An Evolutionary Interpretation of Fertility Decline: New Evidence

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This article presents new evidence that partly reinforces and partly qualifies the results of a recent article on fertility decline published in this journal by Sanderson and Dubrow. Eight panel regression analyses were carried out, four for the period between 1960 and 1990 and four more for the period of the original demographic transition, that between 1880 and 1940. The analyses for the 1960–1990 period show that Sanderson and Dubrow's original conclusion that infant mortality decline was causing fertility decline (rather than the reverse) was correct. On the other hand, Sanderson and Dubrow's conclusion that enhanced female empowerment led to fertility decline proved incorrect. The new analyses reported here show that the reverse was in fact the case: women became more empowered as a result of declining fertility. The panel analyses carried out for the 1880–1940 period showed that infant mortality decline seemed to be an important cause of fertility decline between 1880 and 1910 but not between 1910 and 1940. However, the reverse hypothesis—that fertility decline caused infant mortality decline during this period—was falsified. I conclude that the causes of fertility decline in the modern world may be different, at least to some extent, from those in the original demographic transition. This is an unsatisfying (because unparsimonious) result that suggests the need for more research.

KEY WORDS: fertility; mortality; evolutionary; empowerment.

In an article published recently in this journal (*Population and Environment* 21:511–37, 2000), Sanderson and Dubrow presented a series of multiple regression analyses in which they tested three theories of fertility decline: the argument that it is the declining economic value of children's

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labor with industrialization that causes people to produce fewer children, the evolutionary argument that fertility levels are adjusted primarily to levels of infant mortality, and the notion that female empowerment is the critical factor in fertility decline. Sanderson and Dubrow conducted two studies. The first was a study of fertility and fertility decline in the period between 1960 and 1990, whereas the second looked at the original demographic transition (the period between 1880 and 1940). Their results showed that infant mortality was the best predictor of fertility levels, that female empowerment was an important secondary predictor, and that the economic value of children's labor (as measured by percentage of the labor force in agriculture or in manufacturing and the percentage of the population living in urban areas) was negligibly related to fertility levels. They concluded that both the evolutionary and the female empowerment theories were supported, but that the evolutionary argument was empirically stronger.

However, Sanderson and Dubrow's study contained one serious weakness: it was unable to show statistically that both infant mortality decline and female empowerment *were causal to* fertility and fertility decline rather than merely correlated with it. This article represents an effort to overcome this deficiency by carrying out a series of panel regression analyses. I will first concentrate on the most important predictive variable, infant mortality, and then turn to assess the causal relationship between female empowerment and fertility.

Panel analysis involves regressing a dependent variable measured at one time period on a series of independent variables measured at an earlier time period, while simultaneously controlling for the earlier value of the dependent variable. Eight panel analyses were carried out. The first such analysis (Table 1) regressed 1990 fertility levels on 1960 levels of the independent variables while controlling for 1960 fertility. The results show strong support for the argument that the direction of causation is from infant mortality to fertility. All of the beta coefficients except those for infant mortality and 1960 fertility were small and statistically nonsignificant. The beta for infant mortality was the largest, and it was substantially larger than that for 1960 fertility (.586, $p < .002$ versus .305, $p < .042$). This is an extremely important finding, because we usually expect an earlier level of a variable to be the strongest predictor of a later level of that variable. That this was not the case suggests a strong causal role for infant mortality. Pairwise and mean substitution analyses did not invalidate these results. The outcome was essentially the same for mean substitution. The beta for infant mortality was .497 ($p < .000$) and that for 1960 fertility was .280 ($p < .000$). The pairwise results showed an even bigger causal effect for infant mortality (beta

TABLE 1

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Percentage Urban, Female Empowerment, Infant Mortality, and Fertility on Fertility in 1990

Variable	Zero-order	Partial	St. Beta	t	P <	VIF
LogGNP 1960	–.794	–.026	–.042	–.191	.849	10.658
% Lab. force agri. 1960	.773	–.050	–.094	–.360	.720	14.850
% Urban 1960	–.742	–.114	–.174	–.825	.413	9.658
Female empowerment 1960	–.620	.128	.111	.931	.356	3.052
Infant mortal. rate 1960	.853	.412	.586	3.265	.002	6.946
Fertility 1960	.782	.278	.305	2.085	.042	4.627

$R = .871$
$R^2 = .759$
Adj. $R^2 = .731$
$N = 59$

= .735, p < .000), whereas the effect for 1960 fertility was about the same as in the listwise and mean substitution analyses (beta = .334, p < .003).

