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Economic Impact of Maternal Mortality in Africa: A Panel Data Approach

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Abstract

A previous study used cross-sectional data on 45 countries in the WHO African region to test the hypothesis that Gross Domestic Product (GDP) per Capita was inversely related to Maternal Mortality Ratio (MMR). However, the cross-sectional technique was unable to capture both the individual country and time specific heterogeneity. Therefore, the aim of the present study was to use Panel Data models to test the hypothesis and to further estimate the economic loss due to MMR in the WHO Africa Region. Findings from the study would be beneficial to governments seeking to minimize the impact of MMR on the growth of their economies. Regarding statistical methodology, the study was intended to demonstrate to practitioners the potential of Panel Data Models as more practical approaches to fitting data with cross-section and time series behavior. The estimated model with country dummy was found to be a potentially effective analytical tool for estimating economic loss due to MMR in the WHO Africa Region.

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1 Introduction

The Millennium Development Goals (MDGs), a United Nations Millennium Declaration, aimed at promoting human development and reducing global inequalities. The MDGs include eight ambitious goals to be achieved by 2015. One of the goals, MDG 5, is aimed at reducing Maternal Mortality Ratio (MMR) by 75% by 2015. MMR signifies the number of women who die annually from pregnancy and childbirth related issues. Thus it measures the number of women who die from complications of pregnancy and childbirth per 100,000 live births. As at 1990, the global ratio was around 543,000 and by 2010 it was around 287,000 resulting in about 89.2% decline. Despite this progress, rates are still 15 time higher in developing regions (see [1]). It is reported that about 800 women die every day from complications related to pregnancy and child births (see [1]). It is important to mention that, Africa has the highest ratio of maternal deaths in the world (see [1]). Despite some progress, it is uncertain if most sub-Saharan African countries can reduce MMR by three-quarters (MDG 5) come 2015.

The economic contributions of women to the sub-Saharan African household cannot be overemphasized. The mortality of mothers in the active labour force may result in the reduction of household personal savings and resources necessary for investment (see [2]). Therefore, it is important to focus on the economic influences of MMR. Gross Domestic Product (GDP) is a key economic indicator of development. Thus, the impact of MMR on Gross Domestic Product (GDP) per Capita, especially for sub-Saharan countries should be of immense interest to development experts. Using cross-sectional data, [2] concluded that MMR had a significant inverse relationship with GDP per Capita for 45 States in the WHO African region. The purposes of this study therefore, were to further establish whether GDP per Capita and MMR are inversely related in the light of recent data. To identify a statistical/econometric model for estimating loss in GDP per Capita due to MMR and to estimate the total annual economic loss due to MMR in the WHO Africa Region. To capture both the individual countries and year specific heterogeneities, the present study employed the panel data approach. Information collected over time on the same subject, individual, city, region, country etc. form what is known as panel data. The panel data methodology was introduced in academic research as far back as 1940 by Paul F. Lazarsfeld (see [3] and [4]). The choice of the functional form of the model used in the current study was informed by the characteristics of the data rather than making a nonlinearity assumption. [5] is among few references that list many benefits of using panel data. One benefit of using the panel data approach is that it captures both the cross-sectional and time-series dimensions. Examples of panel data are panel study of Income Dynamics and National Longitudinal Survey on Labor Force in USA (see [6]).

2 Data

The WHO and UNICEF 2013 report (see [1]), World Development Indicators (see [7]), and the African Statistics Year Book 2013 (see [8]) served as the main sources of data. The response and predictor variables were GDP per Capita in US$ and MMR respectively. Mid-Year Population (see [8]) were used as an input in arriving at the total annual economic loss for each country. In estimating the relationship between GDP per Capita and MMR, 42 out of 46 countries were used due to missing observations and the years considered were 1990, 2000 and 2010 per country.

3 Panel Data Models

The Panel Data models considered were Pooled Ordinary Least Squares (Pooled OLS) and the Least Squares Dummy Variable (LSDV) Regression Models (see [6] and [9]).

