Modelling life expectancy in Turkey

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Abstract

This study is concerned with understanding the factors of life expectancy in Turkey for the period 1965-2005. The determinants of life expectancy in Turkey are related to selected social, economical and environmental factors. Bounds testing approach to cointegration is employed to compute the long-run elasticities of longevity with respect to the selected economic, social and environmental factors. There exists no previous study that estimates empirically the determinants of life expectancy in Turkey on the basis of time series data and cointegration framework. Empirical results suggest that nutrition and food availability along with health expenditures are the main positive factors for improving longevity whereas smoking seems to be the main cause for mortality. The results also draw a number of policy recommendations for improving longevity.

JEL classifications: C22; I12.

Keywords: life expectancy; econometrics; cointegration; elasticities; Turkey.

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1. Introduction

Life expectancy or mortality rates in a country are a broad measure of the nation's health status, which is an outcome of several economic, social and environmental factors. There are a number of important policy issues concerning the level of life expectancy which affect economic growth, fertility, human capital investment, intergenerational transfers, and social security claims. Regarding the size and growth of health care related industries and rising costs in medical and insurance costs, the determinants of life expectancy for a given country become a very important issue.

In essence, the main aim of a public health care policy is to maintain and improve the nation's health status. Therefore, it is crucial to identify the factors which contribute to the health of the population. The information on the nation's health status helps policy makers and practitioners in their search for cost effective mechanisms for providing health services and reallocation of health resources to optimize the gains from health expenditures. The measurement of the nation's health status is difficult to measure directly since this situation is produced by a set of economic, social and environmental factors. Some researchers suggest life expectancy at birth or mortality rate for infants and children, as indicators of the health output (see, for example, Behrman and Deolalikar; 1988).

The total Turkish health expenditure accounted for 7.7% of the GDP (Gross Domestic Product) in 2004, which is more than 1 % point below the average of 8.9% across the Organization for Economic Cooperation and Development (OECD) countries. Health spending per capita in Turkey is the lowest among all OECD countries, with spending of 580 US dollars in 2004, in comparison with an OECD average of 2550 US dollars. Yet, health spending per capita in Turkey grew very rapidly, in real terms, by an average of 8.0% per year during 1999-2004. The public sector is the main source of health funding, which accounts for 72% of the total spending in 2004, which is slightly below the average of 73% in OECD countries. The resources in the Turkish health care industry are the most limited in all OECD countries. For example, in 2003, Turkey had 1.4 physicians per 1000 population which is less than half of the OECD average of 3.0. Similarly, there were only 1.7 nurses per 1000 population in Turkey in 2003, compared with an OECD average of 8.3. Although life expectancy at birth in Turkey increased by over 20 years between 1960 and 2004, which stood at 71.2 years in 2004. However, it is still below the OECD average of 78.3. Despite rapid falls in infant mortality rates over the past few decades, Turkey has still the highest infant mortality rates amongst 30 OECD countries. The rate stood at 24.6 deaths per 1000 live births in 2004, still over four times higher than the OECD average of 5.7 (OECD, 2006).

The objectives of this study are as follows: to estimate the elasticities of the life expectancy equation using the ARDL (Auto Regressive Distributed Lag) approach to cointegration methodology; and to implement parameter stability tests to ascertain stability or instability for the estimated model.

The aim of this study is to investigate the main determinants of the life expectancy in Turkey and provide some policy guidelines for the policy makers. The econometric results obtained from this research may lead to appropriate and efficient health policy designs to raise the life expectancy. The stability of the estimated econometric model is also particularly important to make inferences and forecast from it. The brief findings of this article are as follows: nutrition plays a primary role to increase the longevity which is followed by the factor of health spending. Cigarette smoking has a substantial adverse impact on life expectancy. The other socio economic factors such illiteracy, crime and urbanization appear to have minimal impacts for the longevity. Therefore, the health policies should focus on increasing the amount of food availability with nutrients and investing in medical care. Combination of fiscal, social and educational policies should be implemented to reduce smoking habits.

The remainder of this paper is organized as follows: the next section present a brief conceptual framework. Section three provides a selected literature review on health status. Section four outlines the study's model and methodology. The fifth section discusses the empirical results, and the last section concludes.

2. Conceptual framework

The information on the nation's health status is usually derived from its health production function. Health production function describes the relationship or flows of inputs and flows of outputs over a specified period. Output is some measure of health status such as life expectancy or morbidity. Inputs could be health care, medical expenditures, environment, education, life style, genetic factors, etc.

