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Determinants of Gender Disparities on Life Expectancy in Sudan

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ABSTRACT

The main objective of this paper is to examine factors affecting gender disparities on life expectancy in Sudan. The analysis examines the existence of long and short run relationship between gender's life expectancy and its determinants for the period of 1960-2007. The result shows that disparities in life expectancy between genders are statistically significant. Interestingly, the impact on females' life expectancy is different from the males. The study also reveals that education and pollution play a vital role in determining life expectancy amongst the population. The result shows that in the long run, urbanization and education play vital role in determining genders' life expectancy; whilst in the short run, only education and urbanization are significant. For causality analysis, we find that urbanization causes females' life expectancy; and females' life expectancy causes, both economic growth and their education; whilst females' education causes economic growth and urbanization. The study suggests that females' life expectancy can progress through urbanization and better education level. However on the other hand, a better life expectancy would contribute towards higher economic growth and urbanization in a longer period of time.

Key word: gender disparities, life expectancy, determinants, population

INTRODUCTION

In less developed regions, gender disparities exist in various forms and frequently have significant impact on the national economic growth. Since several decades, enhancing women empowerment is been discussed in the international literature to overcome the gender-based inequality. This is a wide spread phenomenon among especially the less developed economies which subsequently influences their culture, religion, nation buildings and income distributions. However, gender discrepancies and their evolution over time manifested themselves in many different ways. Hence, assessment on the gender gap and developing a relevant framework for capturing the magnitude of these disparities are most important to design effective measures for reducing them (Satti 2010).

The rationale for the recent growing interest and increasing concern in the international literature on reducing the gender gap and achieving gender equality is probably related to and consistent with the increasing commitment of the international community towards fulfilling the Millennium Development Goals (MDGs) by United Nation Development Report through its Human Development Report (UNDP-HDR), including the achievement of gender equality between women and men. The first report on the Arab Human Development Report series on *Creating Opportunities for Future Generations*, indicated some obstacles to Arab's human development and recognizes that the gender gap in some dimensions of human development is one of three main limitations hindering human development in the Arab countries (UNDP-AHDR 2002). The fourth report in the Arab Human Development Report (AHDR) series entitled *Towards the Rise of Women in the Arab World* presented an in depth analysis on the problem of insufficient women empowerment. The reports examined the status of Arab women which highlight the problematic nature of the equality of their rights, capabilities and opportunities in the context of history, culture, religion, society as well as the political economy (UNDP-AHDR 2005). It outlined a vision for the achievement of gender equality built on the assurance of full citizenship rights for all through reforms of Arab's governance (UNDP-AHDR 2002, 2005).

In Sudan, as in most Arab countries, gender gap or inequality is a wide spread phenomenon. This paper aims to examine the gender gap in one of the main categories of well being, which is the life expectancy. The case for Sudan represents the issue for the Arab regions. The issue discussed in this paper is relevant and consistent with the recent growing interest in the literature, in particular, in view of the increasing commitment of the international community towards fulfilling the United Nation and UNDP-HDR Millennium Development Goals (MDGs) including the achievement of gender equality between women and men. Assessment of the gender gap in health (life expectancy) in Sudan is particularly useful to attain two objectives, first to create greater awareness among the public regarding factors which caused disparities, and second, to serve as an instrument for change by providing policy-makers in Sudan with information regarding possible determinants on gender disparities in life expectancy, which is considered as one of the important component for human development. From a policy perspective, this paper is useful to help generate some useful insights and policy recommendations to contribute to recent efforts aims at enhancing gender equality.

Specifically, the paper has two main objectives. First, to examines whether economic growth, pollution, urbanization and education have significant role in explaining the gender disparities in life expectancy. Second, to analyses the existence of long and short run relationship between gender's life expectancy and the main determinants for the period of 1960-2007. The paper is organised into five sections. After the introduction, the paper provides a review of literature regarding gender disparities, in particular that relates to health issues and life expectancy. The method and model specification employed for the analysis is explained in the third section. The fourth section presents the results and discussions. The final section provides the conclusions and some policy implications.

LITERATURE REVIEW

The causes of gender disparities in life expectancy can be examined via two perspectives, viz., economic and behavioural perspectives. From the economic point of view, many studies in LDCs showed that, woman compared with men, often have less accessibility to new economic resources as economic progresses. Subsequently, woman eventually looses their traditional sources of economic subsidies. Studies show that woman is likely to be negatively affected by development programmes or policies compared to men. For example, the structural adjustment programmes (SAPs) which were adopted by the Sudan in 1978. However, studies also reveal that the positive effect of life expectancy on development is greater in less developed countries. From the behavioural perspective, women have longer life expectancies than men in nearly every society today. In fact, this gender gap is sometimes are much greater in countries with higher life expectancies. With few exceptions, males are likely to have greater risk of dying at every age, and the possibility of women to survive at older age is much higher compared with men. The gender gap in life expectancy is partially explained by the behavioural differences that affect their health respectively. For example, men are more likely to smoke, use drugs, or engage in dangerous activities compared to women in most society. However, there are also apparent biological factors that favour women's greater longevity.

Recently, studies devoted to examine possible determinants of life expectancy for both sex, discovered that income, educational level, urbanization, health care spending and inputs like number of physicians, access to safe drinking water, nutritional outcome, and geographical location of a country appeared to be statistically significant determinants Mahfuz (2008). Hussain (2002) carried out the most recent detailed analyses of determinants of life expectancy. He examines cross-section determinants for 91 developing countries within a multiple OLS regression framework. The study shows that, per capita GNP, fertility rate, adult illiteracy rate, per capita calorie intake and dummy variable for sub-Saharan Africa turned out to be significant variables.

Generally, economic growth contributes to life expectancy mainly through household, government activity and civil society (NGOs). Households propensity to spend their income on items that contribute directly to health depends on the level and distribution of income across household as well as who controls the allocation of expenditure within household (female or male). In general poor households spend a higher proportion of their incomes on human development items, vice versa. Life expectancy is also higher from greater female control over household income (Ramirez, Ranis & Stewart 1997). Indeed, when women have strong control over income, it appears that expenditure patterns are geared relatively more towards health inputs. Many studies in this respect from different countries confirmed these phenomena (Vonbraun 1988, Garicia 1990, Hoddinatt & Haddad 1991). Expenditure on health related items are also strongly affected by the rate of poverty reduction. If poor household receive extra income, they increase their food expenditure and calorie consumption significantly. From over 38 studies in different countries, 1/3 indicated that at least one-half of additional income is spent for this purpose (Strauss & Thomas 1995).