3.1 The Pooled OLS and LSDV Regression Models

The Pooled OLS and the LSDV regression models are given by (1) and (2) respectively.

$$y_{it} = \alpha + x'_{it}\beta + \epsilon_{it}, \quad i = 1,2,\dots,N; \;\; t = 1,2,\dots,T \qquad (1)$$

y_{it} and x_{it} are the response and predictor variables respectively. α represents the restricted intercepts. β is the slope parameter and ϵ_{it} are the error components.

$$y_{it} = x'_{it}\beta + \alpha_i + u_{it}, \quad i = 1,2,\dots,N; \;\; t = 1,2,\dots,T \qquad (2)$$

y_{it} and x_{it} are the response and predictor variables respectively. α_i are the unrestricted intercepts, all may be different, β is the slope parameter, and u_{it} are the error components. Both (1) and (2) are estimated by the OLS method. In an event that the country-specific fixed effects are statistically significant in (2), the estimated parameters for (1) will be biased and inconsistent as pointed out by [10] and [11]. The procedure for the choice of either (1) or (2) is the simple chow test. The α_i's are treated as $N-1$ dummy variables then a joint significance of these dummies are tested. The steps for the hypothesis testing are as follows:

$$H_0: \alpha_1 = \cdots = \alpha_{N-1} = 0,$$

$$H_a: \alpha_i \neq 0 \text{ for some } i \neq j.$$

The test statistics is the F-statistic defined as:

$$F_0 = \frac{R_2^2 - R_1^2/(N-1)}{1 - R_2^2/(NT-N-K)} \sim F(N-1, NT-N-K)$$

where R_1^2 and R_2^2 are the R-squared from (1) and (2) respectively and K is the number of predictor variables. The test rejects H_0 if $F_0 > F$.

4 Economic Impact Formulas

The loss per death (LD) reflecting the burden of MMR on GDP per Capita was estimated as follows:

$$LD = (\overline{GDP}/\overline{MMR}) \times \hat{\beta}_M \quad (3)$$

where $\overline{GDP}$ and $\overline{MMR}$ are the averages of GDP per Capita and MMR respectively. The $\hat{\beta}_M$ estimates β from either (1) or (2). βmeasures the percentage change in GDP per Capita for a given small change in MMR. The estimated amount of GDP per Capita loss due to MMR for the i^{th} country in the t^{th} year was obtained by multiplying the LD by MMR for that i^{th} country in the t^{th} year. The total annual economic loss for the i^{th} country in the t^{th} year $(TAEL_{it})$ was estimated with the following formula:

$$TAEL_{it} = \left[\left(\frac{P_{it} - P_{it-1}}{100{,}000}\right) \times MMR_{it}\right] \times LD \quad (4)$$

where P_{it} is the mid-year population for the i^{th} country in the t^{th} year. P_{it-1} is the mid-year population for the i^{th} country in the $(t\text{-}1)^{st}$ year (See [2]).

5 Results

Table 1 clearly shows that on the average MMR was on a decline. In 1990 the ratio stood at 740. As at 2010, it was at 464.48 resulting in a decline of about 37%. Another important remark is that, the shape of the distribution of MMR has changed significantly. It was skewed to the left in 1990; however from 2000 till the end of 2010, it shifted to the right.

Table 1: Maternal Mortality Ratio

Year	**Average**	**St. Dev**	**Skewness**	**95% CI**
1990	740	332.33	-0.14	(643.96,836.04)
2000	641.3	292.34	0.26	(556.82,725.78)
2010	464.48	243.84	0.61	(394.02,534.94)

Source: Researchers calculation

GDP per Capita on the average was on ascendency. In 1990 it was at $720.27 and by the close of 2010, it rose to $1851.03 indicating a growth of over one and half fold as evidenced by Table 2.

Table 2: GDP Per Capita

Year	**Average**	**St. Dev**	**Skewness**	**95% CI**
1990	720.27	1047.63	3.83	(410.71,1029.83)
2000	677.5	884.68	2.44	(419.02,935.98)
2010	1851.03	3129.17	3.39	(926.42,2775.64)

Source: Researchers calculation

It is abundantly clear that for the period under review, the growth in GDP per Capita by far outstripped the decline in MMR.

Figure 1 shows the scatterplot of GDP per Capita against MMR when the panel structure was ignored. The figure presents four (4) case scenarios. Case 1 (a) examines the scatterplot where the response variable is GDP per Capita and the predictor variable is MMR. It is evident from the figure that no relationship was obvious. We further examined the relationship between the logarithm transformation of MMR and GDP per Capita as indicated by case 1 (b). Again, no clear pattern was discernable from that. Again, we transformed only GDP per Capita and re-examined the relationship as shown in figure 1 (c). This time around, the relationship looks somewhat obvious. Rising MMR was associated with falling Log (GDP per Capita). Similarly, a much clearer relationship is shown in figure 1 (d) when we transformed both variables. This relationship could be deceptive if the country-specific fixed effects are statistically significant.