Grossman's (1972) model for health is useful for conceptualizing the health production function. According to Grossman's model, people are viewed as producers of health by the choices they make about their behaviors and their use of medical care. As an outcome of this process, lifetimes are more or less healthy. People are constrained in their opportunities to produce health for various reasons: financial constraints, time constraints, baseline endowments of physical and mental health, and the social and natural environments and contexts they occupy. Grossman (1972) theoretical health model can be simplified as follows:

$$H=f(X) \quad (1)$$

where H is a measure of health output and X is a vector of individual inputs to the health production function, f. This theoretical model was designed initially for analysis of health production function at micro level. However, as shown in Fayissa and Gutema (2005), the same analysis can be switched to macro level without losing theoretical ground by dividing X into three sub-categories:

$$h=f(Y, S, V) \quad (2)$$

where h is individual's health status is proxied by life expectancy at birth, Y is a vector of per capita economic variables, S is a vector of per capita social variables, and V is a vector of per capita environmental factors. Grosmann (1972) model for health has been modified according to the adopted econometric procedure. Thus, determinants of life expectancy function are derivative of health production function see for example Shaw *et al.,* (2005) and Kabir, (2008). In the empirical analysis, the list of the variables in each sub-group may differ substantially due to the data limitations, cultural and environmental conditions of a country under study.

3. A brief literature review of health status

The pioneering study of Auster *et al.* (1969), on a population production function for health, investigated affects of health care and environmental factors on mortality. Subsequently a small body of research has emerged which aims at identifying primarily the determinants of life expectancy or mortality rates.

There are two strands in the literature on empirical studies of the nation's health status. The first strand focuses on macro data (average values at the country, state, or national levels). The major advantage of this approach is that estimates of the overall effect of health care utilization on the health status of the population can be obtained. Examples of this approach are: Auster *et al*. (1969), Rodgers (1979), Peltzman (1987), McAvinchey (1988), Babazono and Hillman (1994), Barlow and Vissandjee (1999), Cremieux, *et al*. (1999), Ngongo *et al*. (1999), Filmer and Pritchett (1999), Miller and Frech (2000), Martinez-Sanchez *et al.* (2001), Lichtenberg (2002), Thorton (2002), Audrey (2004), Wang (2003), Fayissa and Gutema (2005), Shaw *et al*. (2005), Chang and Ying (2008), Kabir (2008), and Shin-Jong (2009). The second strand is based on the individuals as the unit of measurement, which is usually related to clinical and epidemiological studies and they rarely yield macroeconomic policy implications; see, for example, Wise (1997) and Khuder (2001). Nixon and Ulmann (2006) provides a good empirical review of literature on the relationship between health expenditures and health outcomes with special references to the links between health status and its determinants. Table 1 displays the summary results of the selected empirical research on health status.

Table 1. Summary results of the selected empirical works on health status					
Author	Health Status	Period	Data	Method	Country
Auster *et al* (1969)	DR at AG	1967	CS	OLS	USA
Rodgers (1979)	LE and DR	NS	CS	OLS	56 countries
McAvinchey (1988)	M	1960-1982	TS	ADL	5 European countries
Peltzman (1987)	DR	1970-1980	CS	GLS	22 countries
Babazono and Hillman (1994)	IM	1988	CS	OLS	21 OECD countries
Barlow and Vissandjee (1999)	LE at birth	1988	CS	OLS	OECD
Cremiux *et al*. (1999)	LE at birth	1978-1992	PTS	GLS	Canada
Filmer and Pritchett (1999)	IM	1990	CS	OLS/IV	119 countries
Ngongo *et al*. (1999)	DR at AG	1980-1992	Panel	DS	Italy
Miller and Frech (2000)	LE at AG	1996	CS	OLS	21 OECD countries
Martinez-Sanchez *et al.* (2001)	DR at AG	1991	CS	DS	Spain
Audrey (2004)	M	1948-1996	TS	ECM	USA
Licthenberg (2002)	LE at birth	1960-1997	TS	ML	USA
Thorton (2002)	DR	1990	CS	2SLS	USA
Wang (2003)	DR at IM	1990	CS	IV	60 low income countries
Fayissa and Gutema (2005)	LE at birth	1990-2000	CS	GLS	31 African countries
Shaw *et al*. (2005)	LE at AG	1990	CS	OLS	19 OECD
Nixon and Ulmann (2006)	IM	1980-1995	CS	OLS	15 EU countries
Kabir (2008)	LE at birth	2002	CS	OLS	91 countries
Chang and Ying (2008)	DR at AG	1982-1999	Panel	GMM	Taiwan
Shin-Jong (2009)	M	1976-2003	Panel	PEM	Asia-Pacific region

Keys: AG (Age Groups) LE (Life Expectancy), NS (Not Specified), IM (infant Mortality), M (All Cause Mortality), DR (Death Rate), CS (Cross-Section), TS (Time Series), PTS (Pooled Time Series), ML (Maximum Likelihood), DS (Descriptive Statistics), OLS (Ordinary Least Squares), ADL (Almon Distributed Lag), IV (Instrumental Variables), 2SLS (Two-Stage Least Squares), GLS (Generalized Least Squares), ECM (Error Correction Model), GMM (Generalized Method of Moments), PEM (Panel Econometric Methods).

In empirical research, life expectancy is measured either at birth as an average for the entire population, as in the case of Peltzman (1987) and Fayissa and Gutema (2005), or it is measured at various age stratums, see for example, Miller and Frech (2000) and Shaw *et al.* (2005), which further distinguishes life expectancy by age and gender. The literature illustrates that the appropriate determinants of the health status function and their relative importance are contentious. The economic determinants of the nation's health status may consist of income, health expenditure, food availability, and pharmaceutical expenditure. Social factors or life style measures of life expectancy include cigarette smoking, alcohol consumption, education, political situation, and marital status. Environmental factors of longevity are related to urbanization, wealth, safety, industrialization and regulation. The selection of these factors ranges from one study to another depending on the preferred model and data availability.