A second panel analysis added considerable support to the results of the first panel analysis. Here I made 1990 infant mortality the dependent variable and regressed it on 1960 levels of the independent variables while controlling for 1960 infant mortality (Table 2). Here we see that infant mortality in 1960 was overwhelmingly the best predictor of infant mortality in 1990 (beta = .832, p < .000), and that fertility in 1960 did not predict infant mortality in 1990 (more accurately, did not predict changes in infant mortality between 1960 and 1990) (beta = –.103, p < .428). In fact, the beta coefficient for fertility in 1960 was negative, and thus running in the opposite direction. When the analyses were run pairwise and with mean substitution they were essentially the same. For pairwise deletion, 1960 infant mortality had a beta of .705 (p < .000) and 1960 fertility a beta of only –.153. For mean substitution, the 1960 infant mortality beta was .630 (p < .000) and the 1960 fertility beta was only –.095.

Now we need to consider the causal relationship between female empowerment and fertility decline. I carried out two panel analyses to test it. Table 3 shows the regression of 1990 fertility levels on 1960 levels of GNP, percentage of the labor force in agriculture, percentage urban, and female empowerment, while at the same time controlling for 1960 fertility levels.

TABLE 2

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Percentage Urban, Female Empowerment, Infant Mortality, and Fertility on Infant Mortality in 1990

Variable	Zero-order	Partial	St. Beta	t	P <	VIF
LogGNP 1960	–.837	–.086	–.121	–.621	.537	10.658
% Lab. force agri. 1960	.806	.019	.032	.138	.891	14.850
% Urban 1960	–.767	–.090	–.122	–.654	.516	9.658
Female empowerment 1960	–.549	.175	.134	1.282	.205	3.052
Fertility 1960	.676	–.110	–.103	–.799	.428	4.627
Infant mortal. rate 1960	.885	.591	.832	5.278	.000	6.946

R = .902
R^2 = .814
Adj. R^2 = .792
N = 59

TABLE 3

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Percentage Urban, Female Empowerment, and Fertility on Fertility in 1990

Variable	Zero-order	Partial	St. Beta	t	P <	VIF
LogGNP 1960	–.794	–.270	–.421	–2.044	.046	7.752
% Lab. force agri. 1960	.773	.006	.013	.046	.964	14.616
% Urban 1960	–.742	–.047	–.077	–.339	.736	9.467
Female empowerment 1960	–.620	.106	.100	.774	.442	3.050
Fertility 1960	.782	.400	.473	3.178	.002	4.053

R = .843
R^2 = .710
Adj. R^2 = .68
N = 59

The results clearly show that female empowerment had little causal influence on fertility decline between 1960 and 1990. The beta for female empowerment was only .100, whereas that for 1960 fertility was .473 ($p < .002$). The results were essentially the same when the analysis was run pairwise (N = 63; female empowerment beta = –.162, 1960 fertility beta = .398) or by mean substitution (female empowerment beta = –.097, 1960 fertility beta = .362).

An additional panel analysis was run in which 1990 levels of female empowerment were regressed on 1960 levels of GNP, percentage of the labor force in agriculture, percentage urban, and fertility, while simultaneously controlling for levels of female empowerment in 1960. This analysis was designed to determine whether the causal relationship was running in the opposite direction, i.e., whether it was fertility decline that caused an enhancement in female empowerment. The results (Table 4) show that this was indeed the case. In this analysis, the beta for 1960 fertility was substantial (–.521, $p < .000$), whereas that for 1960 female empowerment, which should have been the best predictive variable, was astonishingly low (.068). When this regression was run pairwise and with mean substitution, the results were weaker but they still support the argument that it was fertility decline that caused female empowerment rather than the other way around. For pairwise deletion, the beta for 1960 fertility was –.346 (p <

TABLE 4

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Percentage Urban, Female Empowerment, and Fertility on Female Empowerment in 1990

