EXTENDED ABSTRACT

The Effect of Interventions to Reduce Fertility on Economic Growth

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Our goal in this research is to analyze quantitatively the economic effects of interventions that reduce fertility in developing countries. Our analysis and results will speak to long-standing, yet still unresolved debates about the relation between demographic dynamics and the trajectory of economic development. Answers to such questions have important implications for contemporary demographic and economic scholarship, and for policies and programs in the developing world. In our project, we will ask how economic measures such as GDP per capita would compare in the case where some exogenous change reduces fertility to the case where no such exogenous change takes place. The answer to this question will be very different from simply observing the natural co-evolution of fertility and economic development.

There are three key innovations of our approach. First, we build up an answer to the macroeconomic question of how fertility changes affect economic output by starting with microeconomic evidence on how demographic factors affect household economic behavior. These microeconomic effects are then aggregated using simple economic theory and embedded in a dynamic model that follows changes in the demographic structure over time. This micro-based approach represents an alternative to cross-country regressions that have frequently been used (incorrectly, in our view) to examine how fertility changes affect the economy. The second innovation of our approach is that the simulation model we are building can be easily tailored to the specific economic and demographic circumstances of a particular country. The third innovation of our approach is that the simulation model will be wrapped in an interface (accessible via any web browser) that allows users of varying degrees of sophistication to conduct simulations of different demographic interventions, to examine the sensitivity of results to different assumptions about the underlying structure of the economy, and to tailor the exercise to the situation of a particular country.

We do not expect that this research will produce a final, broadly accepted answer to the question of how changes in fertility affect economic growth. We do believe, however, that our research will be able shift the approach of researchers toward the sort of micro-macro synthesis we employ. Further, we think that the model we present is sufficiently general that it can provide a framework in which scholars with differeing views can conduct their debate in a structured, more productive fashion. Unlike aggregate regressions, which are something of a black box, our simulation model, which builds up from microeconomic estimates and simple economic theory, has all its working parts visible. Thus if a reader challenges our estimates because he/she suspects that the treatment of fixed factors, or returns to education, age-specific saving rates, or any other piece of the model is wrong, it will be a simple matter to alter that part of the model and see how the results change.

Background

How declining fertility affects economic growth is a old question, going back at least to Malthus, with the modern setting of the problem posed by Coale and Hoover (1958) some 50 years ago, but it remains an unsettled issued. As discussed in Kelley (2001), the consensus view has moved from fertility declines having strong effects, to their not being very important, and recently back toward assigning them some appreciable significance. Earlier literature on this topic focused on the interaction of population with fixed resources like land, as well as the effect of population growth on actual and required investments in human and physical capital. Recent literature has emphasized the economic importance of the "demographic dividend," the temporary period of low dependency that follows a decline in fertility (Bloom and Williamson, 1998).

Much of the current thinking about the effects of fertility decline relies on results from cross-country regressions, in which the dependent variable is growth of GDP per capita and the independent variables include measures of fertility and mortality, or else measures of the age structure of the population. Unfortunately, because of statistical and econometric specification problems such as omitted variables and reverse causation, the ability to draw inferences from the conditional correlations in these regressions is very weak (See Deaton 1999 for a critique).

While cross-country regressions suffer from severe econometric problems, they do have the advantage – if one is interested in assessing the aggregate effects of fertility decline – of focusing on the right dependent variable. By contrast, microeconomic studies generally examine the link between fertility at the household level and various outcomes for individuals in that household (for example, wages, labor force participation, education, etc.). These studies cannot directly answer the question of the aggregate effects of fertility reduction because many of the effects of such reduction run through channels external to the household; that is, they operate either via externalities in the classic economic sense (for example, environmental degradation) or through changes in market prices, such as wages, land rents, and returns to capital.

In this research we propose to pursue a "third way" to examine the link from fertility decline to aggregate economic growth. In particular, we propose to build up a macro estimate starting from microeconomic evidence on the effect of fertility decline, using economic theory to guide us in putting together the different channels by which fertility reduction works, both internal and external to the household. More specifically, we will build a simulation model that takes proper account of both general equilibrium effects and the dynamic evolution of population age structure, capital accumulation, resource depletion, and so on. Throughout the research, the focus will be on a *quantitative* analysis of changes in fertility, so that we can estimate how much extra output a given intervention (for example, a drop in the TFR by 1) will produce over a specific time period. We hope, by showing how *micro*-level behavioral effects that are often studied in isolation can be integrated to answer *macro*economic questions, to reorient the academic discussion of population and development along more quantitative and practical lines.