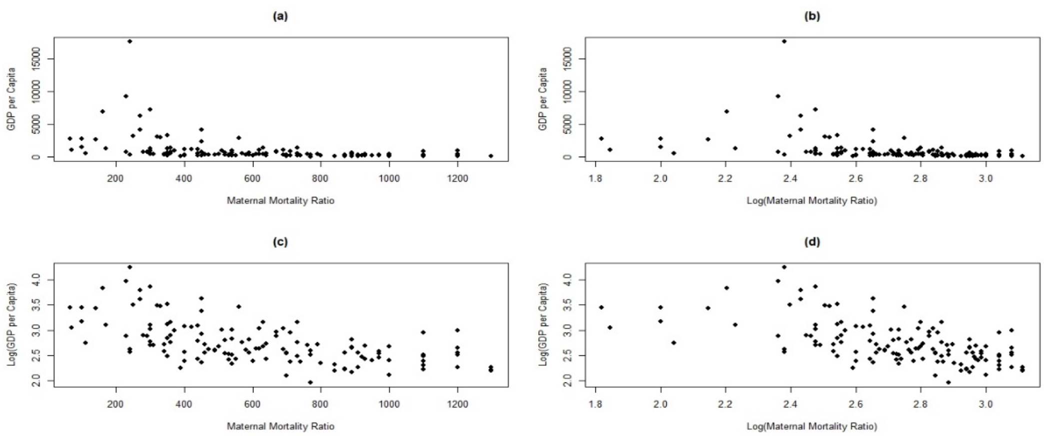

Figure 1: Scatterplot Ignoring Panel Structure

Figures 2-4 show the scatterplots for 1990, 2000 and 2010 respectively. Focusing more on figure (d) for the individual years, one can say some sort of inverse relationship existed between Log (GDP per Capita) and Log (MMR). The steepness of the relationship was not too different year on year.