Government's role also has significant effect on life expectancy of a country through its expenditure on the health sector. The expenditure allocated by the government will help to improve the health sector, and subsequently life expectancy of the people (UNDP 1991). For example, Baldacci et al. (2003) and Gupta et al. (2002) find that social spending is an important determinant of education and health outcomes. The positive effect of social spending on social indicators is also supported by Anand & Martin (1993), Psacharopoulos (1994), Hojman (1996), Bidani & Ravallion (1997), Psacharopoulos & Patrinos (2002). A number of studies find that the contribution of health spending to health status as measured by infant mortality or child mortality-is either small or statistically insignificant (Filmer & Pritchett 1997, Filmer et al. 2000, Musgrove 1996, Pritchett 1996). In contrast, Gupta et al. (2003) find a positive relationship between public spending on health care and the health status of the poor. The mixed results from the literature on the effectiveness of health spending in improving social indicators can be traced to several factors. First, existing studies have been hampered by data availability and measurement problems. Statistics on social spending and the relevant social outcomes are relatively scarce compared to macroeconomic indicators. The use of a large panel data series with better consistency in compilation can help mitigate these problems. Second, there is the issue of model design. Many studies have used traditional linear models to capture the spending-outcome relationship, while in many cases a nonlinear specification yields more results that are robust. Third, the literature has often failed to capture the interaction between education and health sector, as well as the significant spillover between them. In fact, this leads to an understatement of the effect of spending and social indicators (Mayer-Foulkes 2003, Miguel & Kremer 2003).

The basic mechanism, upon which the theoretical model of life expectancy and the environment built, is very simple. On the one hand, environmental quality depends on life expectancy, and on the other hand, longevity is affected by the environmental conditions. Someone who expect to live longer have a stronger concern for future lives, and therefore, is likely to invest more on environmental care. Thus, the causal link between life expectancy and environmental quality may also go the other way round. Studies in medicine and epidemiology, such as by Elo & Preston (1992), Pope (2000), Pope et al. (2004) and Evans & Smith (2005), show that environmental quality is a significant factor affecting health and morbidity, air and water pollution, impoverishment of natural resources, soils deterioration and the like, are all capable of increasing human mortality (thus reducing longevity). Accordingly, it not surprising that, life expectancy is positively correlated across countries with environmental quality. By modelling environmental quality as an asset that can be accumulated over time, Mariani et al. (2010) argued that life expectancy and environmental dynamics can be jointly determined. Their model is also robust to the introduction of a very simple growth mechanism via human capital accumulation. If education depends on life expectancy, and survival probabilities affected by both environmental quality and human capital, the positive dynamic correlation between longevity and environmental quality is preserved, and in the long run, would extend to higher income.

Throughout history, urbanization has been a key element in the process of development. Arguably, these two processes inextricably linked. Development does not occur without urbanization although the causal link between these two processes is not clear-cut. Recent studies addressed such phenomena, they discussed it by distinguish between an overall degree of urbanization and the degree of urban concentration and their effects on the development. However, some benefits of urban scale must exist in order to motivate rural–urban migration. The urban-rural wage gap in both developed and developing countries is high and persistent. In addition, the nature of cities appears to provide incentives for investments in education by their residents. Returns to education are higher in urban areas, as are literacy rates and average educational attainment levels. Rural–urban migrants tend to be more educated than those who do not migrate (Funkhouser 1998). Children in urban areas are more likely enrolled in school. Contributions to endogenous growth theory emphasize the importance of human capital and knowledge accumulation in economic development (Lucas 1988, Romer 1986)). To the extent that urbanization encourages human capital accumulation, cities become the engines of economic growth.

Economists believe that, Urbanization plays a crucial role in determining life expectancy. Urban inhabitants of the developing world generally enjoy improving medical care and means of life, better education, and other improved socio-economic facilities, which impact positively on health outcomes. While examining patterns of regional life expectancy in Lithuania, Kalediene & Petrauskiene (2000) found that, there was a positive correlation between a level of urbanization and life expectancy. Nevertheless, state of urbanization and residential conditions critically related to health status and health outcomes of population of a country. In a study on Rio de Janeiro, Szwarcwald et al. (2000) found the worst health situation in the cluster composed of the harbour area and northern vicinity, precisely in the sector where the highest concentration of slum residents was present. This sector of the city exhibited seven years lower life expectancy than the remainder of the city. Conversely, Rogers & Wofford (1989) found the opposite result; examining life expectancy for 95 developing countries, they revealed that urbanization was less influential in explaining life expectancy than anticipated, perhaps because of an unhealthy condition in cities of the developing countries.

Furthermore, education considered as another influential determinant of life expectancy. Education has both direct and indirect impacts on the health outcome. It enhances labour market productivity and income growth, and educating women has beneficial effects on child health and social well-being. Intuitively, education also raises people's health awareness and thereby actions toward achieving better health status, which itself have significant bearing on extending life expectancy. Rising levels of education improve women's productivity in home, which in turn increases family health and child survival. Benefits of women's Education can be reflected in extending life expectancy in the population (Hill & King 1995). Mortality and life expectancy differed considerably in relation to education (Grabauskas & Kalediene 2002, Kalediene & Petrauskiene 2000). Using individual and multi-level logistic regressions for Canada, Veugelers et al. (2001) found a lower mortality rate among a well-educated group of people; and within advantaged neigh boarhounds, the importance of education for mortality found to be increased in comparison to disadvantaged ones. In a study at North Carolina of the United States, Guralnik et al. (1993) found that black men had the lower life expectancy than white, but education had a substantially stronger effect on life expectancy than race. Based on multiple regression and cross-section analysis include 40 to 97 countries, Williamson & Boehmer (1997) show that women's educational status has a positive and significant impact on female life expectancy. However, based on data from 1979 to 1985 Rogot et al. (1992) estimated determinants of life expectancy for white men and women in the US by education, family income and employment status and revealed that life expectancy varies directly with years of schooling. In a multivariate linear regression analysis on data of 156 countries, Gulis (2000) found that literacy had a statistically significant role in explaining life expectancy. Rogers & Wofford (1989) examined life expectancy for 95 developing countries against six indicators of modernization: (i) percentage of population living in urban areas; (ii) percentage of population engaged in agriculture; (iii) percentage of population who are illiterate; (iv) percentage of population without access to safe drinking water; (v) per capita daily calorie intake; and (vi) population per physician. The result shows that literacy significantly explained variation in life expectancy.

