Infant Mortality in the World-System*

R. Scott Frey and Wanjun Cui

Results of a study of the cross-national determinants of the 2005 infant mortality rate for fifty-nine low and middle-income countries are reported here. We examined the empirical validity of four macro-social change theories: gender stratification theory, modernization theory, dependency/world-systems theory, and developmental state theory. We found strong support for gender stratification theory: female education had a negative effect on infant mortality. Support was also found for modernization theory: as industrialization increased, the infant mortality rate decreased. No support was found for developmental state theory and dependency/world-system theory. Several control variables were examined, but only Sub-Saharan Africa status proved to be an important predictor: Sub-Saharan African countries had a significantly higher infant mortality rate than their non-Sub-Saharan African counterparts. Implications of the findings and suggestions for future research are briefly discussed.

Keywords: *infant mortality rate, gender inequality, Sub-Saharan African status, industrialization, world-system.*

The plight of children improved dramatically over the twentieth century (see, *e.g.*, Black *et al.* 2003). Infant mortality rates, for example, declined globally over the past six decades and the infant death rate has declined across countries occupying very different positions in the world-system, but considerable cross-national variation in infant mortality remains at the beginning of the twenty-first century (CIA 2013) and child mortality reduction goals under the UN's 2015 Millennium Development Goals will not be met (UN 2014). Consider the fact that there is currently a 100-fold variation in the infant mortality rate across countries in the world-system: Monaco had a rate of 1.81 infant deaths per live 1,000 births in 2013, while Afghanistan had a rate of 187.5 infant deaths per 1,000 live births (CIA 2013). Why does infant mortality continue to vary so widely across countries of the world-system?

Researchers have addressed this question by assessing the empirical validity of various macro-social change perspectives (see, *e.g.*, Babones 2008; Caldwell 1990; Frey and Field 2000; Fuse and Crenshaw 2006; Gakidou *et al.* 2010; Jorgenson and Rice 2010, 2012; Moore *et al.* 2006; Schell *et al.* 2007; Shandra *et al.* 2004, 2005, 2011; Shen and Williamson 1997, 2001; Wang 2014; York and Ergas 2011). Given the fact that socioeconomic conditions have improved in many countries since most of the earlier research was conducted, it is important to examine more recent data for countries at risk of high infant death rates: low and middle-income countries. We used circa 2005 data for a sample of fifty-nine low and middle-income countries to estimate six models informed by four theoretical perspectives. Ordinary Least-Squares (OLS) and Reweighted Least-Squares (RLS) regression estimates are reported below and theoretical and policy implications of the re-

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sults and suggestions for future research are discussed, but we first summarize the four key theoretical perspectives.

Alternative Theoretical Perspectives

The four perspectives informing most of the extant cross-national infant mortality research can be referred to as gender stratification, modernization, dependency/world-systems, and developmental state theories. Each is discussed in turn.

Gender Stratification Theory

Proponents of gender stratification theory argue that the enhancement of women's status, especially through education and other means, will greatly increase women's ability to access the socioeconomic resources and knowledge required for proper infant nutrition and care, resulting in reduced infant deaths (Wang 2014). Educated mothers are not only more likely to delay and space births but they are more likely to have fewer children, which reduces infant mortality (York and Ergas 2011). Existing cross-national and sub-national research indicates a strong negative relationship between gender equity measures such as female education and infant and child mortality (see, *e.g.*, Caldwell 1990; Frey and Field 2000; Gakidou *et al.* 2010; Schell *et al.* 2007; Shandra *et al.* 2011; Shen and Williamson 1997, 2001; Wang 2014; York and Ergas 2011, but see Fuse and Crenshaw 2006).

Modernization Theory

Industrialization is an important component of the modernization process and it is central to the modernization perspective (see, *e.g.*, Rostow 1990). Modernization theorists contend that industrialization and the attendant economic development reduce infant mortality through improvements in health care, education, nutrition, and the like. A number of cross-national researchers have confirmed the validity of modernization theory, reporting that infant and child mortality (as well as gender imbalances in infant mortality) vary in a negative fashion with the level of industrialization and alternative measures of economic development (*e.g.*, Babones 2008; Fuse and Crenshaw 2006; Jorgenson and Rice 2010; Moore *et al.* 2006; O'Hare *et al.* 2013; Pamuk *et al.* 2011; Shandra *et al.* 2004, 2005, 2011; Shen and Williamson 1997, 2001; Wang 2014), but research exists questioning this relationship (*e.g.*, Amand and Ravallion 1993; Frey and Field 2000).

