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Life Expectancy and its Determinants: Vector Error Correction Model

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Abstract

Women life expectancy at birth determined by many factors. demographic, social, and economic factors. which include adult mortality rate, total fertility rate, education, and gross domestic product per capita. This research explained the effect of these factors on women life expectancy using Vector Error Correction Model (VECM). The results revealed that women life expectancy in Saudi Arabia will increase over time and that total fertility rate has a positive significant effect on women life expectancy in the long run. Female tertiary education ratio, teenage maternal fertility rate, adult women death rate and GDP per capita have a negative significant impact on women longevity in long run. However, in short run there is no causality running from teenage maternal fertility rate, adult women death rate and GDP per capita. This model achieved all Diagnostics tests including serial correlation, normality, heteroscedasticity, and serial correlation among the model variables. These results emphasis that Saudi Arabia is in the third stage of demographic transition theory; the stage of mature industrial.

Key words: *Life expectancy at birth, fertility, adult mortality rate, vector error correction model (VECM).*

Preamble

Life expectancy is range from about 45 years in low-income countries to over 80 years in high income countries. Life expectancy increased between 1840 and 2000 rapidly and mortality decreased continuously (Meslé and Vallin 2006, Christensen et al. 2009). Shkolnikov et al (2011) found that female life expectancy increased on an average by 0.43 year annually between 1870 – 1920 cohort. The best practice of life acceptancy gain more until 1950 correspondently, it reach 84 in 1950 cohort from 54 in 1870 birth cohort. Shkolnikov et al (2011) expected that life expectancy will reach 95 years in 2050. Since the third of 19th century, the period and cohort mortality rate declined rapidly, and life expectancy increased.

Economic growth improves the health care facilities that insure stable high life expectancy at birth. Lokpriy (2013) represent there is a positive impact of GDP per capita, access to safe water and sanitation, and secondary education on life expectancy in ninety low-income countries but the impact of health expenditure per capita is varies. Ngwen and Kouty (2015) explain the positive relation between life expectancy and economic growth in 141 developing countries from 2000 to 2013. Balan and Jaba (2011) found that life expectancy is positively correlated with number of doctors, beds and readers subscribed in libraries, and wages in Romania's regions in 2008. And the ratio of Roma population and illiterate population is correlated negatively with life expectancy. Life expectancy and it is determinants are homogenous in different region in Romania.

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Life expectancy is associated with the improvement in socioeconomic development. Good socioeconomic development implies reducing mortality and morbidity rate (Sen 1983). Health facilities, better sanitation, clean water, and education level reduce the death rate and raise life expectancy. These factors explain the higher life expectancy in developed countries. On other hand, these same factors decreased the life expectancy in developing countries (Gerring et al., 2005; Navarro et al., 2006; and Mahfuz, 2008).

Women Life Expectancy

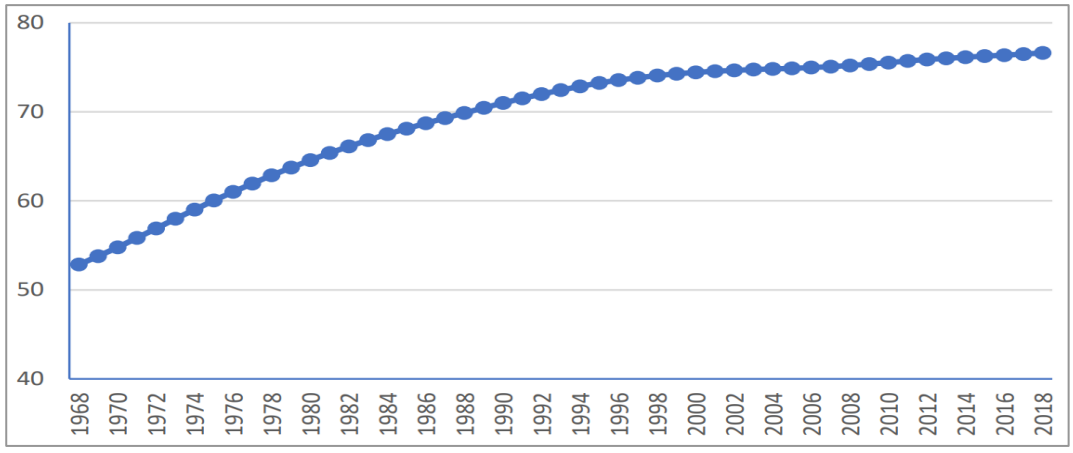

Figure (1): Women Life Expectancy.