For Sudan, as maintained above, no studies conducted to investigate these phenomena. However, lately and in the same respect, Ahemed (2010) made a study to test the gender disparities in human development indicators in Sudan over the period (1990-2005). He utilized the standard formula of UNDP (1999) to calculate the HDI for males (HDIM) and females (HDIF) separately. He finds that average HDIM is estimated at (0.50), while the average HDIF is estimated at (0.39). These results indicate that, males in Sudan are on average in the category of medium human development, while females are characterized by low human development. The contributions of health, education and income to HDIM are estimated at (31%), (36%), (33%), respectively. With regard to the HDIF, the contributions of health, education and income are estimated at (44%), (32%), (24%), respectively. The t- test for the difference between two means assures the existence of the gender gap against females in all human development indicators except for health, in which females are better. The compound growth rates of the HDIM and HDIF in Sudan are estimated at (1.8%) and (3%) per annum, respectively. With these growth rates, both sexes are expected to realize a level of human development equals (0.78) by the year 2023. Another study made by Satti (2010) aimed to examine the correlation between wages (log), education and experience defined by gender in Sudan (2009). Based on primary data based on the preliminary results from the survey of Nour (2009), Satti (2010) estimated Mincerian earning function. The results show the differences defined by gender and imply that the correlation between wage and education, experience and its square for women are relatively higher than men.

METHOD AND MODEL SPECIFICATIONS

This section describes the models that should be adopted to achieve the objectives of the study. We use equation (1) below to test whether economic growth, pollution, urbanization and education have a significant role in explaining the gender disparities in life expectancy. Later we can modify this equation in order to describe the long and short run relationship between these variables and life expectancy defined by gender. The equation is written as follows:

$$Lg_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 S_{it} + \beta_3 U_{it} + \beta_4 CO_{it} + \alpha_5 DS_{it} + \alpha_6 DCo_{it} + \alpha_7 DU_{it} + \alpha_8 DY_{it} + \alpha_9 D_{it} + u_{it} \quad \text{... (1)}$$

where:
t= for time(1960-2007)
i=sex (male, female)

Lg= Life expectancy by years
Y= real per capita GDP by USA dollars in current prices
S= education for all people, measured in terms of average years of schooling for people aged 15 years and over
CO= pollution (measured in terms of CO^2 emission per capita)
U= Urbanization (measured in terms of proportion people living in urban area)
DS= interaction term for education. DCO= interaction term for pollution
DU= interaction term for Urbanization
DY= interaction term for real per capita GDP
D=gender dummy variable (male=1, female =0)

The later equations (2) and (3) below describes the long and short run relationship between these variables and life expectancy defined by gender. The model takes the specific form given by:

F = $\beta_\circ + \beta_1 Co + \beta_2 Sf + \beta_3 U + \beta_4 F + \beta_5 Y + u_t,$ with $\beta 1$, β_3, $\beta 4$, $\beta_5 > 0$ $\beta_2 < 0$ ... (2)

M = $\alpha_\circ + \alpha_1 Sm + \alpha_2 Co + \alpha_3 U + \alpha_4 Y + u_t,$ with $\alpha 1$, $\alpha 3$, $\alpha_4 > 0$ $\alpha_{2<} 0$ ... (3)

where:
M=Male life expectancy at birth
F=Female life expectancy at birth
Sm=Male average years of schooling (over 15 years)
Sf=Female average years of schooling (over 15 years).

For co-integration, current paper employed the auto regressive distributed lag (ARDL) framework developed by Pesaran & Shin (1995, 1999), Pesaran *et al.* (1996) and Pesaran (1997). There are advantages of using this approach instead of the conventional Johansen (1998) and Johansen & Juselius (1990). While the conventional co-integration method estimates the long run relationships within a context of a system of equations, the ARDL method employs only a single reduced form equation (Pesaran & Shin, 1995). The ARDL approach does not involve pre-testing variables, which means that the test on the existence relationship between variables in levels is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1) or mixture of both. This feature alone, given the characteristics of the cyclical components of the data, makes the standard of co integration technique unsuitable and even the existing unit root tests to identify the order of integration are still highly questionable. Furthermore, the ARDL method avoids the larger number of specification to be made in the standard co-integration test. These include decisions regarding the number of endogenous and exogenous variables (if any) to be included, the treatment of deterministic elements, as well as the optimal number of lags to be specified. The empirical results are generally very sensitive to the method and various alternative choices available in the estimation procedure (Pesaran & Smith, 1998). With the ARDL, it is possible that different variables have different optimal lags, which is impossible with the standard co-integration test. Most importantly, the model could be used with limited sample data (30 observations to 80 observations) in which the set of critical values were developed originally by Narayan (2004) by using E-views version 7.

Basically, the ARDL approach to co-integration (see Pesaran et al., 2001) involves estimating the conditional error correction (EC) version of the ARDL model. Consequently, then equation (2) and (3) became after transformation the data by introducing the natural logarithm for all variables and both equations:

$$\Delta Lf_t = \beta_{o+} \beta_1 \sum_{i=1}^{n} \Delta Lf_{t=i} + \beta_2 \sum_{i=o}^{n} \Delta lY_{t-i} + \beta_3 \sum_{i=o}^{n} \Delta lSf_{t-i} + \beta_4 \sum_{i=o}^{n} \Delta lU_{t-i} + \beta_5 \sum_{i=o}^{n} \Delta lCO_{t-i} + +\sigma_1 Lf_{t-1} + \sigma_2 lY_{t-1} + \sigma_3 lSf_{t-1} + \sigma_4 lU_{t-1} + \sigma_5 lCO_{t-1} + \mu_{1t} \quad \text{... (4)}$$

From equation (3), the male life expectancy equation can be written as follows:

$$\Delta Lm_t = \beta_{o+} \beta_1 \sum_{i=1}^{n} \Delta Lm_{t=i} + \beta_2 \sum_{i=o}^{n} \Delta lY_{t-i} + \beta_3 \sum_{i=o}^{n} \Delta lSm_{t-i} + \beta_4 \sum_{i=o}^{n} \Delta lU_{t-i} + \beta_5 \sum_{i=o}^{n} \Delta lCO_{t-i} + +\sigma_1 Lm_{t-1} + \sigma_2 lY_{t-1} + \sigma_3 lSm_{t-1} + \sigma_4 lU_{t-1} + \sigma_5 lCO_{t-1} + \mu_{1t}$$
... (5)