Dependency/World-Systems Theory

Proponents of dependency/world-systems theory contend that dependent relations between core and peripheral countries foster resource and surplus extraction, resulting in limited resources for investment in public health, family planning, nutrition, education, pre-natal and post-natal care programs, and other factors that reduce infant and child mortality (see, *e.g.*, Shandra *et al.* 2011). Research results are mixed on the link between various measures of dependence (including foreign investment, trade dependence, debt dependence and structural adjustment, and export commodity concentration) and infant and child mortality (see, *e.g.*, Frey and Field 2000; Jorgenson and Burns 2004; Jorgenson and Rice 2010; Moore *et al.* 2006; Ragin and Bradshaw 1992; Shandra *et al.* 2004, 2005, 2011; Shen and Williamson 1997, 2001; York and Ergas 2011).

Developmental State Theory

Developmental state theorists contend that strong states can act in ways that promote human well-being and reduce infant mortality (Evans 1995). State actions may include direct efforts to reduce infant mortality through pre-natal and post-natal care programs, as well as

indirect programs such as investment in public health and welfare programs that reduce inequalities in access to proper nutrition, health care, and the like. Results of the existing cross-national research are mixed, ranging from support to no support (Dalton and Springer 2001; Frey and Field 2000; Gruber *et al.* 2014; Schell *et al.* 2007; Shandra *et al.* 2011; Shen and Williamson 1997, 2001; Wang 2014).

Data and Method

The cross-sectional study reported here replicates much earlier work with circa 2005 data for a group of fifty-nine low and middle-income nations. (Countries are listed in Table 1.) Where possible, estimates of models were based on variables and indicators used by previous researchers. Data were collected from online sources, including the ILO (2005), UN (2005), UNESCO (2005), World Bank (2005), and World Resources Institute (2005).

Table 1

Sample of Countries

1. Argentina	31. Mexico
2. Benin	32. Morocco
3. Bolivia	33. Nepal
4. Botswana	34. Nicaragua
5. Brazil	35. Niger
6. Burundi	36. Nigeria
7. Cameroon	37. Pakistan
8. Chile	38. Panama
9. Colombia	39. Papua New Guinea
9. Costa Rica	40. Paraguay
10. Ecuador	41. Peru
11. Egypt	42. Philippines
12. El Salvador	43. Portugal
13. Gabon	44. Republic of Korea
14. Ghana	45. Senegal
15. Guatemala	46. Sierra Leone
16. Haiti	47. Singapore
17. Honduras	48. Sri Lanka
18. India	49. Sudan
19. Indonesia	50. Syria
20. Israel	51. Tanzania
21. Jamaica	52. Thailand
22. Kenya	53. Togo
23. Lesotho	54. Trinidad and Tobago
24. Liberia	55. Tunisia
25. Madagascar	56. Turkey
26. Malawi	57. Uruguay
27. Malaysia	58. Venezuela
28. Mali	59. Zambia
30. Mauritius	

Dependent Variable

Infant mortality was measured as the number of infants who died within the first year of birth per 1,000 live births in 2005. Data were taken from the UN (2005). The natural logarithmic form of the variable was used to correct for high levels of skewness and kurtosis. More on the use of logged independent variables see below.

Independent Variables

Modernization. Industrial employment was used to assess the modernization perspective. It was measured as the percent of the total labor force employed in the industrial sector. Data for this variable were taken from the World Bank (2005) and the ILO (2005). Eleven cases (18.64 per cent of the sample) had missing data. The Multiple Imputation (MI) method was used to impute missing data; this technique is used frequently by social scientists and has certain advantages compared to other imputation methods. MI is based on the Monte Carlo technique to simulate different completed datasets and produces results based on the pooled estimates. This technique produces very accurate estimates when assumptions are met (Rubin 1987).

Economic dependence. Foreign investment dependence, trade dependence, and debt dependence were used in the analyses and data were collected from the World Bank (2005). Investment dependence was measured as the net foreign direct investment inflow as a percent of gross domestic product (hereafter GDP). Trade dependence was measured as the sum of exports and imports of goods and services as a percent of GDP. Debt dependence was measured as total debt stocks as a percent of GDP.