Women life expectancy in Saudi Arabia is increased from 52.84 in 1968 to 76.62 in 2018 (World Bank Data). Figure (1) present the trend of women life expectancy.

Figure (2) show the trend of the model variables, when the women life expectancy increase, we note that total fertility rate, teenage maternal fertility rate (births per 1000 women aged 15-19 years), and adult women death rate are decreased. while the female tertiary education ratio is increased. But the GDP per capita increased until 1980 (36.84) then it decreased to 15.82 in 1985.then it fluctuated between 15.82 and 21.4 thousand USD in year.

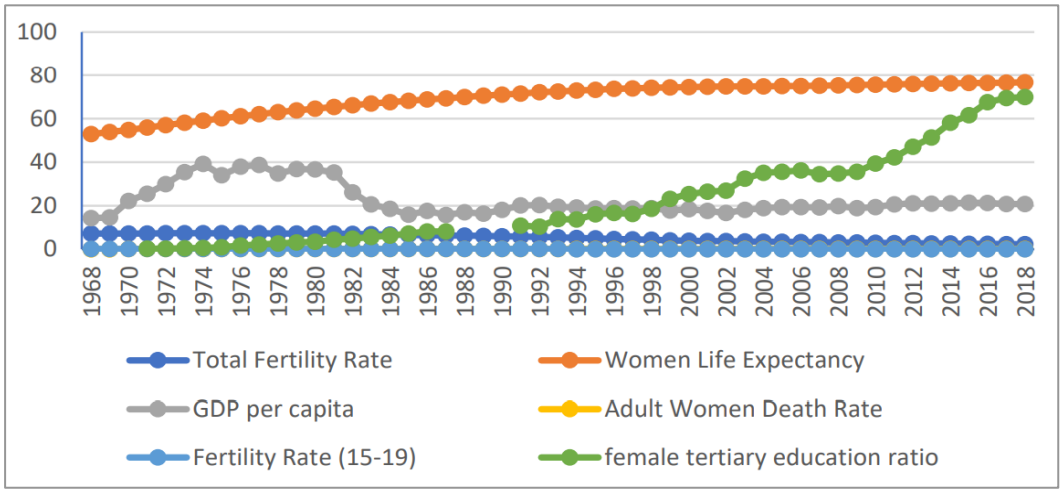

Figure (2): Life Excepectancy - Fertility - Death -GDP Per Capita - Tertiary Education.

The result in table (1) presents the descriptive statistics of the (VECM) variables. These statistics show that total fertility rate, teenage maternal fertility rate (births per 1000 women aged 15-19 years), adult women death rate, and GDP per capita are positively skewed, on other hand, women life expectancy and female tertiary education ratio are negatively skewed. The variables are normally distributed since the values of skewness and kurtosis reveal that all factors are statistically insignificant. Which confirmed by the estimated values of Jaque – Bera that indicate that all factors have zero mean and finite covariance.

Table (1): Descriptive Statistics.

	ELF	TFR	FRU19	AMR1	GDP	EDU
Mean	70.38482	4.962400	0.058813	129.7208	23.19737	22.85706
Median	73.55800	4.754000	0.041104	100.3900	20.15417	16.26193
Maximum	76.61500	7.313000	0.125409	256.3910	39.15208	69.87621
Minimum	55.83900	2.319000	0.007097	76.08000	15.69518	0.270100
Std. Dev.	6.256607	1.863713	0.047755	54.66961	7.197812	20.91535
Skewness	-0.918755	0.051064	0.360058	0.906576	1.211259	-0.806521
Kurtosis	2.499500	1.395260	1.407484	2.465750	2.861792	2.592156
Jarque-Bera	6.800516	4.848040	5.727515	6.699272	11.03942	5.190457
Probability	0.033365	0.078565	0.057054	0.035097	0.004007	0.074629
Observations	45	45	45	45	45	45

Where:

ELF: women life expectancy. TFR: Total fertility rate.