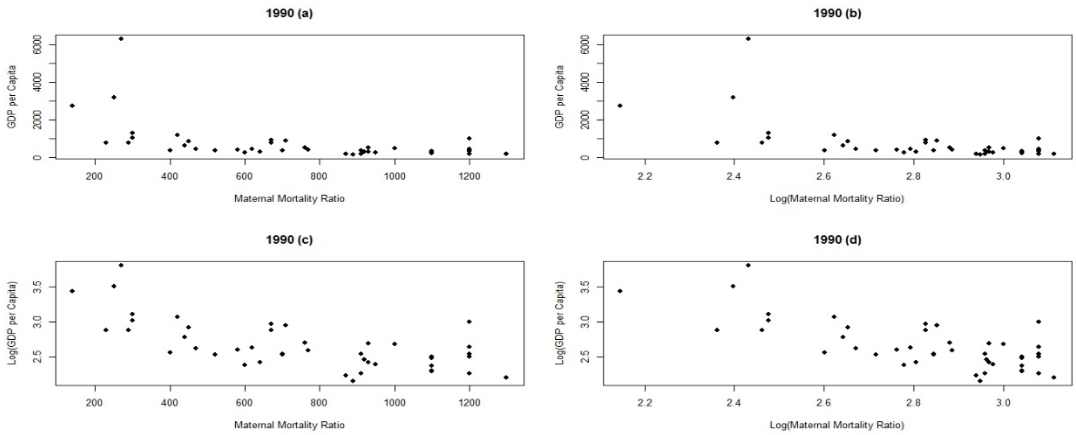

Figure 2: Scatterplot for 1990

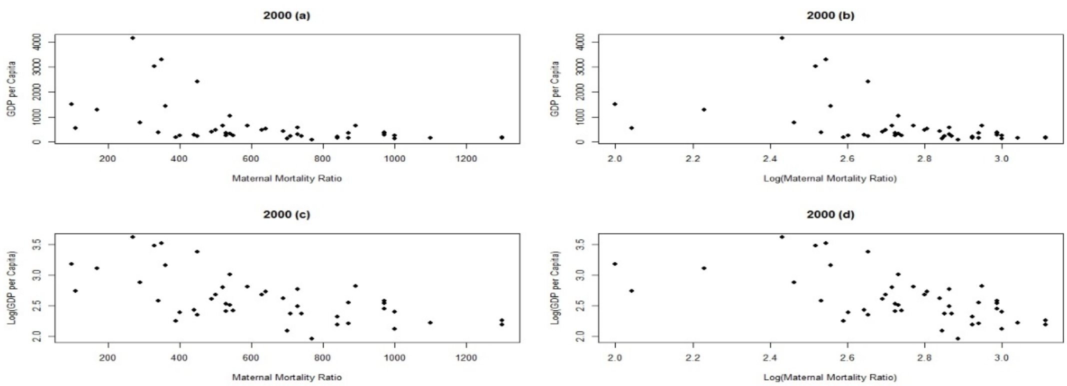

Figure 3: Scatterplot for 2000

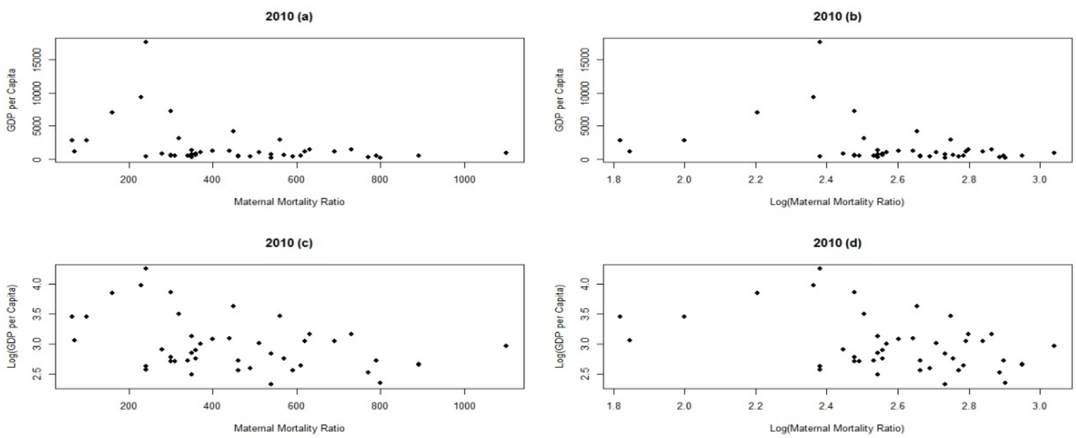

Figure 4: Scatterplot for 2010

Table 3 displays the regression results for both the Pooled OLS and the LSDV models. In both models, the Log (MMR) was statistically significant at 1% and 5% levels (the standard errors are in parentheses). The LSDV model explained 99.7% of the variability in the Log (GDP), however, only 43.1% of the variability in the Log (GDP) was explained by the Pooled OLS model.

Table 3: Regression Table

	Pooled OLS	**LSDV**
Intercept	5.874***	-
	(0.323)	-
Log (MMR)	-1.138***	-1.075***
	(0.117)	(0.146)
$\mathbf{R^2}$	**0.431**	**0.997**

*** p-value < 0.001

The chow test indicated that the null hypothesis can be rejected since the F-value computed from the sample data was significantly greater than the F-value obtained from the F-table (F_0 =381.935 > $F_{41,\,83}$(0.05) = 1.535; p-value = 0.000). The statistical implication is that, the country specific fixed effects cannot be discarded therefore, we used the estimated coefficient of Log (MMR) from the LSDV model for the rest of the estimation process. Further, by (3) we obtained the LD as follows:

$\hat{\beta}_M = -1.075,\ \overline{\text{GDP}} = \$1903.535,\ \overline{\text{MMR}} = 472.763$

$$\text{LD} = \frac{\$1903.535}{472.763} \times -1.075 = -\$4.33.$$

The interpretation is that, if maternal mortality goes up by 1 person per year, GDP per Capita decreases by $4.33 on the average. This is the burden of MMR on GDP per Capita. Example of estimating total annual economic loss in the case of Ghana

- MMR in 2010 was 350
- Mid-Year Population in 2009 was 23,824,000
- Mid-Year Population in 2010 was 24,392,000

Table 5: Distribution of Estimated Loss in GDP per Capita
and Total Annual Economic Loss by Region

Region	**Number of Countries**	**Estimated Loss in GDP per Capita due to MMR (US$)**	**Total Annual Economic Loss (US$)**
South Africa	4	6,062.00	8,191.49
North Africa	3	3,879.68	30,554.04
Middle Africa	8	20,351.00	87,672.54
East Africa	12	22,083.00	147,871.23
West Africa	15	33,600.80	196,443.01

Therefore, the estimated loss in GDP per Capita for Ghana in 2010 was $\$4.33 \times 350 = \$1{,}515.50$. From (4), the total annual economic loss for Ghana in 2010 was estimated at $8,653.51. For the rest of the countries see Table 4 (in Appendix). The distribution of estimated loss in GDP per Capita and total annual economic loss due to MMR by East, Middle, North, South, and West Africa are shown in both Table 5 and Figure 5. It is evident from the table and the figure that the economic impact was higher within the West African Sub-region, followed by East Africa and then Middle Africa. The total estimated loss in GDP per Capita and total annual economic loss due to MMR among the 42 WHO African countries for 2010 amounted to $85, 97648 and $470,732.31respectively.