The econometric methodologies and procedures of health status function vary from simple statistical descriptive analysis to panel data econometrics. As far as this study is concerned, there exists no previous study that estimates empirically the determinants of life expectancy on the basis of the ARDL approach to cointegration; therefore, this research aims at expanding the health economics literature from this point of view. Moreover, it appears that there has not been any empirical investigation into aggregate determinants of Turkish health status function. Hence, this study endeavours to fill this gap in the literature.

4. Model and econometric methodology

Following the empirical literature in health status function, the determinants of life expectancy in semi- logarithmic form is constructed as:

$$le_t = a_0 + a_1 me_t + a_2 f_t + a_3 s_t + a_4 IR_t + a_5 CR_t + a_6 UR_t + \varepsilon_t \quad (3)$$

where le_t is life expectancy at birth total (in logarithm), me_t is real medical expenditures per capita (in logarithm), f_t is food production index (in logarithm), s_t is cigarette smoked per capita (in logarithm), IR_t is illiteracy rate, CR_t is crime rate per capita, UR_t is urbanization and ε_t is the regression error term.

Economic factors of life expectancy are assumed to be represented by real health expenditures per capita and food production index. Social determinants of life expectancy are explained via cigarette smoking per capita and illiteracy rate. Finally, it is deemed that crime rate per capita and urbanization may represent appropriately environmental factors of life expectancy. Life expectancy at birth is usually being used as the dependent variable indicating that the number of years a newborn infant would live if the existing conditions of mortality at the time of its birth remain to be the same throughout its life span.

As for the expected signs in equation (3), one expects that $a_1 > 0$ or $a_1 < 0$. In the case of the first situation, higher medical expenditures should result in an increase in the provision of health facilities, which ultimately may improve longevity, providing that the rise in expenditure has no adverse impact on the person's health situation. The latter situation may occur if the medical expenditures are financed from user fees or taxes and if the fees and tax payments decrease financial resources of the individual preventive health care, such as food, clothing and housing. This situation implies that the forgone benefits from preventive health care are greater than the marginal impact of a rise in the medical provisions. The food production index represents availability of nutrition and consumption. The index consists of food crops that are considered edible and include nutrients. Some foods such as coffee and tea are excluded from the index as they have no nutritive value. One expects that the index has a positive impact on life expectancy, $a_2 > 0$.

The negative relationship between cigarette consumption and poor health is well established and documented. There are a number of fatal diseases such as cancer related to cigarette consumption; therefore it is reasonable to expect that $a_3 < 0$. Adult illiteracy rate is employed as a proxy for education. It is argued that the people in this category may not make many plausible decisions in finding jobs, in pursuing a healthy life style, in avoiding unhealthy habits, and in efficient use of medical facilities. Therefore, the more literate a society is, the healthier its people will be, implying that $a_4 < 0$.

Crime rates in a society reveal the level of peace and public order. The societies with a strong security force and obedience to law provide peaceful living environments, which in turn have a positive impact on life expectancy. Violence and civil unrest may have a negative impact on life expectancy. Crime is measured as the ratio of convicts to the population. Urbanization is measured as the percentage of the population that lives in cities and towns. This variable is used as a proxy for a collection of potential negative and positive health related factors including pollution, congestion, and access to medical care. Urbanization is generally associated with pollution and congestion which both have adverse effects on health. On the other hand, urbanization avails access to medical care and health information. Urban public health institutions are better equipped with the specialist medical knowledge and manpower. Thus, the impact of urbanization on life expectancy depends on the net effect of the two contradictory factors.

The recent advances in econometric literature dictate that the long-run relation in equation (3) should incorporate the short-run dynamic adjustment process. It is possible to achieve this aim by expressing equation (3) in an error-correction model as suggested in Engle-Granger (1987).

$$\Delta le_t = a_0 + \sum_{i=1}^{m1} a_{1i}\Delta le_{t-i} + \sum_{i=0}^{m2} a_{2i}\Delta me_{t-i} + \sum_{i=0}^{m3} a_{3i}\Delta f_{t-i} + \sum_{i=0}^{m4} a_{4i}\Delta s_{t-i} + \sum_{i=0}^{m5} a_{5i}\Delta IR_{t-i} + \sum_{i=0}^{m6} a_{6i}\Delta CR_{t-i} + \sum_{i=0}^{m7} a_{7i}\Delta UR_{t-i} + \gamma\varepsilon_{t-1} + \mu_t \qquad (4)$$

where Δ represents change , γ is the speed of adjustment parameter and ε_{t-1} is the one period lagged error correction term, which is estimated from the residuals of equation (3). The Engle-Granger method requires all variables in equation (3) are integrated of order one, $I(1)$ and the error term is integrated order of zero, $I(0)$ for establishing a cointegration relationship. If some variables in equation (1) are non-stationary we may use a new cointegration method offered by Pesaran *et al*. (2001). This approach, is also known as the ARDL approach to cointegration, combines Engle-Granger (1987) two steps into one by replacing ε_{t-1} in equation (4) with its equivalent from equation (3). ε_{t-1} is substituted by linear combination of the lagged variables as in equation (5).