Gender equality. Many researchers have used female education to measure gender equality (*e.g*., Gakidou *et al.* 2010; Schell *et al.* 2007; Wang 2014; York and Ergas 2011). The percent of secondary school age females enrolled in secondary school was used in analyses reported here. Data were taken from the UNESCO (2005).

State strength. The sum of the central governmental expenditures for public health, military, and public education as a percent of GDP in circa 2010 was used to measure state strength. Previous researchers have used public expenditure data to assess state strength and found it to be a significant negative predictor of infant mortality (see, *e.g*., Shandra *et al.* 2004). Public health expenditure data were taken from the World Resources Institute (2005). Military expenditure data were taken from the World Bank (2005). Public education data were taken from the UNESCO (2005).

Control Variables

Researchers have used Sub-Saharan African status as a control variable and they report that infant deaths are higher in Sub-Saharan African countries than in their counterparts (Frey and Field 2000). Sub-Saharan African status was included as a control in the analyses: Sub-Saharan African countries were coded 1 and the remaining countries were coded 0. Additional variables were included as controls (democracy, alternative measures of economic dependence, and population pressure), but these variables had little impact on infant mortality so estimates are not reported here.

Method of Analysis

Ordinary Least-Squares regression was used to estimate the net effect of each of the five predictor variables. The MI method, as noted above, was used to impute missing values for the industrialization variable, and the natural logs of the four independent and dependent variables were used in the estimates. Use of natural logs corrects for non-normality and

heteroskedasticity of variables and allows coefficients to be interpreted as elasticities: the coefficient indicates the expected percentage change in the dependent variable for a one-percent change in the independent variable, when other independent variables are held constant.

Standard regression diagnostics were used to determine the stability of estimates. Procedures included the Breusch-Pagan test for *heteroskedasticity* and variance inflation factors (VIFs) for assessing the degree of collinearity. The null hypothesis of constant variance was rejected, suggesting limited heteroskedasticity (a condition that was reduced by natural log transformations). All VIFs were smaller than 2.50, suggesting that collinearity did not degrade estimates. The Cook's D method was used to filter out influential cases with large residuals and leverage, which resulted in a total sample of 56 countries (Nigeria, Sierra Leone, and Togo were excluded from estimates). Reweighted Least-Squares regression was used to further assess the robustness of estimates.

Results

Ordinary Least-Squares Regression

OLS regression estimates are presented in Table 2. Three separate models were estimated to assess the effect of the three alternative indicators of economic dependence on infant mortality. Models 1, 2, and 3 are based on foreign investment dependence, trade dependence, and debt dependence, respectively.

Table 2. OLS Estimates for Regression of 2005 Infant Mortality on Selected Predictor Variables

Predictor variables	Model 1	Model 2	Model 3
Industrial Employment	–0.598 (.158)***	–0.582 (.148)***	–0.644 (.164)***
Foreign Investment	–0.098 (.059)		
Trade Dependence		–0.526 (.151)**	
Debt Dependence			–0.175 (.130)
Female Education	–2.334 (.885)*	–1.887 (.849)*	–2.357 (.916)*
State Strength	–0.428 (.272)	–0.255 (.252)	–0.246 (.281)
Sub-Saharan Africa	0.660 (.211)**	0.679 (.197)**	0.759 (.229)**
R-Square	0.771	0.714	0.688
Adjusted R-Square	0.681	0.683	0.657
N	56	56	56

Note: All variables, with the exception of Sub-Saharan African status, are in natural logarithmic form. Unstandardized coefficients reported and standard errors presented in parentheses. We do not report y-intercepts.

*p < .05 **p <.01 ***p <.001

Estimates of Model 1 (the foreign investment model) indicate that industrial employment had a strong negative effect on infant mortality ($b = –0.598$, $p < .001$). For every

one-percent increase in the total labor force employed in the industrial sector, a 0.598 percent decrease in the infant mortality rate would be expected when controlling for the other variables in the model. Female education also had a strong negative effect on infant mortality ($b = –2.334$, $p < .05$). For every one-percent increase in female enrollment in secondary school, a 2.334 percent decrease in the infant mortality rate would be expected. Sub-Saharan African countries were found to have a substantially higher infant mortality rate than their counterparts ($b = 0.660$, $p < .01$). Central government expenses and foreign investment dependence had little net impact on infant deaths. Estimates for Model 1 clearly support the gender stratification and modernization perspectives, but provide no support for the other two theoretical perspectives.

