, parents that are eligible will receive financial help to pay for nursery or daycare centers registered with the Department of Social Welfare amounting to about RM100 every month, and payment aids of RM50 every month for children in pre-school education.

In addressing the problem of low fertility in Malaysia, all parties must play their role. The information generated from the results in this study can be used as a primary source for the government to design appropriate policies to mitigate dwindling fertility rates among Malaysian women i.e. provide income supports for families with children, and longer maternity and paternity leave. The government also can introduce a policy to provide free nurseries at all government agencies and linked companies in reducing the burden of childcare and to assist families in achieving work-life balance. Besides the government, the findings can also benefit the government agencies such as the National Population and Family Development Board. This agency can focus on the state with low fertility index such as W.P Labuan, Perlis, and Terengganu to provide more family planning services and fertility treatment.

The findings from this study make several contributions to the current literature. Based on certain crucial factors that influence the fertility rate in Malaysia, we propose the women fertility index as an indicator for verifying and measuring the degree of ability of the women population in Malaysia to have children. However, we accept that the choice to bear children is personal decision. However, this issue supposed to be taken seriously, with full of responsibility. It is important for married couples to motivate themselves to have more children with good quality of education as it can enhance the economic productivity in our country. Because, after all, not only increasing number of children being born is important, the quality of life of the children is also equally important for the long term benefit of the country.

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REFERENCES

[1] J. M. Fernandez-Crehuet, J. I. Gimenez-Nadal, and I. D. del Valle, "The International Multidimensional Fertility Index: The European Case", *Social Indicators Research*, 1-28, 2016.

[2] Department of Statistics Malaysia, "Population Distribution and Basic Demographic Characteristic Report 2010", 2010.

[3] V. K. Dwivedi, T. Sediadie, and N.O. Ama, "Factors affecting children ever born (CEB) in Botswana:Application of Poisson Regression Model", *Research Journal of Mathematical and Statistical Sciences*, 4(10), 1-9, 2016.

[4] D. L. Poston Jr, and S. L. McKibben, "Using zero-inflated count regression models to estimate the fertility of US women", *Journal of Modern Applied Statistical Methods*, 2(2), 10, 2003

[5] T. N. Peng, "Social, economic and ethnic fertility differentials in Peninsular Malaysia", in *IUSSP Conference on Southeast Asia's Population in a Changing Asian Context, held at the Siam City Hotel, Bangkok, Thailand*, 2002, pp. 10-13.

[6] M. Zulkifli, N.Ismail, A. M. Razali, and M. M. Kasim, "Development of car theft crime index in peninsular Malaysia", in AIP Conference Proceedings, 1602(1), 2014, pp. 975-982.

[7] F. H. Lotfi, and R. Fallahnejad, "Imprecise Shannon's entropy and multi attribute decision making", *Entropy*, 12(1), 53-62, 2010.

[8] N. H. M. Desa, A. A. Jemain, and M. M. Kasim, "Construction of a composite hospital admission index using the aggregated weights of characteristics", *Sains Malaysiana*, 44(2), 239- 247, 2015.

[9] R. Ginevičius, and V. Podvezko, "Objective and Subjective Approaches in Determining the Characteristics Weights in Multicharacteristics Models", *Transport and Telecommunication*, 6(1), 133- 137, 2005.

[10] Z. Hellwig, "On the Optimal Choice of Predictors", in *Toward a System of Quantitative Indicators of Components of Human Resources Development*, United Nations Educational, Scientific and Cultural Organization, 1968, pp. 10-15.

[11] C. E. Shannon, "A mathematical theory of communication", *The Bell System Technical Journal*, 27, 379-423, 1948

[12] C. L. Hwang, and K. Yoon, "Methods for multiple attribute decision making", in *Multiple attribute decision making*, Springer Berlin Heidelberg, 1981, pp. 58-191.

[13] Program Inisiatif Peduli Rakyat, Kerajaan Negeri Selangor, 2016.