The *F* test is used for testing the existence of long-run relationship. When the long-run relationship exists, *F* test indicates which variable should be normalized. The null hypothesis for no co-integration among variables in equation (1) is H0: $\delta 1 = \delta 2 = \delta 3 = \delta 4 = \delta 5 = 0$ against the alternative hypothesis H1: $\delta 1 \neq \delta 2 \neq \delta 3 \neq \delta 4 \neq \delta 5 \neq 0$. The *F*-test has a non-standard distribution which depends on (i) whether variables included in the model are I(0) or I(1), (ii) the number of regressors, and (iii) whether the model contains an intercept and/or a trend. Given a relatively small sample size in this study of 30 observations, the critical values used are as reported by Narayan (2004) which based on small sample size between 30 and 802. The test involves asymptotic critical value bounds, depending whether the variables are I(0) or I(1) or a mixture of both. Two sets of critical values are generated which one set refers to the, I(1) series and the other for the, I(0) series. Critical values for the I(1) series is referred to as *upper* bound critical values, while the critical values for I(0) series are referred to as the *lower* bound critical values. If the *F* test statistic exceeds their respective upper critical values, we can conclude that there is evidence of a long-run relationship between the variables regardless of the order of integration of the variables. If the test statistic is below the upper critical value, we cannot reject the null hypothesis of no co-integration and if it lies between the bounds, a conclusive inference cannot be made without knowing the order of integration of the underlying regressors.

If there is evidence of long-run relationship (co-integration) of the variables, the following long-run model is estimated for the equation (2) and (3) respectively:

$$\mathrm{lf_t} = \beta_{o+} \sum_{i=1}^{n} \mathrm{B_{1i}\,lf_{t-i}} + \sum_{i=o}^{n} \beta_{2i}\,\mathrm{ly_{t-i}} + \sum_{i=o}^{n} \beta_{3i}\,\mathrm{lsf_{t-i}} + \sum_{i=o}^{n} \beta_{4i}\,\mathrm{Lu_{t-i}} + \sum_{i=o}^{n} \beta_{5i}\,\mathrm{Lco_{t-i}} + \mathrm{vt} \qquad \text{... (6)}$$

$$\mathrm{lm_t} = \beta_{o+} \sum_{i=1}^{n} \mathrm{B_{1i}\,lm_{t-i}} + \sum_{i=o}^{n} \beta_{2i}\,\mathrm{ly_{t-i}} + \sum_{i=o}^{n} \beta_{3i}\,\mathrm{lsm_{t-i}} + \sum_{i=o}^{n} \beta_{4i}\,\mathrm{Lu_{t-i}} + \sum_{i=o}^{n} \beta_{5i}\,\mathrm{Lco_{t-i}} + \mathrm{vt} \qquad \text{... (7)}$$

The orders of the lags in the ARDL model are selected by either the Akaike Information criterion (AIC) or the Schwarz Bayesian criterion (SBC), before the selected model is estimated by ordinary least squares. For annual data, Pesaran & Shin (1999) recommended choosing a maximum of 2 lags. From this, the lag length that minimizes SBC is selected. The ARDL specification of the short-run dynamics can be derived by constructing an error correction model (ECM) of the following form for equation (1) and (2) respectively:

$$\begin{aligned}\Delta\mathrm{Lf_t} &= \beta_{o+}\ \mathrm{\beta_1} \sum_{i=1}^{n} \Delta\mathrm{Lf_{t=i}} + \mathrm{\beta_2} \sum_{i=o}^{n} \Delta\mathrm{lY_{t-i}} + \\ &\beta_3 \sum_{i=o}^{n} \Delta\mathrm{lSf_{t-i}} + \mathrm{\beta_4} \sum_{i=o}^{n} \Delta\mathrm{lU_{t-i}} + \mathrm{\beta_5} \sum_{i=o}^{n} \Delta\mathrm{lCO_{t-i}} + + \sum_{i=o}^{n} \omega\mathrm{ECM_{t-1}} + \mathrm{vt}\end{aligned} \qquad .(8)$$

$$\begin{aligned}\Delta\mathrm{Lm_t} &= \beta_{o+}\ \mathrm{\beta_1} \sum_{i=1}^{n} \Delta\mathrm{Lm_{t=i}} + \mathrm{\beta_2} \sum_{i=o}^{n} \Delta\mathrm{lY_{t-i}} + \\ &\beta_3 \sum_{i=o}^{n} \Delta\mathrm{lSf_{t-i}} + \mathrm{\beta_4} \sum_{i=o}^{n} \Delta\mathrm{lU_{t-i}} + \mathrm{\beta_5} \sum_{i=o}^{n} \Delta\mathrm{lCO_{t-i}} + + \sum_{i=o}^{n} \omega\mathrm{ECM_{t-1}} + \mathrm{vt}\end{aligned} \qquad .(9)$$

Where $\mathrm{ECM_{t-1}}$ is the error correction term, defined for equation (2) as:

$$\mathrm{ECM_t{=}f_t} - \ \beta_{o+} \sum_{i=1}^{n} \mathrm{B_{1i}}\Delta\,\mathrm{f_{t-i}} - \sum_{i=o}^{n} \beta_{2i}\ \Delta\mathrm{y_{t-i}} - \sum_{i=o}^{n} \beta_{3i}\ \Delta\mathrm{sf_{t-i}} - \sum_{i=o}^{n} \beta_{4i}\ \Delta\mathrm{u_{t-i}} \sum_{i=o}^{n} \beta_{5i}\ \Delta\mathrm{co_{t-i}} \qquad (10)$$

And as following foe equation (3)

$$\mathrm{ECM_t{=}m_t} - \ \beta_{o+} \sum_{i=1}^{n} \mathrm{B_{1i}}\Delta\,\mathrm{f_{t-i}} - \sum_{i=o}^{n} \beta_{2i}\ \Delta\mathrm{y_{t-i}} - \sum_{i=o}^{n} \beta_{3i}\ \Delta\mathrm{sm_{t-i}} - \sum_{i=o}^{n} \beta_{4i}\ \Delta\mathrm{u_{t-i}} \sum_{i=o}^{n} \beta_{5i}\ \Delta\mathrm{co_{t-i}} \qquad (11)$$

All coefficients of short-run equation are coefficients relating to the short run dynamics of the model's convergence to equilibrium and ω represent the speed of adjustment.

