Research Article

Time Series Analysis of Child Mortality in Pakistan: An Application of Bootstrap ARDL

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Abstract | Contemporary development theories realize the importance of social indicators such as education and health status of masses along with per capita income. This study aims to empirically test the hypotheses of Modernization Theory (MT) and the Social-Democratic Theory (SDT) related to child mortality in Pakistan. The study adopts the framework of Ferreira and Schady (2009) and Baird *et al.* (2011) to carry out empirical estimation via ARDL and Bootstrap ARDL. Confirming the co integration relationship, the study identifies that real GDP per capita is a significant variable responsible for decline in child mortality thereby confirms the hypothesis of MT. The study however, does not find statistical evidence in favor of the hypothesis of SDT due to meager allocation to health sector in case of Pakistan. Allocation of sufficient fund to health sector specifically targeting maternal and child health is expected to reduce child mortality in a rapid speed in the country.

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1. Introduction

Human centric policies have been the focal concern of both developed and developing nations across the world in the 20th century. Progress among the nations can be gauged from the education and health status besides per capita income in this modern era. It is not the mere size of per capita income that promises respected position for a country among the nations, but adequate progress in social fields like education and health has to be shown. Besides education, health status proxy by child mortality rate is often regarded as a yardstick of how well a nation is meeting its people's needs (Buckley, 2003). Among eight goals of Millennium Development Goals (MDGs) in the beginning of 21st century, each member nation of the United Nations was required to ensure substantial reduction in child mortality besides eradication of poverty and hunger, universal primary education and the like by 2015 (Todaro and Smith, 2012).

After the declaration of MDGs, significant improvement has been observed in infant and child mortality rates in majority of the developing countries. Child Mortality Rate (CMR) which is the number of deaths of children per 1000 live birth during five years is considered as one of the main indicators measuring the quality of life, health status (Gayawan *et al.*, 2016) and even the level of socio-economic development of a country (Gayawan and Turra, 2015; Kyei, 2012) and therefore, cannot be over-emphasized (Kyei, 2012). Research has shown that health and income are strongly correlated, but controversies exist on the extent of influence of income over health and their causal relationship (Baird *et al.*, 2011). Investigating the relationship between GDP per capita income and

Infant Mortality Rate (IMR) of over 1.7 billion births in 59 developing countries, Baird *et al.* (2011) find negative impact of per capita income over IMR. The study also arrives at the conclusion that female IMR is more sensitive to economic shocks than the male one and therefore demands more focus from the policy makers especially during down-turn to protect health status of the females. In a seminal work Pritchett and Summers (1996) argue that "wealthier is healthier" but the studies of Jamison *et al.* (2004) and Deaton (2006) criticized their identification and conclusion.

Over the past five decades, a hand full amount of research has been published both quantitatively and cross-national that examines the factors influencing infant mortality rate. Some insightful research including the studies of Lee *et al.* (2016), Adedini *et al.* (2015), Kayode *et al.* (2014), Kalter *et al.* (2011), Van de Poel *et al.* (2007), Shandra *et al.* (2003), Shen and Williamson (2001), Frey and Field (2000) have covered different dimensions of child mortality across the world. Comparing child health outcomes in advanced and poor nations, one can observe large disparities in child mortality between the two categories. Such disparities appeal for understanding its root causes and consequences throughout the developing world in order to allocate sufficient resources to raise population health.

Lee *et al.* (2016) in case of Vietnam estimate the socioeconomic and demographic determinants of IMR and CMR over a period of 1986-2011. The study arrives at the conclusion that women living in mountainous area, having low level of education, minor ethnic group and with multiple children increases the chances to have experienced child deaths. Tarverdi and Rammohan (2017) using System GMM Dynamic Panel over cross-country data find significant negative impact of governance on CMR, while report ambiguous effect of health aid.

Although Pakistan has made a moderate improvement in CMR from 260 per 1000 live births in 1960's to 79 in 2016, it is still lagging behind other South Asian countries with similar socioeconomic conditions. There exist limited studies in the context of Pakistan on the issue of CMR. Using Binary Logistic Regression Analysis, Ahmed *et al.* (2016) investigated the factors influencing CMR in Pakistan and identified mother education, birth order and preceding birth interval, region, baby's size at the time of birth, family size and breastfeeding are the significant variables. Globally CMR under-five has declined to 53 per 1000 live birth, and is still far away from MDG4 target of 31 deaths. Considerable difference exist regarding the magnitude of progress of CMR among different regions and South Asian region is still lagging behind with 51 deaths per 1000 in 2015 (Ahmed*et al.*, 2016).