The simulation model that we build is general, but it has characteristics that can be tailored to the situation of particular countries. In addition to country-specific demographic characteristics (vital rates, initial age structure), the model can incorporate country-specific measures of the role of natural resources in aggregate production. We discuss applying particular parameters for Nigeria, India, and Mexico in our model further below.

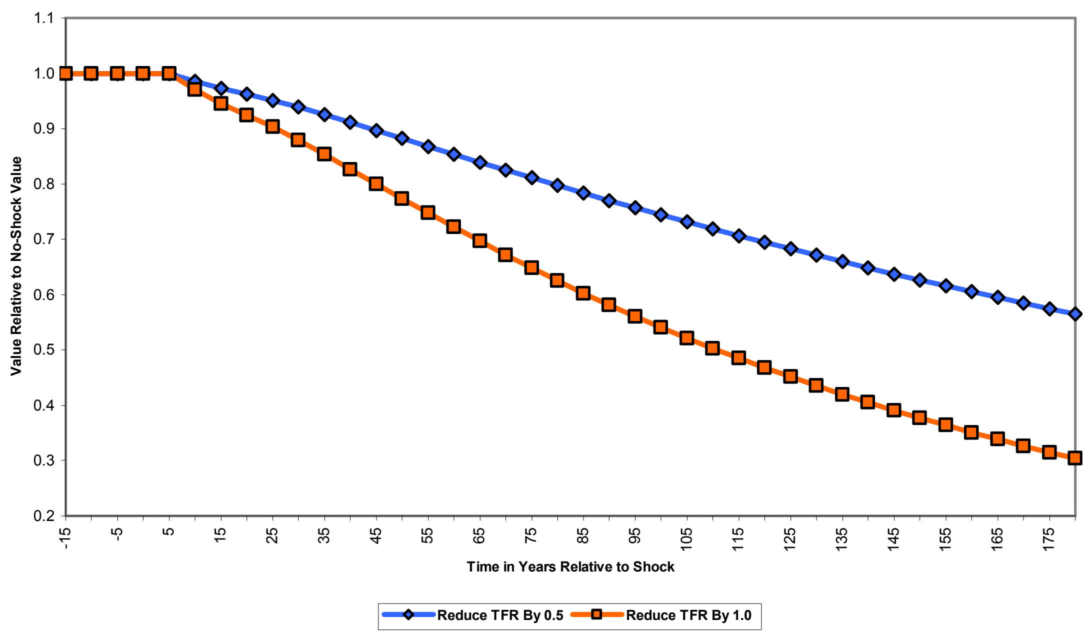
Preliminary results.

As stressed above, our interest is not in outlining the general pattern of co-movement of population measures and economic growth, since the co-movements that arise in the data result from the endogeneity of both population and economic growth. Rather, our concern is with identifying the economic effects of an *exogenous* change in fertility. The natural way to communicate the results from our exercise is by showing a projected path of economic outcomes relative to a baseline in which the exogenous change in question does not take place. Specifically, we can show time series plots of outcomes in particular scenarios relative to what would happen in the base case of no intervention. Time series charts like these have the advantage of fully laying out the dynamic aspects of the adjustment that takes place when fertility is changed. They are also very easy for policy makers, students, journalists, and others to read.

