Does Fertility Track Mortality? A Natural Experimental Test of the Evolutionary Theory

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Abstract

Using retrospective birth history information collected in a nationally representative sample survey in China in 2001, the proposed study aims to identify the causal effect of changes in infant mortality pattern on women's fertility behaviors. The rapid spread of the highly effective prenatal care service during the 1970s and 1980s in China, which accounts for a significant proportion of the continuous decline in infant mortality during the same period, creates an opportunity to tackle the endogeneity in the relationship between the mortality and fertility changes. Because prenatal care can drastically decrease the risk of infant mortality but does not directly influence fertility, prenatal care use can be used an instrument to estimate the causal effect of infant and child mortality on women's fertility preference and fertility behavior. Such knowledge may be the key missing link toward an integrated evolutionary explanation of the demographic transition.

Demographic transition, the process through which a population changes from a high-mortality and high-fertility state to a low-mortality and low-fertility state, has attracted a great deal of attention in the past. Various explanations for this process have been proposed, including the intra-household wealth flow explanation, modernization and urbanization explanation, and the empowerment of women explanation (Harris and Ross, 1987; Caldwell, 1976; Jejeebhoy, 1995; Sanderson and Dubrow, 2000). The transition first occurred in Europe and then gradually spread to other parts of the world. The demographic transition is particularly interesting from an evolutionary perspective. The fact that people in an increasing number of societies worldwide voluntarily reproduce at a lower level rather than maximize their reproductive success poses a major challenge to evolutionary theories (Borgerhoff Mulder, 1998). In fact, some social scientists identified this puzzling trend as the ultimate challenge to the evolutionary explanation of human behaviors (Vining, 1986).

The demographic transition puzzle has two different aspects: (1) Why do people choose to have fewer children than they could? (2) Why do high status people have even fewer children than low status people? Much research attention has been devoted to the relationship between status and number of children (Hill and Reeve, 2005; Huber et al., 2010; Mace, 2000; Milot et al., 2011; Kanazawa, 2003; Perusse, 1993). In the current research, I will focus on the question of why people choose to have fewer children than before.

Carey and Lopreato (1995) proposed the argument that (1) natural selection favors fertilities that meet and only slightly exceed corresponding mortalities, and (2) a "two-surviving-children psychology" has evolved among humans. In other words, fertility tracks mortality to ensure that at least two children will survive to reproductive age. In the past, when mortality was high, many more than two childbirths were required to ensure two surviving children. As the mortality level continues to decline, fewer and fewer childbirths are required to achieve the same goal. Some researchers are not comfortable with the two-surviving children psychology claim (Sanderson and Dubrow, 2000), but the general idea that fertility tracks mortality, especially infant mortality, seems intuitively appealing. In fact, the idea that fertility tracks mortality has a long history in demography. Empirical evidence, which mainly came from historical demographic records from European countries in the past few centuries, however, has been mixed (Matthiessen and McCann, 1978; Van de Walle, 1986).

As informative as these studies are, they are all observational in nature and subject to endogeneity bias. For example, an observed positive association between fertility and mortality may suggest that (1) fertility is influenced by mortality, (2) mortality is influenced by fertility, or (3) mortality and fertility are both influenced by the same set of other factors. As Penn and Smith (2007) demonstrated, childbirth incurs fitness costs on both men and women, especially women, and each additional childbirth is associated with increased mortality for both mothers and infants. Without experimental manipulation, it is difficult to establish a *causal* relationship from statistical associations. The inherent weakness in observational design can at least partially explain the mixed results reported in previous studies. The critical first step toward establishing a sound causal knowledge regarding the relationship between mortality and fertility suggested by Carey and Lopreato (1995) is to identify exogenous mortality change that cannot be attributed to differential fertility behaviors or any fertility determinants.

Angrist et al. (1996) identified five assumptions under which an instrumental variable method can be used to extract local average treatment effect (LATE) of the treatment of interest, including the stable unit treatment value assumption (SUTVA), the ignorable assignment assumption, exclusion restriction assumption, the nonzero average causal effect of the assignment on the treatment assumption, and the monotonicity effect assumption.