In Pakistan, limited studies exist on the issue of CMR, its determining factors and consequences. Micro-level studies that covered different dimensions of under-five child mortality include the study of Irum and Butt (2008), who examine the impact of demographic, environmental and household level factors on CMR in Pakistan. The study identifies mother feeding and education as the explaining variables. In a micro level study by Bennet (1998) conducted in Rawalpindi city of Pakistan found non-economic factors to be significantly correlated with CMR. The study shows that mother's age and her age at marriage, household hygienic condition and contraceptive use are significant factors. Besides these, the cultural norm of bearing large number of children and household health-seeking behavior also play significant factors in explaining CMR. Micro-level studies have their own significance in explaining the phenomenon of CMR, and the identification and conclusion seems to be very contextual to a particular geographical location, culture and other non-economic factors. The current endeavor is therefore an attempt to investigate the impact of macroeconomic variables on CMR in Pakistan. The study is likely to insert interesting insights to the existing empirical literature on CMR by employing recent econometric methodology of Bootstrap ARDL in the context of Pakistan with high CMR among other South Asian countries with similar level of development.

1.1 Theoretical and empirical frameworks

This study aims to assess determining factors of child mortality on the basis of two theoretical viewpoints. These points include the famous Modernization Theory (MT) and Social-Democratic Theory (SDT). The first theory is linked with the Neo-Classical theory and view the economic growth as narrowing down the gap between poor and advanced countries. Economic development results in high standard of living and leads to improvement in medical technologies and as a consequent child mortality falls (Shen *et al.*, 2008). The present study uses per capita real GDP as gauge of this perspective, although researchers have used

different indicators including per capita income, literacy rates, percent of urban population and even per capita energy consumption (Kelly and Cutright, 1980; Williamson, 1987; Shen *et al.*, 2008). Contrary to the MT, the SDT focuses on the state commitment to people's welfare and health. This research work uses public expenditure as percent of GDP to measure state commitment to its people health and welfare and as indicator in the perspective of SDT.

Many developing countries are confronted with the problem of high mortality rate and a significant amount of research has been gathered around this global issue (Tarverdi and Rammohan, 2017). This study adopts the framework of Ferreira and Schady (2009) and Baird *et al.* (2011) to carry out empirical estimation via ARDL and Bootstrap ARDL. The framework includes public health expenditure, dedicated time to child care by parents and consumption of health-enhancing goods which is the function of household income.

2. Materials and Methods

Annual data range from 1972 to 2014 on CMR, female labor force participation rate, per capita real GDP and health expenditure as percent of GDP are utilized to carry out empirical analysis. To analyze the long-run and short run relationships between CMR and the variables of our interest, we would likely to rely on Pesaran *et al.* (2001) ARDL model. The ECM version of this method is as:

$$\Delta CMR_t = \alpha + \beta_1 \sum_{i=1}^{p} \Delta CMR_{t-i} + \beta_2 \sum_{i=0}^{p} \Delta FLFPR_{t-i} + \beta_3 \sum_{i=0}^{p} \Delta PCI_{t-i} + \beta_4 \sum_{i=0}^{p} \Delta HEXP + \lambda_1 CMR_{t-1} + \lambda_{t-1} FLFPR_{t-i} + \lambda_{t-1} PCI_{t-i} + \lambda_{t-1} HEXP_{t-i} + \varepsilon_t \quad ------(1)$$

Compared with other co-integration methods, this method has many advantages. It can be estimated by OLS, and both short and long term relationships can be calculated, regardless of whether the variables are integrals of the same order. In addition, the method is suitable and effective in small sample study (Narayan, 2005). Compared with other competing methods, it has better statistical characteristics (Banerjee *et al.*, 1998). However, many authors use this approach without considering their underlying assumptions. A bootstrap ARDL method is proposed by McNown *et al.* (2017) to deal with the co-integration relationship, which involves the resampling of ARDL test to identify degenerate cases. It is pointed out that the ARDL test does not reflect degenerate cases of the co-integration relationship, and misleading conclusions may be drawn if the ARDL technique is mishandled in its application.