As we know, the co-integration test requires making a test for existence of the unit root problem before starting examine the long run relationship, since many macroeconomic series appear to be non-stationary, as Nelson & Plosser (1982) affirmed, we first need to check for the stationary of the series. Several unit root tests exist to check for stationary of the series. In order to proceed to the co integration analysis, one must establish that the variables possess the same order of integration. The process examined the time series' characteristics of the variables selected, overcome the problems of spurious correlation often associated with non-stationary time series and generate long-run equilibrium relationships concurrently. The data series was tested for stationary using the Augmented Dickey Fuller (ADF) and Philip-Perron (PP) test as the starting point to assess the order of integration. The ADF test and the Phillips-Perron test are widely used methods of investigating the presence of a unit root in single time series. Unfortunately, in finite samples these tests suffer from limited power against near unit root alternatives (Maddala & Kim, 1998). DeJong et al. (1992), for example, report evidence that the Dickey-Fuller test has a low power against auto regressive alternatives with near unit roots.

Current paper and ether to avoid such a problem or to resolve the contradictory results when use the ADF and PP tests, or to confirm the results obtained by the other two tests, we use the KPSS test (Kwiatkowski et al. 1992) as a third unit root test. In fact, the main difference between this test and the previous ones (ADF and Phillips - Perron) is the null hypothesis. Whereas the ADF-test and the Phillips-Perron test are tests for unit roots (or non-stationary), the null hypothesis of the KPSS-test is the absence of a unit root (or stationery of the series). So, in a way, the KPSS test complements the ADF-test and Phillips-Perron test. Kwiatkowski et al. (1992) conclude that by testing both the unit root hypothesis and the stationary hypothesis, one can distinguish series that appear to be stationary, series that appear to have a unit root, and series for which the data (or the tests) are not sufficiently informative to be sure whether they are stationary or integrated.

The data used in this study collected from different sources, concerning the data about life expectancy per sex, Carbon dioxide emission by metric tons per capita, population living in the urban areas, real per capita GDP growth, are obtained from the World Bank.

While the data about average years of schooling for the population over 15 years for during the period 1960-2009 obtained from Barro & Lee (2010). In fact, most of the international centers depend on Barro & Lee as references, when want to study or evaluate the education attainment in any country. Which can be calculated as followed. The number of years of schooling for the population aged 15 and above, *st* , is constructed as:

$$s_t=\sum_{a=1}^{g} \int_t^a s_t^a$$

Where $\int_t^g$ the population share of group g in population 15 and above and s_t^a the number of years of schooling of age group *a*— (*a* =1: 15–19 age group; *a* =2: 20–24 age group; *a* =13: 75 and above).

The number of years of schooling of age group *a* in time *t* is:

$$s_t^a = \sum_j h_{j,t}^a Dur_{j,t}^a$$

Where $h_{j,t}^a$ the fraction of group *a* having attained the educational level *j* = *pri*, *sec*, *ter*, and *Dur* Indicates the corresponding duration in years. The duration of the data takes account of changes in the duration system over time in a country. We suppose that changes in the duration of schooling at the primary level applied to new entrants in primary school (that is, ages 5–9) at the time of change(all the data attached in the appendix (1)

RESULTS AND DISCUSSIONS

Firstly, we apply Ordinary Least Square (OLS) technique on equation (1) to investigate whether economic growth, pollution, urbanization and education have a significant role in explaining the gender disparities in life expectancy in addition to their role in determinants of life expectancy for all people. Recall that, all the data of the selected variables in the form of pool data covering the period 1960-2007. Table (1) describe the results.

From these results, we observe the estimated equation is significant at 1% as indicated by F value, while the selected variable explained on average 98% the varieties in the life expectancy for all people in Sudan during the period (1960-2007)). The Durbin-Watson's statistic (D.W) indicates that e absence of an autocorrelation problem. First to explain whether the selected variables' determinants the health of all people, we use the following formula which describes the differential process for life expectancy for people with respect to the selected variable:

$$\frac{\partial Lg}{\partial X_i} = \beta Xi + \alpha DXi \qquad (4)$$

Where, X denote to the specific variable, and i for education, growth, pollution and urbanization. From the results, per capita GDP has positive and insignificant influence on people health, with a coefficient equal to (0.001), and as maintained above, economic growth contributes to life expectancy mainly through household, government activity and civil society (NGOs). Therefore, their insignificant influence for Sudanese people might be due, for example, to increase both inequality in the distribution of income and the rate of the poverty. In this respect, Hassan (2008) argued that for Sudan, during the period 1990-99 poverty increased by an annual rate of 0.87 percent. For the first half of the 1990s poverty increased marginally at an annual rate of 0.24 percent but for the second half the increase in the headcount ratio was very significant at the rate of 2.4 percent. These results are not qualitatively different from the most recent results reported for Sudan, which compare absolute poverty in1990 to that in 1996. According to to these results, the incidence of poverty (as measured by the head-count ratio) has increased by an annual rate of 2.62 percent per annum from 77.5% in 1990 to 90.5% in 1996. Moreover, it is reported that the head-count ratio for 1996 was 81.4 percent for the urban areas (using an urban poverty line of £S.292 Thousand per person per year) and 94.8 percent for the rural areas (using a poverty line of £S.261 thousand per person per year).Regarding inequality in the distribution of income and according to the World Food Programme (2006), Information on income distribution in Sudan is very thin. In addition to that, related measures for Sudan are not reported in the standard references. Recent study available calculated poverty rates, Gini coefficients and average income levels for a number of localities in northern Sudan using data from 1996. In this study, the mean and median values for the Gini coefficients were 61.13 and 60.5, respectively. This would have placed Sudan among the top 5 percent of countries for which Gini coefficients were reported in the most recent Human Development Report, supporting the impression that the income distribution in Sudan is highly skewed. The average income in the wealthiest locality was greater than ten times the average value and more than 100 times that of the poorest locality.

Furthermore, from the table, urbanization plays a negative and insignificant impact on people health, with a coefficient equal (-0.03). In Sudan, urbanization has been a growing phenomenon over the past couple of decades, partly due to labour migration and partly due to population displacement resulting from the civil war between the Southern rebels and the Federal Government. Recurrences of severe droughts and environmental degradation in western and northern Sudan have also caused population movement from rural to urban areas, particularly during the 1980s and 1990s. El Moula (1991) fund that, drought, desertification and lack of development have been the main causes of migration in the rural areas of Western Sudan. Thus, the negative impact of urbanization on health might be due to an unhealthy condition in cities of the developing countries or the health services not expand with the same rate of migration reflect in shortage in supply of health centres.