Infant mortality has been declining in China since the early 1950s, with the only exception during the Great Leap Forward Famine period. Such a secular decline in infant mortality in China was at least partly driven by the increased supply and utilization of prenatal care (Song and Burgard, 2011). Prenatal care use can be used as an instrument to identify the causal effect of infant mortality on people's fertility intention and behaviors because it meets all five assumptions outlined by Angrist et al. (1996): the SUTVA is met because the death of other people's children is unlikely to influence individual's fertility decision; the ignorable assumption is met conditionally on education and urban-rural status, as suggested by Song and Burgard (2011); the exclusion restriction assumption is clearly met because prenatal care reduces infant mortality but has no direct effect on fertility decision; the highly significant effect of prenatal care use on infant mortality means that the nonzero average effect of Z on X is also met; monotonicity assumption is met because prenatal care use only *decreases* infant mortality, not increase it. With these assumptions in place, an instrumental variable approach, as depicted in Equations (1) and (2), can be used to identify such causal effect.

$$Z_i = \alpha_0 + \alpha_1 X_i + \delta_i \tag{1}$$

$$Y_i = \beta_0 + \beta_1 Z_i + \varepsilon_i \tag{2}$$

Two dependent variable Y will be investigated in this study, including (1) the number of children each woman ended up having (i.e., fertility behaviors) and (2) the total number of children each woman wanted to have (i.e., fertility preference). The endogenous causal explanatory variable X refers to whether any of the children a woman gave birth to died at infancy, and the identifying instrument Z refers to whether the selected woman ised prenatal care or not. All of the information required to estimate such a model, infant mortality, childbirth, and medical prenatal care use is available in the 2001 National Reproductive Health and Fertility Survey, which is of high quality and has been used in a number of papers (Song and Burgard, 2011; Song, 2013).

References

Angrist, J.D., G.W. Imbens, and D.B. Rubin. 1996. “Identification of Causal Effects Using Instrumental Variables.” *Journal of the American Statistical Association* 91:444–455.

Borgerhoff Mulder, M. 1998. “The demographic transition: are we any closer to an evolutionary explanation?” *Trends in ecology & evolution* 13:266–270.

Caldwell, J. C. 1976. “Toward a restatement of demographic transition theory.” *Population and development review* 2:321–366.

Carey, A. D. and J. Lopreato. 1995. “The evolutionary demography of the fertility-mortality quasi-equilibrium.” *Population and Development Review* 21:613–630.

Harris, M. and E. B. Ross. 1987. *Death, sex, and fertility: Population regulation in preindustrial and developing societies*. New York, NY: Columbia University Press.

Hill, S. E. and H. K. Reeve. 2005. “Low fertility in humans as the evolutionary outcome of snowballing resource games.” *Behavioral Ecology* 16:398–402.

Huber, S., F. L. Bookstein, and M. Fieder. 2010. “Socioeconomic status, education, and reproduction in modern women: An evolutionary perspective.” *American Journal of Human Biology* 22:578–587.

Jejeebhoy, S. J. 1995. *Women's education, autonomy, and reproductive behaviour: experience from developing countries*. Oxford, UK: Oxford University Press.

Kanazawa, S. 2003. "Can evolutionary psychology explain reproductive behavior in the contemporary United States?" *The Sociological Quarterly* 44:291–302.

Mace, R. 2000. "An Adaptive Model of Human Reproductive Rate Where Wealth Is Inherited Why People Have Small Families." In *Adaptation and human behavior: an anthropological perspective*, edited by L. Cronk, Chagnon, N. A., and W. Irons, p. 261. Aldine de Gruyter.

Matthiessen, P. C. and J. C. McCann. 1978. "The role of mortality in the European fertility transition: Aggregate-level relations." In *The Effects of Infant and Child Mortality on Fertility. Academic Press, New York, USA*, edited by S. H. Preston. New York: Academic Press.

Milot, E., F.M. Mayer, D.H. Nussey, M. Boisvert, F. Pelletier, and D. Réale. 2011. "Evidence for evolution in response to natural selection in a contemporary human population." *Proceedings of the National Academy of Sciences* 108:17040–17045.

Penn, D. J. and K. R. Smith. 2007. "Differential fitness costs of reproduction between the sexes." *Proceedings of the National Academy of Sciences* 104:553.

Perusse, D. 1993. "Cultural and reproductive success in industrial societies: Testing the relationship at the proximate and ultimate levels." *Behavioral and Brain Sciences* 16:267–267.

Sanderson, S. K. and J. Dubrow. 2000. "Fertility decline in the modern world and in the original demographic transition: Testing three theories with cross-national data." *Population & Environment* 21:511–537.

Song, Shige. 2013. "Identifying the Intergenerational Effects of the 19591961 Chinese Great Leap Forward Famine on Infant Mortality." *Economics & Human Biology* .

Song, S. and S. Burgard. 2011. "Dynamics of Inequality: Mothers Education and Infant Mortality in China, 1970-2001." *Journal of Health and Social Behavior* 52:349–364.

Van de Walle, F. 1986. "Infant mortality and the European demographic transition." In *The decline of fertility in Europe*, edited by A. J. Coale and S. C. Watkins. NJ: Princeton University Press.

Vining, D. R. 1986. "Social versus reproductive success: The central theoretical problem of human sociobiology." *Behavioral and Brain Sciences* 9:167–87.