$$\begin{aligned}\Delta le_t &= a_0 + \sum_{i=1}^{n1} a_{1i}\Delta le_{t-i} + \sum_{i=0}^{n2} a_{2i}\Delta me_{t-i} + \sum_{i=0}^{n3} a_{3i}\Delta f_{t-i} + \sum_{i=0}^{n4} a_{4i}\Delta s_{t-i} + \\ &\sum_{i=0}^{n5} a_{5i}\Delta IR_{t-i} + \sum_{i=0}^{n6} a_{6i}\Delta CR_{t-i} + \sum_{i=0}^{7} a_{7i}\Delta UR_{t-i} + \\ &a_8 le_{t-1} + a_9 me_{t-1} + a_{10} f_{t-1} + a_{11} s_{t-1} + a_{12} IR_{t-1} + a_{13} CR_{t-1} + a_{14} UR_{t-1} + v_t\end{aligned} \quad (5)$$

To obtain equation (5), one has to solve equation (3) for ε_t and lag the solution equation by one period. Then this solution is substituted for ε_{t-1} in equation (4) to arrive at equation (5). Equation (5) is a representation of the ARDL approach to cointegration.

Pesaran *et al.* cointegration approach, also known as bounds testing, has some econometric advantages in comparison to other single cointegration procedures. They are as follows: i) endogeneity problems and inability to test hypotheses on the estimated coefficients in the long-run associated with the Engle-Granger (1987) method are avoided; ii) the long and short-run parameters of the model in question are estimated simultaneously; iii) the ARDL approach to testing for the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely *I*(0), purely *I*(1), or a combination of the two; iv) the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration, as argued in Narayan (2005).

A brief outline of Pesaran *et al*. procedure is presented as follows. The bounds testing procedure is based on the F or Wald-statistics and is the first stage of the ARDL cointegration method. Accordingly, the null of no cointegration hypothesis, (H_0: $a_8 = ... = a_{14} = 0$) is tested against the alternative hypothesis (H_1: not all $a_8 \ to \ a_{14} = 0$). Thus, Pesaran *et al*. compute two sets of critical values for a given significance level with and without a time trend. One set assumes that all variables are *I*(0) and the other set assumes they are all *I*(1). If the computed F-statistic exceeds the upper critical bounds value, then the H_0 is rejected. If the F-statistic falls into the bounds then the test becomes inconclusive. Lastly, if the F-statistic is below the lower critical bounds value, it implies no cointegration. This study, however, adopts the critical values of Narayan (2005) for the bounds F-test rather than Pesaran *et al.* (2001). As discussed in Narayan (2005) given a relatively small sample size in this study (41 observations), the critical values produced by Narayan (2005) are more appropriate than that of Pesaran *et al*. (2001). The critical values of Pesaran *et al.* (2001) are computed for a large sample size (T=500 to T=40,000). Narayan and Narayan (2005) argued that these critical values are biased considerably downwards. Therefore, the critical values produced in Narayan (2005) for small sample sizes ranging from T=30 to T=80 are more appropriate to use.

The short-run effects between the dependent and independent variables are inferred by the size of coefficients of the differenced variables in equation (5). The long-run effect is measured by the estimates of lagged explanatory variables that is normalized on estimate of a_8 .

Once a long-run relationship has been established, equation (5) is estimated using an appropriate lag selection criterion. At the second stage of the ARDL cointegration procedure, it is also possible to obtain the ARDL representation of the error correction model. To estimate the speed with which the dependent variable adjusts to independent variables within the bounds testing approach, following Pesaran *et al*. (2001) the lagged level variables in equation (5) are replaced by EC_{t-1} as in equation (6).

$$\Delta le_t = a_0 + \sum_{i=1}^{q1} a_{1i}\Delta le_{t-i} + \sum_{i=0}^{q2} a_{2i}\Delta me_{t-i} + \sum_{i=0}^{q3} a_{3i}\Delta f_{t-i} + \sum_{i=0}^{q4} a_{4i}\Delta s_{t-i} + \sum_{i=0}^{q5} a_{5i}\Delta IR_{t-i} + \sum_{i=0}^{q6} a_{6i}\Delta CR_{t-i} + \sum_{i=0}^{q7} a_{7i}\Delta UR_{t-i} + \lambda EC_{t-1} + \mu_t \quad (6)$$

A negative and statistically significant estimation of λ not only represent the speed of adjustment but also provides an alternative means of supporting cointegration between the variables.