FRU19: Teenage maternal fertility rate. AMR: Adult women death rate.

GDP: GDP per capita.

EDU: female tertiary education ratio.

Vector Error Correction Model

In this research total fertility rate, teenage maternal fertility rate (births per women aged 15-19 years), adult women death rate, and GDP per capita will be used as endogenous variables to explain the improvement of women life expectancy in Saudi Aribia using the model Vector Error Correction (VECM).

Granger causality test is used to test the causality relationship between the women life expectancy and its determinants. Since the Granger causality test is one of many approaches that widely used with the vector error correction model (VECM) Engle and Granger (1987).

Table (2): Pairwise Granger Causality Tests.

Null Hypothesis:	Observations	F-Statistic	P- value
EDU does not Granger Cause ELF	41	15.2624	0.0000***
ELF does not Granger Cause EDU		0.90535	0.4134
AMR1 does not Granger Cause ELF	49	6.88990	0.0025**
ELF does not Granger Cause AMR1		8.03370	0.0011**
FRU does not Granger Cause ELF	49	2.15064	0.1285
ELF does not Granger Cause FRU		6.54243	0.0033**
GDP does not Granger Cause ELF	49	2.77924	0.0730
ELF does not Granger Cause GDP		8.44289	0.0008***
TFR does not Granger Cause ELF	49	3.26738	0.0475*
ELF does not Granger Cause TFR		11.2876	0.0001***

Granger causality test reveals that that there is bidirectional causality running between women life expectancy with total fertility rate and adult women death rate. There is one directional causality running from female tertiary education ratio to women life expectancy. There is one directional causality running from women life expectancy to teenage maternal fertility rate and GDP per capita. So, we can determine the VECM variables: total fertility rate, adult women death rate, female tertiary education ratio, teenage maternal fertility rate and GDP per capita are the endogenous variables in this model. Table (2).

Table (3): Unit Root Test.

variable	ELF	TFR	FRU19	AMR1	GDP	EDU
Augmented Dickey-Fuller test statistic	-2.597966	-2.8365	-1.86431	-1.082260	-2.06108	3.940679
P – value	0.1005	0.0611	0.3460	0.7158	0.2609	0.9998

Since the p-value of the Augmented Dickey – Fuller test is greater than 0.05, the variables are not stationary. All the series data have unit root problem which cause unfavorable regression results for policy effects Nelson and Ploser (1982). Then the absence of stationarity is necessary and sufficient to test the cointegration among the model variables. Table (3).

Table (4): VAR Lag Order Selection Criteria.

Lag	FPE	AIC	SC	HQ
0	0.039871	13.80509	14.06102	13.89692
1	4.37e-13	-11.45585	-9.664323	-10.81307
2	2.88e-15	-16.61308	-13.28596	-15.41934
3	1.56e-17*	-22.21350*	-17.35078*	-20.46880*

Table (4) show that the optimum lag order is (2) for the endogenous variables in the model using the information criterions: Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ).

The endogenous variables in this model have a long run relationship in explaining the increasing of women life expectancy over time in Saudi Arabia. Because Johansen cointegration test using maximum eigenvalues indicates that the null hypothesis of no cointegration among the endogenous variables of this model was rejected at level 5% and the second hypothesis which support co-integration of order

(1) among the variables of the model was accepted Table (5). Since the model variables are non-stationary at level, and they are cointegrated of order (1). The Vector Error Correction model (VECM) using (2) lags will estimate.

Table (5): Unrestricted Cointegration Rank Test (Maximum Eigenvalue).