Estimates of Model 2 (the trade dependence model) indicate that industrial employment and female education had significant negative effects on infant mortality. Sub-Saharan African countries had a higher infant mortality rate than their counterparts. Trade dependence had a significant negative effect on infant mortality ($b = –0.526$, $p < .01$), which is contrary to expectations of dependency/world-systems theory. For every one-percent increase in trade dependence, a .526 percent decrease in the infant mortality rate would be expected. State strength had little net impact on infant mortality. Estimates of Model 2 are generally consistent with those of Model 1, though the trade dependence variable had a significant negative effect on infant mortality unlike foreign investment. Clearly, trade engagement in the international economy appears to have had beneficial effects for countries in the sample during this time period.

Estimates of Model 3 (the debt dependence model) are generally consistent with those reported for Models 1 and 2. Specifically, industrial employment, female education, and Sub-Saharan African status had the expected effects on infant deaths. Debt dependence and state strength in turn were found to have little net impact on infant mortality. Estimates of Model 3, like those of Models 1 and 2, indicate that more than 60 percent of the total variance in infant mortality was explained by the three key variables.

Robust Regression

RLS regression was used to assess the robustness of the OLS estimates since OLS regression is sensitive to outliers and it can produce biased results if its underlying assumptions are violated. Table 3 contains RLS estimates for the three models. Robust regression estimates of Model 4 (the foreign investment dependence model) are similar to the OLS estimates, though the impact of several variables proved slightly stronger. Industrial employment, female education, and Sub-Saharan status each had the expected effect on infant mortality, while foreign investment and state strength did not have the expected effects. Similar estimates were found for Model 5 (the trade dependence model) and Model 6 (the debt dependence model). In sum, robust regression estimates replicate the OLS estimates reported above: estimates support the modernization and gender stratification theories, and they indicate quite clearly that Sub-Saharan African status was one of the more important drivers of infant mortality during the period examined.

Table 3. Robust Regression Estimates for the Regression of 2005 Infant Mortality Selected Predictor Variables

Predictor Variables	Model 4	Model 5	Model 6
Industrial Employment	–0.415 (.133)**	–0.462 (.140)**	–0.432 (.147)**
Foreign Investment	–0.084 (.050)		
Trade Dependence		–0.357 (.143)*	
Debt Dependence			–0.043 (.116)
Female Education	–2.505 (.746)**	–2.477 (.804)**	–2.773 (.820)**
State Strength	–0.231 (.229)	–0.072 (.239)	–0.127 (.252)
Sub-Saharan Africa	0.680 (.178)***	0.616 (.186)**	0.674 (.205)**
N	56	56	56

Note: All variables, with the exception of Sub-Saharan African status, are in natural logarithmic form. Unstandardized coefficients reported and standard errors presented in parentheses. We do not report y-intercepts.

*p < .05 **p <.01 ***p <.001

Conclusions and Implications

Results of six tests of the four theoretical perspectives indicate that both industrialization and female education had the expected negative effect on infant mortality, Sub-Saharan African status had a strong positive effect on infant mortality, and neither state strength nor the three measures of economic dependence had the expected positive effect on infant mortality. These results provide strong support for the modernization and gender stratification theoretical narratives and indicate that Sub-Saharan African nations are at significantly higher risk of infant mortality than their counterparts, while no support was found for the developmental state and dependency/world-systems theoretical narratives. Results have clear policy implications and suggest new directions for future research.

Sub-Saharan African countries are in need of infant mortality reduction programs and investment in female education appears to be one of the best single means for reducing infant mortality in Sub-Saharan Africa and elsewhere in the peripheral sectors of the world-system. Future researchers should identify those characteristics of Sub-Saharan African countries that contribute to high infant mortality rates, including environmental conditions such as access to clean water and basic sanitation, the legacy of colonialism and the slave trade, the HIV/AIDS epidemic, political instability and violence, the 'resource curse' and its adverse consequences, and the rapid urbanization and subsequent over-urbanization and the attendant growth of slum settlements in many of these countries. Several of these factors have received some attention by cross-national researchers (*e.g.*, Jorgenson and Burns 2004; Jorgenson and Rice 2010, 2012; Shandra *et al.* 2011), but they require more detailed investigation. In conclusion, and as suggested by previous researchers (Gakidou *et al.* 2010; Schell *et al.* 2007), increasing female education may be the most rational means for reducing infant deaths in the peripheral zones of the world-system.

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