Environmental quality is a very significant factor affecting health; from the results, pollution has negative and significant influence on people health at 5% level, by other words, decreasing carbon emission by one metric ton, lead to increase in life expectancy of all people by approximately four years. This confirmed the results obtained by Elo & Preston (1992), Pope (2000), Pope et al. (2004) and Evans & Smith (2005). Education is another important factor that has positive influence on the health of people, from the results above, increasing the average years of schooling by one year, lead to increase life expectancy of people by five years. In fact, fact, education has both direct and indirect impacts on the health outcome. It enhances labour market productivity and income growth, and educating women has beneficial effects on child health and social well-being. Intuitively, education also raises people's health awareness and thereby actions toward achieving better health status, which itself have significant bearing on extending life expectancy.

Regarding the different impact of these variables on life expectancy by gender, the(α) coefficient here reflects the size and type (positive, negative) of effects for specific variables on life expectancy by gender, therefore, taking in the consideration that male is the control variables (female=0), from the results above, all the selected variables have an insignificant role in explaining the disparities on life expectancy in Sudan during the period of study, but their impacts varies according to sex. Estimated coefficients of the dummy variable are significant at the 1% level, which imply that there is a statistically significant gap between male and female in life expectancy and this gap is in favour of female. The coefficient of the average years of schooling has a positive power in the gap between people in health, which means a positive (negative) relationship between male (female) educations and male (female) health. Economic growth also has a positive role in explaining this gap, which means, more economic growth lads to more gaps in life expectancy between male and female and against female health, this confirmed the results obtained by Ahemed (2010) who find the existence of a gender gap against females in all human development indicators except for health, in which females are better in Sudan during the period 1990-2005.

Urbanization has a negative contribution to disparities in life expectancy between the two sexes. In fact, in the most developing country most of the services concentrated in urban areas, which lead to increase the rate of migrated people from rural to urban area, but for the case of Sudan, urbanization has a positive effect on female health. This may be due to the efforts exerted in the Safe Motherhood Program to improve health conditions in terms of vaccination and maternal health, which mainly concentrated in urban area.

Regarding the pollution and their effect on the life expectancy gap, it’s clear that it has a positive effect on this gap, but the influence is insignificant. This means that, increasing the pollution would lead to increase in the gap between the two sexes, as well as against female. However, pollution has a different impact on each sex because the negative impact on female health might be due to the fact that females are more been affected by pollution than males. For example, study by a woman environmental network in 2010 shows that in households across the UK, women are fundamental since around 27% of carbon dioxide emissions are generated from household activities. In the European heat wave in 2003, 75% more women died compared to men, with factors including, poverty, deprivation, living alone, and vulnerability to associated air pollution. While the positive impact on males' health can be justified by the fact that, with economic growth the males gain benefits (increasing their income) which have a positive impact on their health. However, at same time, with this economic growth they lost some of their welfare from pollution. Subsequently, the positive effects dominated the negative ones.

The Co-Integration Analysis

The first step for testing existence of long run relationship between life expectancy by sex and their main determinants is to apply unit root tests. Table 2 display the ADF, PP and KPSS unit root test results in levels with intercept and with intercept and trend. From the result of the tests, we are unable to reject the null hypothesis of unit root at 1% and 5 % significance level.

From Table 2 it is obviously the series is not stationary, thus, we proceeded to the first difference to see if the variables are stationary and the results can be seen in Table (3). It's clear from the table, most of the time series are stationary in first deference, that means I (1), except for the variable (U), which both ADF and PP indicate we cannot reject the null hypothesis on 1% or 5%, but the KPSS indicates that this variable is stationary in the first level, Therefore, the variable (U) is I (1) because KPSS more power full than the other two tests. Furthermore, regarding the variable (F) the ADF indicates that the variable, I (1) , while the PP indicates the variable is not stationary at first difference, to resolve the contradictory, KPSS confirm the result obtained by ADF which is the variable, I (1). Otherwise all the three tests agree concern the others variable that its, I (1).

Since all the variables are integrated in order one I (1), the next step is where equations (2) and (3)are estimated to examine the long-run relationships among the variables. As suggested by Pesaran & Shin (1999) and Narayan (2004), since the observations are annual, we choose 2 as the maximum order of lags in the ARDL and estimate for the period of 1960-2007. In fact, we also used the Schwarz-Bayesian criteria (SBC) to determine the optimal number of lags to be included in the conditional ECM (error correction model), whilst ensuring there was no evidence of serial correlation, as emphasized by Pesaran et al. (2001). The lag length that minimizes SBC is one for equation (3) and four for equation (2). The calculated *F*-statistics for the co-integration test is displayed in Table 6. The critical value is reported together in the same table which based on critical value suggested by Narayan (2004) using small sample size between 30 and 80. The calculated *F*-statistic for both equations are higher than the upper bound critical value at 1% level of significance, using intercept and no trend.. This implies that the null hypothesis of no co-integration cannot be accepted at 1% level for the both equations and therefore, there is a co-integration relationship among the variables.

The empirical results of the long-run for the two equations are presented in Table 5. So, it's clearer that, in the long run urbanization playing a vital role in increasing life expectancy for both sex in Sudan as indicate by *t* statistic value. Education also has strong positive influence in the long run on the life expectancy for both sex as indicated by the t statistic value. The elasticity of life expectancy with respect to male and female education is (0.071648), (0.032035) respectively, which is small, but significant at 1%. Other factors even thought have the positive relationship but insignificant in long run.

The results of the error correction model for the two equations are presented in Tables 6 and 7 respectively. Like the long run, both education and urbanization playing the important role in extending life expectancy for both sex, but relatively, her education is more significant than urbanization in their effecting health status. Furthermore, both, pollution made positive insignificant influence in the health of both sex. In the short run, economic growth has positive and significant influence in female health and positive and insignificant influence for male health. D.W. statistics for both equations indicate the absence of the autocorrelation problem. Furthermore, the selected variable explained on average 99% the varieties in the gender gap in female life expectancy and 56% for male life expectancy, which means that existence of other important factors contribute with or without these variables to the male health.

The significant of an error correction term (ECT) shows the evidence of causality in at least one direction. The lagged error term (ECTt-1) in our results for both equations is negative and significant at 1% level. The coefficients of --0.21447, and -0.013249 indicates suitable rate of convergence to equilibrium, by the other word ,last period disequilibrium is, on the average corrected by about 16% and 10% for equations (2) and (3) respectively in the flowing year.