Variable	Zero-order	Partial	St. Beta	t	P <	VIF
LogGNP 1960	.846	.394	.504	2.640	.012	9.535
% Lab. force agri. 1960	–.799	–.042	–.067	–.259	.797	17.640
% Urban 1960	–.747	–.137	–.183	–.853	.399	12.002
Female empowerment 1960	.785	.098	.068	.604	.549	3.332
Fertility 1960	–.878	–.577	–.521	–4.359	.000	3.732

R = .924
$R^2 = .855$
Adj. $R^2 = .836$
N = 44

.002) whereas the beta for 1960 female empowerment was .275. In the case of mean substitution, the beta for 1960 fertility was −.295 ($p < .000$) and the beta for 1960 female empowerment was .211.

In sum, the panel regression analyses carried out here show that infant mortality was not only by far the best predictor of fertility, but also that it was infant mortality decline that *determined* fertility decline rather than the other way around. These results thus support the evolutionary argument which emphasizes that people are adjusting their fertility levels primarily to the levels of infant mortality, and to some extent child mortality, that prevail in their society. Contrary to what was argued in the original article, the results also undermine the argument that it was enhanced female empowerment that *caused* lower fertility. The two variables are clearly related, but female empowerment seems to have been a *result* of fertility decline rather than one of its causes. It appears that, with their infant and child care burdens lessened, it is easier for women to seek more education and to enter the labor force, two of the key dimensions of female empowerment. Female empowerment is thus still an important part of the story, even if not in the way that Sanderson and Dubrow originally thought.

In their earlier analysis of the demographic transition period, Sanderson and Dubrow found that infant mortality was easily the best predictive variable for 1880, 1910, and 1940. But in order to determine which way the causal arrows were pointing, I performed four panel analyses. In the first, 1910 fertility levels were regressed on 1880 levels of infant mortality, percentage of the labor force in agriculture, and percentage of the labor force in manufacturing, while at the same time controlling for 1880 fertility levels. Running the analysis with listwise deletion of missing cases (Table 5) suggests that infant mortality was not an important causal variable. Here the beta coefficient for infant mortality was very low (.134), and most of the fertility decline between 1880 and 1910 was explained by fertility levels in 1880 (beta = .744, $p < .000$). However, when the analysis was run pairwise and with mean substitution the results were much better. In the pairwise analysis ($N = 17$), 1880 infant mortality emerged as the most important cause of the 1880–1910 fertility decline. Its beta was .503 ($p < .009$), whereas the beta for 1880 fertility was only .386. Mean substitution produced very similar results (infant mortality beta = .518, $p < .001$; fertility 1880 beta = .422, $p < .004$). Thus, two of the three panel analyses showed infant mortality decline to be an important causal variable for the 1880–1910 period.

A second panel analysis was run for the 1910–1940 period (Table 6). Here 1940 fertility levels were regressed on 1910 levels of the independent variables, while simultaneously controlling for 1910 levels of fertility. The

TABLE 5

Effects of 1880 Levels of Infant Mortality, Percentage of the Labor Force in Agriculture, Percentage of the Labor Force in Manufacturing, and Fertility on 1910 Fertility

Variable	Zero-order	Partial	Stand. Beta	t	P <
Infant mortal. rate 1880	.594	.334	.134	1.227	.243
% L.F. in agri. 1880	.528	.487	.280	1.930	.078
% L.F. in manufac. 1880	−.298	−.173	−.252	−.608	.554
Fertility 1880	.887	.895	.744	6.933	.000

R = .956
R^2 = .914
Adj. R^2 = .885
N = 17

results show that infant mortality was a very poor predictor (beta = .011, p < .964), and they only improved modestly when the analyses were run pairwise and with mean substitution (pairwise, infant mortality beta = .273, p < .371; mean substitution, infant mortality beta = .183, p < .388). In all three regression analyses for this period, fertility in 1910 was easily the best

TABLE 6

Effects of 1910 Levels of Infant Mortality, Percentage of the Labor Force in Agriculture, Percentage of the Labor Force in Manufacturing, and Fertility on 1940 Fertility

Variable	Zero-order	Partial	Stand. Beta	t	P <
Infant mortal. rate 1910	.519	.014	.011	.047	.964
% L.F. in agriculture 1910	.419	−.230	−.252	−.784	.450
% L.F. in manufact. 1910	−.529	−.354	−.401	−1.254	.236
Fertility 1910	.793	.637	.713	2.742	.019

R = .823
R^2 = .678
Adj. R^2 = .561
N = 16

predictor of fertility in 1940, and percentage of the labor force in manufacturing emerged as the second best predictor.