The existence of a cointegration derived from equation (5) does not necessarily imply that the estimated coefficients are stable, as argued in Bahmani-Oskooee and Chomsisengphet (2002). The overall stability of coefficients of regression equations are, by and large, tested by means of Chow (1960), Brown *et al*. (1975), Hansen (1992), and Hansen and Johansen (1993). The Chow stability test requires *a priori* knowledge of structural breaks in the estimation period and its shortcomings are well documented, see for example Gujarati (2003). In Hansen (1992) and Hansen and

Johansen (1993) procedures, stability tests require $I(1)$ variables and they check the long-run parameter constancy without incorporating the short-run dynamics of a model into the testing - as discussed in Bahmani-Oskooee and Chomsisengphet (2002). Hence, stability tests of Brown *et al*. (1975), which are also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests based on the recursive regression residuals, may be employed to that end. These tests also incorporate the short-run dynamics to the long-run through residuals. The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the break points of the model. Provided that the plots of these statistics fall inside the critical bounds of 5% significance, one assumes that the coefficients of a given regression are stable. These tests are usually implemented by means of graphical representation.

5. Empirical results

Annual data over the period 1965-2005 were used to estimate equation (5) by the Pesaran *et al.* (2001) procedure. Data definition and sources of data are cited in Appendix A.

To implement the Pesaran *et al*. procedure, one has to ensure that none of the explanatory variables in equation (3) is above $I(1)$. It is; therefore, essential to apply some unit root tests. Three unit root tests were implemented: Augmented Dickey-Fuller (ADF) (1979, 1981), Phillips-Perron (PP) (1988), and Elliott-Rothenberg-Stock (ERS) (1996). The unit root test result displayed in Table 2 verify that the model variables in equation (3) are in mixture of $I(0)$ and $I(1)$, which also warrant to implement the Pesaran *et al*. cointegration approach.

Table 2. Order of Integration			
Series	ADF	PP	ERS
le_t	3.59*	4.08*	1.42
me_t	0.13	0.10	2.01
f_t	2.37	3.06*	1.73
s_t	8.91*	11.15*	0.56
IR_t	1.89	3.17	1.65
CR_t	2.39	2.64	1.37
UR_t	1.18	0.62	0.44
Δle_t	4.37*	5.92*	4.17*
Δme_t	4.03*	7.76*	4.09*
Δf_t	4.95*	12.44*	5.02*
Δs_t	3.27*	3.87*	4.73*
ΔIR_t	3.43*	4.02*	3.17*
ΔCR_t	5.86*	5.15*	5.92*
ΔUR_t	2.82	3.05*	2.76*

Notes: Sample levels 1966-2005 and differences 1967-2005. ADF test values are computed from the model. The critical values for ADF and PP with constant and a trend at the 5% level of significance are 2.93. The critical value for ERS with constant with no trend at the 5% level of significance is 2.38. All test statistics and critical values are expressed in absolute terms for convenience. Rejection of unit root hypothesis is indicated with an asterisk. Δ stands for first difference.

Equation (5) was estimated in two stages. In the first stage of the ARDL procedure, the long-run relationship of equation (3) was established in two steps. Firstly, the order of lags on the first–differenced variables for equation (5) was obtained from unrestricted VAR by means of Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). The results of this stage are not displayed here to conserve space. Secondly, a bounds F test was applied to equation (5) in order to establish a long-run relationship between the variables.

Narayan and Smyth (2006) present a detailed procedure to explain if one needs to implement the bounds F test with or without a time trend. It is possible that at the end of this testing procedure, one may end up with more than one possible cointegration relationship: one with a time trend and one without a time trend. As Narayan and

Smyth (2006, p.116) argue that "in the spirit of the bounds test, model two with a time trend is invalid because for the model to be valid there should be only one long-run relationship". In order to avoid a possible selection problem at this stage, one may follow the procedure of Bahmani-Oskooee and Goswami (2003) which sequentially test the long-run cointegration relationship in equation (5) on the basis of different lag lengths. This study adopts the second approach which implicitly assumes that equation (5) is free from a trend due to the differenced variables. In summary, the F tests indicate that there exists a cointegrating relationship without a time trend in which the dependent variable is life expectancy. The procedures of this stage and the results of the bounds F testing are presented in Table 3.

Table 3. The Results of F-test for Cointegration

F critical value bounds			F computed statistics at different lag levels		
Significance level	$I(0)$	$I(1)$	1 lag	2 lags	3 lags
1%	3.80	5.64	$F(7, 20)= 3.86^{*}$	F(7, 13)=2.15	F(7, 6)=3.48
5%	2.79	4.21			
10%	2.35	3.59			

Critical values are obtained from Narayan (2005), p.1988, Case III (unrestricted intercept and no trend) and with six regressors. * denotes that the F statistic falls above the 90% upper bound.

Given the existence of a long-run relationship, in the next step the ARDL cointegration procedure was implemented to estimate the parameters of equation (5) with maximum order of lag set to 2 to minimize the loss of degrees of freedom. This stage involves estimating the long-run and short-run coefficients of equations (3) and (5). In search of finding the optimal length of the level, variables of the short-run coefficients was based on AIC. The long-run results are presented in Panel A of Table 4. The short-run estimations are presented in Panel B of Table 4. On the basis of the estimated model, the long-run and short-run elasticities of the life expectancy with respect to the explanatory variables were computed and displayed in Panel C of Table 4. The short-run elasticities, as expected, are smaller than the long-run elasticities.