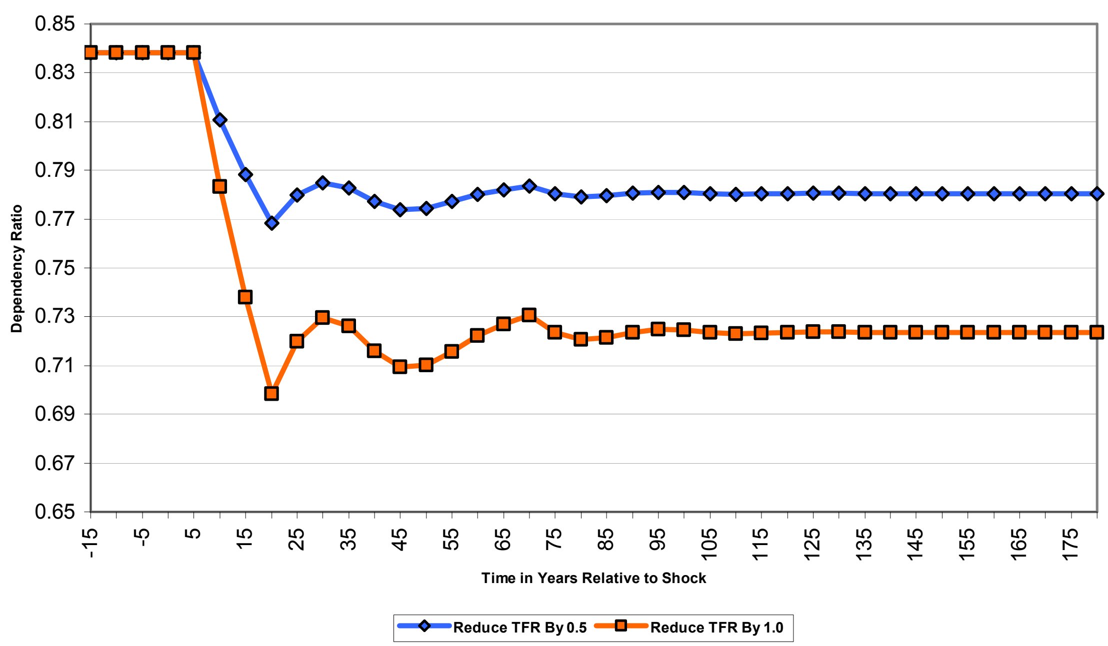
We have already built a working version of our dynamic population/economic model, although it incorporates only some of the economic channels discussed in section e below. We use data from Nigeria. Starting with current age-specific fertility and mortality, we build a stable population. Our base case holds these vital rates constant. We consider two alternative scenarios in which the TFR drops by .5 and by 1.0, with fertility at each age falling proportionally (the current TFR is 5.6).

The first panel shows total population in the two scenarios relative to the base case. After 50 years, population is at 77% of the base case level when TFR falls by 1.0 and at 88% of the base case level when TFR falls by 0.5 (in the base case, population after 50 years is 3.1 times as large as in year zero). The second panel shows the dependency ratio. The last panel shows output per capita in the two fertility reduction scenarios relative to the baseline case. After 50 years, output per capita is 7.5% higher in the case of 0.5 reduction in the TFR and 16.1% higher in the case of a 1.0 reduction in the TFR.

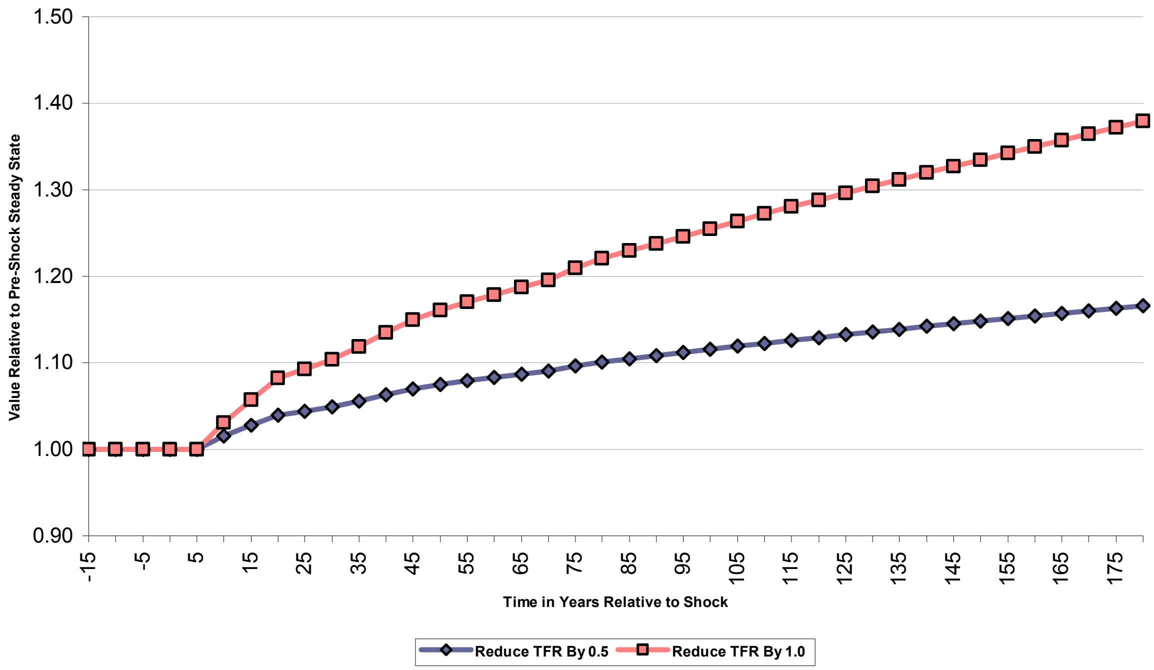
The Time Path of the Total Population Relative to the No-Shock Scenario