To explain the Bootstrap ARDL, the ECM representation is as:

$$\Delta CMR_t = c + \phi\, CMR_{t-1} + \gamma\ FLFPR_{t-1} + \delta PCI_{t-1} + \alpha HEXP_{t-1} + \sum_{i=1}^{p-1} \eta_i \Delta CMR_{t-i} + \sum_{i=1}^{p-1} \mu_i \Delta FLFPR_{t-i} + \sum_{i=1}^{p-1} \theta \Delta PCI + \sum_{i=1}^{p-1} \lambda \Delta HEXP + \upsilon_t \quad -----(2)$$

Pesaran *et al.* (2001) insist that Co integration would require the rejection of t-test on the lagged dependent variable (T_{dep}) H_0: $\phi = 0$ besides the rejection of F-test that is H_0: $\phi = \gamma = \delta = \alpha = 0$ and. However, some authors like McNown *et al.* (2017) advise an additional F-test on lagged independent variables that is (F_{indp}) H_0: $\gamma = \delta = \alpha = 0$ to supplement Pesaran's test. This is likely to identify the exact situation and would be helpful to discern the case of true Co integration from no Co integration and even the degenerate cases. In the ARDL Co integration test, significant F- and T-tests of lagged dependent variable represents degenerate Case-I provided that T-test on lagged independent variable is insignificant. Similarly, the chances of degenerate Case-II will occur when both F- and T-tests are found to be significant on lagged independent variables, while T-test becomes insignificant in case of lagged dependent variables. A threshold is provided by recent studies only for this case, but not for Case-I. However, if the dependent variable is an integral of the first order, the possibility of degenerate Case-I is ruled out. But unit root test is usually affected by low power test. Therefore, the ARDL test solves this problem by performing additional tests on lagged independent variables.

In study of Asumadu-Sarkodie and Owusu (2016) in case of Ghana wrongly applied ARDL while estimating the impact of GDP, household consumption, fertility rate and food production index on child mortality rate. The study did not take care of degenerate cases; as the dependent variable is stationary at 5% level. To our knowledge no single study attempted to investigate the macroeconomic determinants of child mortality while focusing the long run besides the short-run dynamics in case of Pakistan.

3. Results and Discussion

To test stationarity of variables we rely on Augmented Dickey-Fuller (ADF) besides Phillips-Perron (PP)

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test. The calculated results are being reported in Table 1. the variables are stationary at one thereby justifying the application of ARDL based on small size sample of 43 annual observations in the current study.

Table 1: Unit Root (ADF and PP).

Variables	ADF-test				PP-test			
	Drift		Drift and trend		Drift		Drift and trend	
	Level	1st Δ	Level	1st Δ	Level	1st Δ	Level	1st Δ
CMR	-1.09	-3.31**	-2.48	-3.46***	-1.17	-3.04**	-1.52	-2.74
PCI	0.26	-4.22*	-2.98	-4.11**	0.23	-4.18*	-2.35	-4.17**
FLFPR	0.34	-6.48*	-1.92	-6.52*	0.56	-6.52*	-1.94	-6.59*
HEXP	-1.33	-6.13*	-2.30	-6.34*	-1.91	-4.76*	-2.60	-6.92*

Notes: 1%, 5% and 10% level of significance are being represented by *, **, *** respectively.

The bound-test is then computed via Eviews-10 software and the analyses are being reported in Table 2. F-Statistics (11.155) exceeds the finite critical values; n=40 of upper bound that is 6.61. This rejects the null hypothesis at 1% level.

Table 2: ARDL result.

Probability	Wald F-Test =11.155	
	I(0)	I(1)
10%	2.93	4.02
5%	3.55	4.80
1%	5.02	6.61

Note: Wald F-test is based on AIC criterion. Top 20 models on the basis of Akaike Information Criteria have been reported in Supplementary Figure 1.

However, contrary to the bound F-test, inconclusive result appears on the basis of bound t-test. The value of t-statistic (-2.013) given in Table 3 actually falls in the critical region even at 10% level. In plain words, insignificant t-test shows the occurrence of degenerate case-II in this situation. It is therefore concluded that the bootstrap ARDL method appears to be more efficient as it is based on actual distribution of the test statistic as compared to the asymptotic distribution test statistic in Pesaran *et al.* (2001) approach.

Table 3: t-bounds test for dependent variable (Degenerate case-II).