The diagnostic test results of equation (5) for short-run estimation are placed in Panel D of Table 4. The estimated model displays the expected signs for the regressors and they are statistically significant at 5% level of significance apart from per capita smoking and urbanization, which become statistically significant at 20% level of significance. The short-run model passes a series of standard diagnostic tests such as serial correlation, functional form, and heteroscedasticity, except normality.

Table 4. ARDL Results for the 1965-2005 Time Span

Panel A: long-run results Dependent variable le_t				Panel B: short-run results Dependent variable Δle_t			
Regressors	Coefficient	St.error	T-ratio	Regressors	Coefficient	St. error	T-ratio
me_t	0.06	0.018	(3.31)*	Δme_t	0.35	0.081	(4.28)*
f_t	0.13	0.054	(2.39)*	Δf_t	0.03	0.250	(0.12)
s_t	- 0.08	0.044	(1.78)**	Δs_t	- 0.01	0.005	(1.90)*
IR_t	- 0.004	0.001	(3.94)*	ΔIR_t	- 0.02	0.011	(1.74)**
CR_t	- 0.7E-4	0.4E-4	(1.74)**	ΔCR_t	- 0.2E-6	0.1E-6	(1.35)***
UR_t	- 0.003	0.002	(1.33)***	ΔUR_t	- 0.01	0.006	(1.72)**
Constant	4.06	0.332	(12.20)*	*Constant*	2.18	0.644	(3.38)*
				EC_{t-1}	- 0.53	0.171	(3.09)*
				$\bar{R}^2$	0.48		
				F statistic	5.46*		
				DW statistic	2.05		

Panel C: the long-run elasticities

	me_t	f_t	s_t	IR_t	CR_t	UR_t
	0.06	0.13	- 0.08	- 0.002	- 0.0012	- 0.002

Panel D: the short-run diagnostic test statistics

χ^2_{SC} (1)=0.37; χ^2_{FC} (1)=3.05; χ^2_N (2)=5.53; χ^2_H (1)=1.90

Notes for Panel A and B: The absolute value of t-ratios is in parentheses. Note for Panel C: Elasticities for the non-logarithmic variables are computed at their mean values during 1965-2005 time spans. The short-run elasticities are not computed as they are not plausible in the case of life expectancy equation since the life expectancy is not a short-run phenomenon.

$\chi^2_{SC}, \chi^2_{FC}, \chi^2_N$, and χ^2_H are Lagrange multiplier statistics for tests of residual correlation, functional form mis-specification, non-normal errors and heteroskedasticity, respectively. These statistics are distributed as Chi-squared variates with degrees of freedom in parentheses. At the 5% significance level, $\chi^2_{(1)} = 3.84$ and the critical value of $\chi^2_{(2)} = 5.99$. * , **, and ***, indicate 5 % , 10 % and 20% level of significances, respectively. Δ stands for first difference.

Error-correction representation in equation (6) was estimated as an auxiliary model. The estimation results with some selected diagnostics are illustrated in Panel B of Table 4. The error-correction term is statistically significant and it is plausible. Considering the reported diagnostic test results and the statistical significance of the coefficients estimated in the long run and short-run, the estimated model provides reasonable coefficients which may be used for statistical inference and policy recommendations.

The marginal impacts of each individual explanatory variable on life expectancy are analysed on the basis of *ceteris paribus*, which indicates that whilst one explanatory variable varies, the others are assumed to be constant. The medical expenditure elasticity is 0.06 in the long-run suggesting that the marginal contribution of medical care expenditures in increasing life expectancy in Turkey is moderate. The point estimate indicates that a 1% rise in medical expenditure will improve the life expectancy by 0.06%. The results suggest that a 1% increment in food availability can generate about 0.13% improvement in the life expectancy, which is higher than the marginal contribution of medical care expenditures. The coefficients of medical care expenditures and food production index suggest that life expectancy could improve substantially if economic policies successfully aim at increasing health expenditures and food production.

The elasticity of life expectancy with respect to smoking in the long-run is –0.08 pointing out that smoking has a substantial adverse impact on life expectancy. The cigarette smoking elasticity is –0.01 in the short-run, suggesting that cigarette smoking preventive policies such as taxation or price increases result in little positive impact on longevity. This habit is related to around 50 fatal diseases. Therefore, the result is not surprising regarding the attitude towards smoking in Turkey during the estimation period. Despite a law passed in the Turkish National Assembly in January 2008 which effectively requires almost a total ban of cigarette smoking in public places from July 2009, Turkey is still in the top 10 countries in terms of cigarette smoking, (World Health Organization - WHO: 2008). The number of active smokers in Turkey is around 17 million according to some estimates of National Committee of Health and Cigarette (NCHC) of Turkey, which is about one third of the population in the age group of 14 - 65 years old. NCHC predicts that 4 million out of 17 million smokers will die in 7 years and another 4 million will be dead in 22 years due to smoking-related illnesses. One quarter of cigarette smokers decrease their life expectancy by 23 years and one quarter of them die in their 70s. The estimated cost of health expenditure to recover from cigarette smoking related diseases is around 8.5 billion US dollars. Smokers in Turkey spend annually about 6.5 billion US dollars on their habit as of 2007 (NCHC: 2007). Thus, Turkey should seriously reconsider its policies to minimize the adverse impact of cigarette smoking in health status. The illiteracy elasticity in the long-run is – 0. 002 and that indicates a minimal adverse impact on longevity. It is reasonable to expect that this problem may disappear in the long-run totally since the education facilities are more widely available nowadays. The impacts of the environmental factors on life expectancy seem to be rather minimal as well. The first environmental factor, crime rate elasticity is just –0.0012 in the long-run, implying that Turkey is a relatively safe country and people do not suffer from serious violence and crime. The second environmental factor is urbanization, which has a low adverse impact on health status in the long-run. The error-correction term is –0.53 with the expected sign, suggesting that when the life expectancy equation is above or below its equilibrium level, it adjusts by 53% within the first year. The full convergence process to its equilibrium level takes less than two years. Thus, the speed of adjustment is significantly fast in the case of any shock to the life expectancy equation.