Two final panel analyses were performed in order to test for the possibility that fertility decline may have been producing infant mortality decline. Table 7 shows the regression of 1910 infant mortality levels on 1880 levels of the independent variables while controlling for 1880 levels of infant mortality. It is clear that fertility decline was not causing infant mortality decline during this period. The beta for 1880 fertility was only .146 ($p < .350$), whereas that for 1880 infant mortality was a very large .772 ($p < .000$). Extremely similar results were obtained with pairwise deletion and mean substitution of missing cases (pairwise, 1880 fertility beta = .144, $p < .239$, 1880 infant mortality beta = .802, $p < .000$; mean substitution, 1880 fertility beta = .166, $p < .086$, 1880 infant mortality beta = .832, $p < .000$).

Basically the same results were produced for the 1910–1940 period (Table 8). The best predictor of infant mortality in 1940 was infant mortality in 1910 (beta = .807, $p < .004$). Not only was fertility in 1910 not causing infant mortality decline between 1910 and 1940, but its sign was reversed (beta = –.377). Much the same pattern was found when the analysis was performed pairwise and with mean substitution (pairwise, 1910 fertility beta = –.119, $p < .596$, 1910 infant mortality beta = .851, $p < .001$; mean substitution, 1910 fertility beta = .212, $p < .267$, 1910 infant mortality beta = .661, $p < .001$).

All four panel analyses for the original demographic transition period show mixed and inconclusive results. Infant mortality decline did appear

TABLE 7

Effects of 1880 Levels of Fertility, Percentage of the Labor Force in Agriculture, Percentage of the Labor Force in Manufacturing, and Infant Mortality on 1910 Infant Mortality

Variable	Zero-order	Partial	Stand. Beta	t	P <
Infant mortal. rate 1880	.880	.825	.772	5.062	.000
% L.F. in agri. 1880	.307	.261	.190	.938	.367
% L.F. in manufac. 1880	–.041	.002	.001	.007	.994
Fertility 1880	.646	.270	.146	.973	.350

$R = .912$
$R^2 = .832$
Adj. $R^2 = .776$
$N = 17$

TABLE 8

Effects of 1910 Levels of Fertility, Percentage of the Labor Force in Agriculture, Percentage of the Labor Force in Manufacturing, and Infant Mortality on 1940 Infant Mortality

Variable	Zero-order	Partial	Stand. Beta	t	P <
Infant mortal. rate 1910	.675	.737	.807	3.616	.004
% L.F. in agri. 1910	.496	.203	.213	.687	.506
% L.F. in manufac. 1910	–.553	–.354	–.387	–1.257	.235
Fertility 1910	.434	–.414	–.377	–1.506	.160

$R = .837$
$R^2 = .701$
Adj. $R^2 = .592$
$N = 16$

to be an important cause of fertility decline between 1880 and 1910 but not between 1910 and 1940. However, I have eliminated the reverse hypothesis for both periods: that the high correlations between infant mortality and fertility—.814 in 1910 and .567 in 1940—are due to the impact of fertility on infant mortality. Also, there is perhaps slightly more support here for the role of the changing economic value of children's labor than was the case for the 1960–1990 period in that the percentage of the labor force in manufacturing seemed to be exerting some effect on fertility decline during the original demographic transition. This means that, at least to some extent, the causes of fertility decline in the modern world appear to be different from those in the original demographic transition. This is a rather unsatisying result because it does not give us a highly parsimonious explanation. Is this another instance of a "beautiful theory being killed off by an ugly fact"? Perhaps. My provisional—and, to this point, only justified—conclusion is that we have learned something important and trustworthy about the causes of fertility decline in the modern world, but we have a muddier picture concerning the original demographic transition. More research with better data, and perhaps a larger number of time periods, is clearly needed.

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