The Causality Test

Since long run relationships have detected, we developed a dynamic error correction model (ECM) of this relationship. To establish the causality test, for example, to test whether urbanization, education, economic growth, pollution does not cause life expectancy for both sex; we apply the Granger's causality test. Tables (8) and (9) present the results for this test for the two equations. It's clear that female life expectancy causes both economic growth (at 5%) and education (at 10%), and no reverse causation. In the other hand, urbanization cause both economic growth and life expectancy for female. Only bilateral causality existed between economic growth and female education. This result implies that, economic growth lead to increase of household income, this increase in income will be devoted to female education, which in turn lead to increase in female productivity, which makes a significant contribution for economic growth, while female education cause urbanization, which means that when female become more educated, they move to urban area to achieve better job.

In the other hand, namely male, Table (9) describes the result of causality between male health and determinations. The result shows that, male life expectancy is independent from all the variables that expected to determine it. These results suggest that there are other variables with/without this variable contribute more to male health. The better result is the feedback causality between male education and urbanization. These results imply that, more educated male migrate to urban area to find a better job (urban more attractive), and in turn this educated male contributes to their new area by good planning and extending the social services, and then this urbanization lead to more economic growth because as the result shows its cause economic growth. However, in the education side, economic growth cause male education, while the verse relation is not true, this result implies that increasing the income lead to increasing the male level education, while as a result of unemployment, male not find an opportunity to transform their skills to better things.

CONCLUSION

This paper examined from an empirical point of view, whether economic growth, pollution, urbanization and education have a significant role in explaining the gender gap in life expectancy. Apart from this paper attempt to test whether these variables are the main determinants of life expectancy for all people in the Sudan during the period 1960-2007. The result shows that disparities in life expectancy between the two sexes are statistically highly significant, but all selected variables play an insignificant role in explaining these disparities, in addition to that, their impact on female health different from that of male. Furthermore, the study reveals that education, and pollution plays a vital role in determining the life expectancy for people. Other factors even have the positive or negative relationship but insignificant.

Therefore, the Sudan's' government should make efforts to improve education services, reduce the sources of pollution, equality in the distribution of income between both people and between rural and urban areas simultaneously. These policies are required in order to ensure that we get the ultimate objective from the development process. With respect to overcome gender disparities in life expectancy, additional studies required to determining which factors are responsible for these disparities in order to fulfil the Millennium Development Goals (MDGs).

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TABLE 1: The Regression Result for Equation (1)

Variables	Coefficients	t-Statistic	Prob.
C	42.62090	109.7157	0.0000
S	4.837150	6.047112	0.0000
U	0.006087	0.079253	0.9370
Y	0.000688	1.385335	0.1695
CO	-4.961799	2.443842	0.0166
DS	0.141883	0.126274	0.8998
DU	-0.032238	-0.298668	0.7659
DY	0.000325	0.462853	0.6446
DCO	0.791290	0.276605	0.7827
D01	-2.745363	-5.000179	0.0000
R-squared	0.981974	Mean dependent var	50.58625
Adjusted R-squared	0.980088	S.D. dependent var	4.665278
S.E. of regression	0.658323	Akaike info criterion	2.100089
Sum squared residual	37.27142	Schwarz criterion	2.367209
Log likelihood	-90.80427	Hannan-Quinn criteria.	2.208063
F-statistic	520.5455	Durbin-Watson stat	1.988924
Prob (F-statistic)	0.000000	Mean dependent var	50.58625

TABLE 2: ADF, PP and KPSS Unit Root Tests in Levels

Variables	ADF test		PP test		KPSS test	
	intercept	Intercept and trend	intercept	Intercept and trend	intercept	Intercept and trend
U	0.850361 (0.9939)	-1.80111 (0.6882)	3.33532 (1.0000)	0.04653 (0.9958)	0.891089	0.213443
CO	-1.674562 (0.44)	-1.668752 (0.7494)	-1.904834 (0.3274)	-1.901456 (0.6380)	0.119687	0.101516
Y	-0.109514 (0.9422)	-1.136249 (0.8789)	-0.515287 (0.8789)	-1.605217 (0.7759)	0.603880	0.112172
F	1.68577 (0.9995)	-3.204713 (0.0974)	-0.859985 (0.7921)	-1.596055 (0.7796)	0.907248	0.071592
M	-2.231570 (0.19820	-1.031017 (0.9296)	-2.225017 (0.2004)	-1.060014 (0.9250)	0.908593	0.177396
Sf	2.465063 (1.0000)	-1.244403 (0.8889)	1.784883 (0.9996)	-1.501215 (0.8152)	0.891089	0.202788
Sm	-0.033326 (0.9504)	-1.136395 (0.9116)	-0.145887 (0.9380)	1.698225 (0.7364)	0.894480	0.122937

*We use Scharwz Information Criteria with a maximum lag length of 9.. For PP and KPSS unit root test, we use Bartlett Kernel Spectral estimation method and select Newey-West automatic bandwidth. The p-values are given in brackets for ADF and PP, while KSSS critical value with intercept under 1% and 5% are (0.739000) and (0.463000), with intercept and trend under 1% and 5% are (0.216000) and (0.146000) respectively from the Kwiatkowski Phillips Schmidt-shin(1992) Table 1.

TABLE 3: ADF, PP and KPSS Unit Root Tests in First Differences

Variables	ADF test		PP test		KPSS test	
	intercept	Intercept and trend	intercept	Intercept and trend	intercept	Intercept and trend
U	-1.020472 (0.7838)	-1.701511 (0.7346)	-1.030882 (0.7345)	-1.730700 (0.7213)	0.578938*	0.126890*
CO	-6.664775* (0.0000)	-6.587093* (0.0000)	-6.705040* (0.0000)	-6.634277* (0.0000)	0.127853*	0.127844*
Y	-5.187616* (0.0001)	-5.235298* (0.0005)	-5.158839* (0.0001)	-5.313863* (0.0004)	o.149090*	0.114401*
F	-9.787161* (0.0000)	-9.384130* (0.0000)	-2.024182 (0.2758)	-2.199225 (0.4787)	0.128546*	0.095498*
M	-5.940230* (0.0000)	-6.629458* (0.0000)	-5.957411* (0.0000)	-6.637001* (0.0000)	0.414265*	0.054742*
Sf	-2.984026** (0.0441)	-6.064142* (0.0000)	-5.956817* (0.0000)	-6.265418* (0.0000)	0.405545*	0.132357*
Sm	-5.159676* (0.0001)	-5.0983612* (0.0007)	-5.393612* (0.0000)	-5.336381* (0.0000)	0.209301*	0.208868*

*We use Scharwz Information Criteria with a maximum lag length of 9.. For PP and KPSS unit root test, we use Bartlett Kernel Spectral estimation method and select Newey-West automatic bandwidth. The p-values are given in brackets for ADF and PP, while KSSS critical value with intercept under 1%, 5% are (0.739000),(0.463000) and with intercept and trend under 1% ,5% are (0.216000)(0.146000) respectively ,from Kwiatkowski Phillips Schmidt-shin(1992) table (1). * and ** denotes significance at the 1% and 5% level respectively.