The CUSUM and CUSUMSQ stability tests were applied to the AIC based error-correction model and the graphs representing the tests are presented in Figures 1 and 2. As can be seen from Figures 1 and 2, the plots of CUSUM and CUSUMSQ statistics are well within the critical bounds, implying that all coefficients in the error-correction model are stable. Therefore, the model can be used for policy decision-making purposes such that the impact of policy changes considering the explanatory variables will not cause major distortion in the life expectancy equation, since the parameters in this equation seems to follow a stable pattern during the estimation period.

Figure 1. Plot of CUSUM

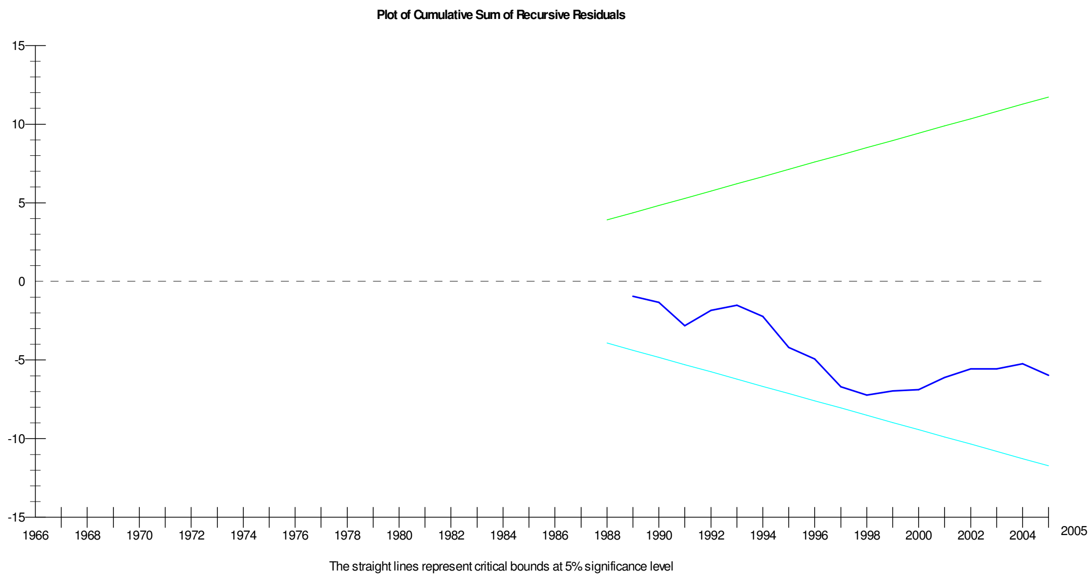
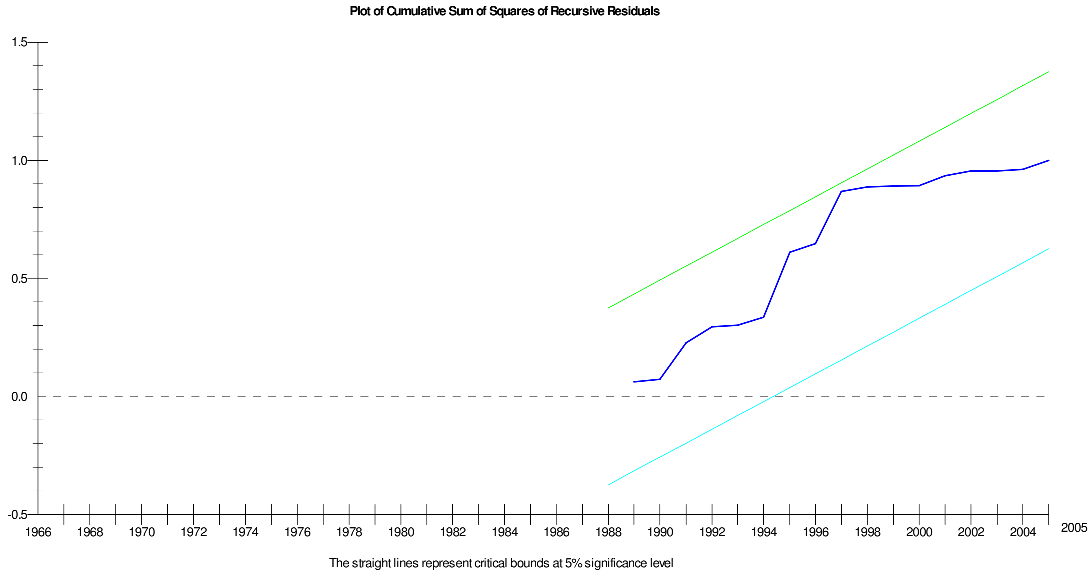