Statistic	Computed value	Probability	I(0)	I(1)
t-stat.	-2.012753	10%	-2.57	-3.46
		5%	-2.86	-3.78
		1%	-3.43	-4.37

F-Statistic computed via bootstrap ARDL method is 4.689 and is being reported in Table 4 and is found to be significant at 1% level. Asides this, the computed t-statistic (-2.18 is also significant at 5% level. These rules out the possibility of degenerate case-II as against the conventional ARDL test. F-statistic on independent variables which is 6.240 is also significant at 1% probability and therefore rules out the occurrence of degenerate Case-1. Thus the advantages of bootstrap ARDL are evident; on one hand side it eliminates the uncertainty associated with conventional ARDL and supplements it on the other hand.

Table 4: Bootstrap ARDL test results.

Test-Stat	Bootstrap estimated value	Bootstrap critical values		
		0.90	0.95	0.99
Over all F-Stat	4.689	2.409	3.059	4.480
T-Stat (Dep. Var)	-2.189	-1.429	-1.837	-2.623
F-Stat (Indep. Var)	6.240	2.587	3.266	4.739

The impact of the selected variables on CMR in the long run are estimated and being reported in Table 5. The impact of participation in the labor market by female is positively related to child mortality and the effect is found to be significant at 10% level. The plausible explanation for the positive relationship of FLFPR is that the dedicated time a mother spends in child care activities falls and as a consequent the chances of a child to become ill increase. In Pakistan, raising a child is the prime responsibility of a woman along with other household level activities. Aside this, our results are in conformity with the MT. In our study we relied on real per capita GDP as proxy for level of economic development and the estimated impact is not only negative but is also significant at 1% level. The effect of health expenditure on CMR is insignificant but the sign is in conformity with SDT. The plausible reason for such insignificant impact is the state commitment in the allocation of meager amount to public health.

Table 5: ARDL Long-run coefficients (Case 3).

Variable	Co-eff.	Std. Er.	t-Stat.	P
FLFPR	4.796130	2.771157	1.730732	0.0934
PCI	-0.287494	0.083876	-3.427615	0.0017
HEXP	-8.850636	13.42440	-0.659295	0.5146

The coefficient of CointEq (-1) is speed of adjustment and is reported in Supplemenatry Table 4. Luckily

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the sign of the ECM term is not only negative but also is less than unity. But one should note it down that the test statistic of ECM does not follow the t-distribution in its standard form. The absolute value of computed test statistic -6.99 exceeds than the value of upper bound (-4.37) and is therefore significant at 1% probability level.

The conventional diagnostic tests results reported in Supplemenatry Table 5 depict that the model passes the tests of normality, autocorrelation, heteroscedasticity and functional form. Similarly, parameters stability tests for the model are reported in Supplemenatry Table 6. From both the tests of CUSUM and CUSUM of square, the parameters of the models are stable.

Conclusions and Recommendations

The objective of sustainable development con not be materialized without focusing human centric policies. Significant improvement has been observed in infant and child mortality rates in majority of the developing nations, after the declaration of MDGs. Although Pakistan has made a moderate improvement in CMR from 260 per 1000 live births in 1960's to 79 in 2016, it is still lagging behind other South Asian countries with similar socioeconomic conditions. There exist limited studies in the context of Pakistan on the issue of CMR. This study aims to assess macro determinants of CMR while relying on famous theoretical perspectives MT and SDT. The study adopts the framework of Ferreira and Schady (2009) besides the influential work of Baird *et al.* (2011) to carry out empirical estimation via ARDL and Bootstrap ARDL. Annual data range from 1972 to 2014 on CMR, female labor force participation rate, per capita real GDP and health expenditure as percent of GDP are utilized to carry out empirical analysis. The model identifies that level of economic growth proxy by real GDP per capita is a significant variable responsible for decline in child mortality thereby confirming the hypothesis of MT. The study however, does not find statistical evidence in favor of the hypothesis of SDT due to meager allocation to health sector in Pakistan. Allocation of sufficient fund to health sector specifically targeting maternal and child health is expected to reduce mortality in a rapid speed in the country.

Novelty Statement

Empirically test the hypotheses of Modernization Theory (MT) and the Social-Democratic Theory (SDT) related to child mortality in Pakistan. The study adopts the framework of Ferreira and Schady (2009) and Baird *et al.* (2009) to carry out empirical estimation via ARDL and Bootstrap ARDL.

Author's Contribution

IH background of the study and econometric methodology. UH review of literature and results interpretation. AA estimation of the model and interpretation. KK theoretical and empirical framework.

Supplementary Material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.jis/2020/6.2.137.143

Conflict of interest

The authors have declared no conflict of interest.

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