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	P-value
None *	0.418361	30.56922	25.87211	0.0121
At most 1	0.090584	4.557739	12.51798	0.6606

The long run model (cointegrating equations) is:

$$ect_{t-1} = 1.00\,ELF + 0.014\,EDU(-1) - 1.852\,TFR(-1) + 0.0198\,FRU19(-1)$$

$$+0.079\,AMR(-1) + 0.012\,GDP(-1) - 0.2389\,@TREND3 - 66.66 \quad \text{….. eq. (1)}$$

Equation (1) represent the long run model for the women life expectancy as target variable which increase every year by 0.24, total fertility rate has a positive significant effect on women life expectancy in the long run. Female tertiary education ratio, teenage maternal fertility rate (births per 1000 women aged 15-19 years), adult women death rate and GDP per capita have a negative significant effect in long run; so, when these variables increased by one unit the women life expectancy will decreased by 0.1128 year.

Table (6): Vector Error-Correction Model Short Run Model Dependent Variable (ELF).

Variables	D(ELF)	T-Statistics	
		Value	P-Value
ect_{t-1}	-0.067	-5.100	0.000***
D (ELF (-1))	1.599	25.797	0.000***
D (ELF (-2)	- 0.822	-15.688	0.000***
D (EDU (-1))	0.000	1.250	0.223
D (EDU (-2))	0.001	2.416	0.023*
D (DMR (-1))	- 0.002	-1.453	0.158
D (DMR (-2))	0.000	0.322	0.750
D (FRU19 (-1))	0.000	0.257	0.799
D (FRU19 (-2))	- 0.001	-1.620	0.117
D (GDP (-1))	0.00003	0.110	0.913
D (GDP (-2))	- 0.0001	-0.329	0.745
D (TFR (-1))	0.700	6.802	0.000***
D (TFR (-2))	- 0.684	-5.177	0.000***
constant	0.084	5.959	0.000***
Adj. R-squared		0.99995	
F-statistic		37811.56***	
Prob(F-statistic)		0.000000	
Akaike AIC		-8.550261	
Schwarz SC		-7.959154	

The short run dynamic among the model variables through the Vector Error Correction Model (VECM) reveal the impact of endogenous variables on women life expectancy. The t-statistics value and its p- value show that there is a short run causality running from the total fertility rate and female tertiary education ratio to the women life expectancy at 5% level. But there is no short run causality running from teenage maternal fertility rate (births per 1000 women aged 15-19 years), adult women death rate and GDP per capita to the women life expectancy. Table (6).

At the long run there is a causality impact between women life expectancy and the endogenous variables as the significant negative value (-0.067) of ECM shows. ECM determine the speed of adjustments within which the model will restore its equilibrium following any disturbances, and the negative sign introduce the ability to bounce back to equilibrium. In this model ECM value explain that short run needs 14.9 years to converge in the long run equilibrium. These results introduce the variables that need to put a plan for to control the women life expectancy determinants in a long run to achieve the target level of women life expectancy in Saudi Arabia.

Diagnostics Tests

Usually, VECM attacked by one or more of these problems: serial correlation, normality, heteroscedasticity. Therefore, Lagrange multiplier test used to test the absence of serial correlation among the model variables; the p-value of the test was greater than 5% which

indicate that there is no serial correlation among the model variables. Residuals are normally distributed based on a test of skewness and kurtosis of residual. The Breusch and Pagan – Godfrey test show that the residuals are homoscedastic because the p-value of the test is greater than the 5%. Since the estimated model fulfill all the requirement of good regression model, we can used it for forecasting. Table (7).

Table (7): Diagnostic Tests.

Test Statistics	value	P – value
1. Serial Correlation	0.355	0.7046
2. normality	1.208	0.5464
3. heteroscedasticity	0.794	0.6865

1. Lagrange Multiplier test of serial correlation.
2. Based on a test of skewness and kurtosis of residual.
3. Breusch and Pagan – Godfrey test.