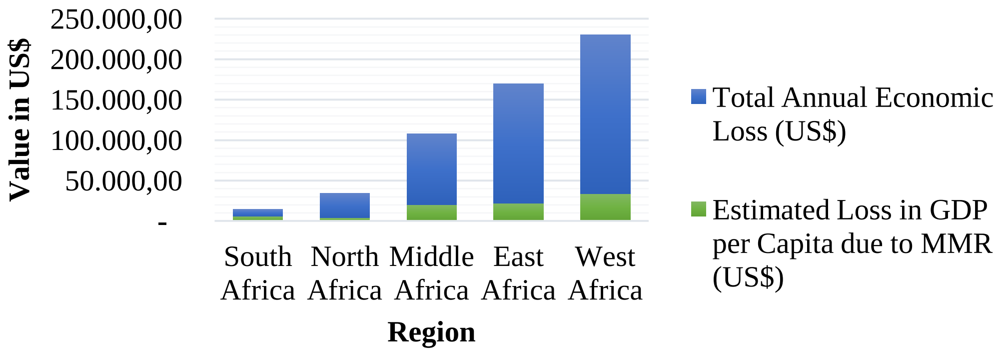

Figure 5: Distribution of Estimated Loss in GDP per Capita and Total Annual Economic Loss by Region

6 Conclusion

The present study investigated the economic impact of MMR on GDP per Capita for the WHO Africa region. The results indicate that the LSDV with country dummy is a potentially effective analytic tool for estimating economic loss due to MMR in Africa. The data showed that MMR had an inverse relationship with GDP per Capita. As [2] noted, MMR is both an indicator and a cause of underdevelopment. Consequently, some development professionals have called for MMR to be considered as a development indicator (see [12]). Hopefully, policy-makers in sub-Saharan Africa would heed to this call and consider MMR as a key development index.

Appendix

Table 4: Distribution of Estimated Loss in GDP per Capita and Total Annual Economic Loss by Country

Country	Total Mid-Year Population in Thousands for 2010	Estimated Loss in GDP per Capita due to MMR (US$)	Total Annual Economic Loss (US$)
Angola	19,549	1,948.50	12,119.67
Benin	9,510	1,515.50	4,076.70
Botswana	1,969	692.8	117.78
Burkina Faso	15,540	1,299.00	5,780.55
Burundi	9,233	3,464.00	10,599.84
Cameroon	20,624	2,987.70	15,536.04
Central African Republic	488	3,853.70	77.07
Chad	11,721	4,763.00	16,670.50
Comoros	683	1,212.40	206.11
Congo	4,112	2,424.80	2,837.02
Ivory Coast	18,977	1,732.00	6,512.32
Democratic Republic of the Congo	62,191	2,338.20	39,866.31
Egypt	78,076	285.78	3,718.00
Equatorial Guinea	696	1,039.20	197.45
Ethiopia	87,095	1,515.50	34,204.84
Gabon	1,556	995.9	368.48
Gambia	1,681	1,558.80	826.16
Ghana	24,263	1,515.50	8,653.51
Guinea	10,876	2,641.30	7,474.88

Guinea-Bissau	1,587	3,420.70	1,231.45
Kenya	40,909	1,558.80	16,897.39
Lesotho	2,009	2,684.60	510.07
Liberia	3,958	3,334.10	4,567.72
Madagascar	21,080	1,039.20	6,068.93
Malawi	15,014	1,991.80	8,783.84
Mali	13,986	2,338.20	9,984.11
Mauritania	3,609	2,208.30	1,987.47
Morocco	31,642	433	1,580.45
Mozambique	23,967	2,121.70	12,857.50
Niger	15,894	2,554.70	15,098.28
Nigeria	159,708	2,727.90	118,036.23
Rwanda	10,837	1,472.20	4,519.65
Senegal	12,951	1,602.10	5,831.64
Sierra Leone	5,752	3,853.70	4,277.61
South Africa	51,452	1,299.00	7,300.38
Sudan	35,652	3,160.90	25,255.59
Swaziland	1,193	1,385.60	263.26
Tanzania	44,973	1,991.80	26,550.69
Togo	6,306	1,299.00	2,104.38
Uganda	33,987	1,342.30	15,074.03
Zambia	13,217	1,905.20	7,468.38
Zimbabwe	13,077	2,468.10	4,640.03

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