TABLE 4: *F*-statistic of Co-integration Relationship

Equations	F- value	Lag	Significance Level	Bound Critical values(intercept and no trend)	
				I(0)	I(1)
No(2)	7.4710*	4	1%	3.817	5.122
No(3)	7.7939*	1	1%	3.817	5.122

* Indicate significant at the 1% level.

TABLE 5: Long-run Coefficients

Equation No	Dependent variables	Long run coefficients				
		C	LY	LU	LSF/LSM	LCO
No(2)	Lf	3.5169 (67.0170)	0.0049217 (1.8791)*	0.14490 (12.4098)***	0.032035 (5.8888)***	0.0017260 (0.50087)
No(3)	Lm	3.4630 (59.8286)	0.4687E-3 (0.16770)	0.13049 (9.3497)***	0.071648 (5.7351)***	0.0069152 (1.5802)

*; **; *** denote significant at the 10%; 5% and 1% level respectively.

TABLE 6: Error Correction Model for Life Expectancy for Male

Equation No	Dependent variables	Coefficients					
		C	ΔLY	ΔLU	ΔLSM	ΔLCO	ECM(-1)
No(3)	ΔLm	0.74272 (3.8247)	0.1005E-3 (0.16352)	0.02798 (2.9529)**	0.015367 (3.7856)***	0.0014831 (1.7654)	-0.21447 - (3.6725)***
R-Squared		0.61569					
R-Bar-Squared		0.56231					
F-stat.		11.5349					
DW-statistic		2.2317					

The t-statistic is in parentheses, and *; **; *** indicate significant at the 10%; 5% and 1% level respectively.

TABLE 7: Error Correction Model for Life Expectancy For Female

Equation No	Dependent variables	Coefficients							
		C	ΔLf_1	ΔLf_2	ΔLY	ΔLU	ΔLSf	ΔLCO	ECM(-1)
No(3)	ΔLf	0.046595 (4.1353)	1.8018 (46.0607)	-0.89088 - (23.3518)	0.6521E-4 (2.0797)*	0.0019198 (3.5459)***	0.4244E-3 (3.7322)***	0.2287E-4 (0.53819)	-0.013249 (- 4.0683)***
R-Squared		0.99881							
R-Bar-Squared		0.99857							
F-stat.		4085.6							
DW-statistic		2.5065							

The t-statistic is in parentheses, and *; ** and *** indicate significant at the 10%; 5% and 1% level respectively.

TABLE 8: Causality Test for Female Life Expectancy

Null Hypothesis	F-Statistic	Prob.	Conclusion
SF does not Granger Cause LF LF does not Granger Cause SF	0.61908 2.37993	0.6519 0.0704	Lf $\Longrightarrow$ Sf*
U does not Granger Cause LF LF does not Granger Cause U	2.13678 1.28394	0.0969 0.2950	U $\Longrightarrow$ Lf*
Y does not Granger Cause LF LF does not Granger Cause Y	0.47681 2.95768	0.7525 0.0332	Lf $\Longrightarrow$ Y**
CO does not Granger Cause LF LF does not Granger Cause CO	1.16279 1.10620	0.3439 0.3691	Accept the Null
U does not Granger Cause SF SF does not Granger Cause U	1.98591 4.91499	0.1182 0.0030	Sf $\Longrightarrow$ U***

Y does not Granger Cause SF SF does not Granger Cause Y	2.83135 2.90548	0.0391 0.0355	Sf ⇔ Y**
CO does not Granger CauseSF SF does not Granger Cause CO	0.44141 1.60381	0.7778 0.1951	Accept the Null
Y does not Granger Cause U U does not Granger Cause Y	1.42011 3.21694	0.2477 0.0238	U ⇒ Y***
CO does not Granger Cause U U does not Granger Cause CO	3.59149 1.10633	0.0148 0.3690	CO ⇒ U*
CO does not Granger Cause Y Y does not Granger Cause CO	1.06129 1.30229	0.3902 0.2882	Accept the Null

*; **and *** denote reject the null hypothesis at the 10%; 5% and 1% level respectively.

TABLE 9: Causality Test for Male Life Expectancy

Null Hypothesis	F-Statistic	Prob.	Conclusion
SM does not Granger CausLM LM does not Granger Cause SM	0.13971 2.49337	0.7104 0.1215	Accept the Null
U does not Granger Cause LM LM does not Granger Cause U	0.01590 0.28120	0.9002 0.5986	Accept the Null
Y does not Granger Cause LM LM does not Granger Cause Y	0.00027 2.23846	0.9870 0.1418	Accept the Null
CO does not Granger CausLM LM does not Granger Cause CO	0.95833 0.06944	0.3330 0.7934	Accept the Null
U does not Granger Cause SM SM does not Granger Cause U	7.25344 8.52063	0.0100 0.0055	U ⇔ Sm***
Y does not Granger Cause SM SM does not Granger Cause Y	13.8471 1.08297	0.0006 0.3037	Y ⇒ Sm*
CO does not Granger CausSM SM does not Granger Cause CO	0.31512 0.07546	0.5774 0.7848	Accept the Null
Y does not Granger Cause U U does not Granger Cause Y	1.08947 3.15370	0.3023 0.0827	U ⇒ Y*
CO does not Granger CausU U does not Granger Cause CO	5.90506 0.03100	0.0192 0.8611	C ⇒ U**
CO does not Granger Cause Y Y does not Granger Cause CO	2.67259 0.39089	0.1092 0.5351	Accept the Null

*; ** and *** denote reject the null hypothesis at the 10%; 5% and 1% level respectively.