To examine the parameters constancy in this model used the cumulative sum of square of recursive residual CUSUM test. Because the inconstancy of parameters leads to misspecification of the model and that may give bias results which influence the explanation of the model. Hansen (1996). Figure (1) represent the plot of CUSUM which reveals that the parameters are constancy since the test is within the critical bounds at 5% significant level.

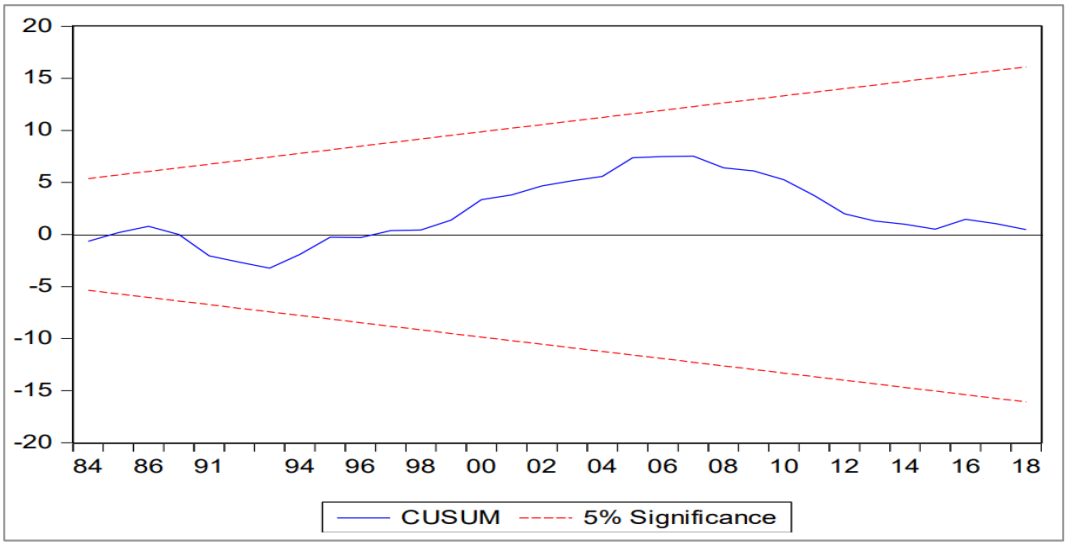

Figure (3): Cumulative Sum of Square of Recursive Residual.

Conclusions

This empirical model analyzed the impact of women life expectancy determinants in short and long run. the results reveal that total fertility rate, teenage maternal fertility rate, adult women death rate, GDP per capita, and female tertiary education ratio have influenced on women life longevity in long run. The results show that fertility rate has a positive effect on women life longevity, despite women life expectancy increased from 52.884 to 79.615 in 50 years and the fertility rate decreased from 7.267 to 2.319; these results implies that more reduction in fertility rate and good living standard will eventually result in an aging population John (2014),

and notes that total fertility tend to reach the replacement level 2.1 in few years in Saudi Arabia. This result support that Saudi Arabia in third stage of the demographic transition, Industrial stage in which population increase despite declining birth rates and low death rates, resulting from increased living standards. Female tertiary education ratio has a positive effect in short run. But it has a negative impact on women longevity in long run, maybe this occurred because of lifestyle for more educated women that they have more stress and complex explosibilities Bilas et al. (2014). Decreasing in teenage maternal fertility rate (births per 1000 women aged 15-19 years) is a result of delaying first marriage age because of women education which appear in the female tertiary education ratio. The improvement in health care services: Prenatal and maternity care decrease the adult women death rate in Saudi Arabia which has a positive impact on women longevity in long run. The empirical model explains that GDP per capita has a negative significant effect on women life longevity. More aging women will create an economic burden on the shrinking working population in long run.

Finally, these determinants have a significant impact in improving women life longevity. this research make recommends for the policy makers to increase productivity and economic growth and improve the work conditions that will decrease the bad affection of lifestyle such as bad nutrition and low physical activities which minimize the women longevity in long run.

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