Figure 2. Plot of CUSUMSQ



6. Conclusions

This paper attempted to measure the determinants of life expectancy in Turkey using time series data with a view to providing some policy tools for an efficient public health policy. The results suggest that the most important factor in determining longevity is food availability or nutrition. The impact of the health expenditures on longevity is positive but small in magnitude, implying that health care spending yields moderate improvement in life expectancy. OECD (2006) health data confirms that health resource allocation in Turkey is far from efficient. The data illustrates that the number of acute care hospital beds in Turkey in 2004 was 2.4 per 1000 population, below the OECD average of 4.1 beds per 1000 population. In most OECD countries, the number of hospital beds per capita has fallen over recent decades but not in Turkey, where it has increased from 1.5 per 1000 population in 1984. Regarding fact that more than 70% of health spending in Turkey is currently funded by public sources, reallocation of these resources on the basis of quality and efficiency is essential to maintain and improve longevity. To this extent, the literature recommends that policy decision-makers may consider using DEA (Data Envelopment Analysis) to test the efficiency of health care systems, see, for example, Puig-Junoy (1998), Steinmann *et al*. (2004), and Pilyavsky and Staat (2006).

This study reveals that cigarette smoking is the most negative impact on longevity. Despite OECD (2006) health data which indicates that Turkey has achieved some progress in reducing cigarette smoking, with current rates of daily smokers among adults decreasing from 43.3% in 1989 to 32.1% in 2003, WHO (2008) data shows that Turkey still ranks 10th in the world in terms of cigarette smoking per capita. The adverse impact of cigarette smoking may be minimized through a number of financial and non-financial policies. Tansel (1993, p.521) presents that "public education about adverse health effects of smoking may be more effective in reducing consumption and less regressive on consumer's income than raising the price of cigarettes". On following the complete cigarette smoking ban in public places in some European countries, Turkey has enacted a similar law which requires a total smoking ban from mid 2009. The positive contribution of this policy on longevity is likely to be felt in a decade. This research reports that illiteracy has an adverse effect on longevity which may disappear in the long-run considering the educational provisions provided for adults in Turkey. The negative contributions of other social and environmental factors on longevity are rather minimal. Therefore, they require little urgency for designing policies in order to eliminate these adverse effects.

The parameter stability of the selected model was checked through the CUSUM and CUSUMSQ tests which both indicated the stability. Thus, the life expectancy equation may be used for policy simulations and forecasting purposes.

As for the limitations of this study, it should be noted that the econometric results presented are simply the approximation of the real situations with the available data sets. Therefore, like all the econometric models, the econometric model of this study would be improved further providing that all the data required are available for the selected time span. For instance, the life expectancy in Turkey could be estimated at different age groups or regions or ethnicities should the data is available on these categories. Even one may consider the impacts of different diseases or epidemics on the longevity in the case of availability data these variables. The future empirical studies relating to the life expectancy in Turkey may focus on the limitations of this study.

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Appendix A

Data definition and sources

All data are collected from 2007 World Development Indicators of World Bank (WB), 2007 International Financial Statistics of International Monetary Fund (IMF), Economic and Social Indicators of Turkish Statistical Institute (Turkstat), Annual Health Statistics of Turkish Ministry of Health (MoH), Suleyman Ozmucur (SO) of 1995, and Aysit Tansel (AT) of 1993.

Variables

le is life expectancy at birth total, (in logarithm). Source: WB.
me is real public health expenditures per capita in thousands of Turkish Lira (TL), (in logarithm). 1965-1990 health expenditures data comes from Ozmucur (1995). Subsequent years are obtained from Turkish Ministry of Health. Health expenditures are deflated by the consumer price index (CPI) of 2000=100 and are divided by midyear population. CPI and population data are taken from IMF. Sources: SO, MoH, and IMF.
f is food production index (in logarithm), which includes food crops that are edible with nutrition but excludes coffee and tea. The index base year is 1999-2001=100. Source: WB.
s is cigarette smoking per capita in packs of 20 cigarettes. The measurement of tobacco consumption is based on the data methodology of Tansel (1993). Tansel

(1993) provides the data of per capita cigarette consumption for the period of 1960-1988. The data for remaining years are collected from TSI. Sources: AT and Turkstat.

IR is illiteracy rate which represents the percentage of people above 14 years who cannot write or read. Source: WB.

CR is crime rate per capita, which is measured as the ratio of convicts to the population over 14 years old. Source: Turkstat.

UR is urbanization which stands for the percentage of people live in cities. Source: WB.

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