The Time Path of the Dependency Ratio



The Time Path of Income Per Capita



In addition to results of the type just presented, we hope to use our model to generate additional results regarding the complementarity of investments in family planning, on the one hand, and health, on the other. A good deal of recent discussion has centered on the potential role of health improvements in raising worker productivity, and thus output per capita. However, for many potential health improvements in developing countries, there will also be the side effect of rapidly speeding up population growth, which will have negative economic effects. We can use our model to trace out the dynamic impacts of health interventions alone compared to the case where health interventions are paired with compensating measures to reduce fertility.

2. Description of the Model

Our project encompasses two pieces. The first is the creation of a simulation model which traces through the economic effects of changes in a country's fertility. The key parameters of this model are drawn from microeconomic studies of household behavior. The second piece of our project is the creation of a web interface that will allow a user to run the simulation model. In this section we further describe the demographic/economic model. We describe the user interface in part **f** of this proposal.

Demographic Model

We take as a starting point baseline paths of age-specific fertility and mortality. The exact source of these estimates will depend on the country we are examining. For example, for most countries, we can start with the current and future projected paths of total TFR, along with age-specific fertility from a recent point in time. Future paths of TFR come from, e.g. the UN, and are obviously fairly speculative. As an alternative, we can simply have the baseline be that the TFR remains unchanged. Scaling current age-specific fertility rates by the change in the TFR gives age-specific fertility for each point in the future. We would follow a similar procedure for mortality. Using the fertility and mortality rates, along with the current age structure of the population, we can then forecast population by age going forward in time. (In our initial, scaled down versions of the exercise, we simply take the current age specific fertility and mortality rates as a baseline for future fertility and mortality, and use a stable population generated from these rates as an initial population.)

Our main experiment is to alter the fertility profile via some (unspecified) intervention. One form that this can take is a reduction in TFR below the base-case path (either permanently or temporarily – the latter would be the case if an intervention speeded up a reduction in TFR that was forecast to take place anyway), with age-specific fertility falling at all ages proportionally. Alternatively, we can consider alterations to age specific fertility that would be consistent with a change in birth spacing or particular changes in age- and parity-specific birth hazards. Using our simple population model, we would then be able to calculate population numbers in each age group for the baseline and intervention cases.

Economic Model

The economic model takes population characteristics as inputs and produces individual, household, and economy-wide economic outcomes as outputs. The most important parts of the model are the parameters governing production as well as household responses to changes in the demographic and economic environment. These parameter estimates will come from a variety of sources, including existing published estimates, re-analysis of existing microeconomic data sets, and (perhaps down the road) new data collected from countries that are undergoing or have exogenously induced declines in fertility.

Below we list several of the key channels through which reduced fertility affects economic growth, and discuss how they are parameterized and incorporated into our model.

Slower labor force growth

Reduced fertility implies (with a lag) slower growth in the labor force. Holding the national saving rate fixed, slower growth of the labor force will in turn lead to a rise in the level of physical capital per worker (capital deepening), and a corresponding increase in output per worker. This is the "Solow" effect that is present in simple textbook analyses of economic growth models (it is also the driving force in Young's (2005) analysis of the effect of HIV on economic growth in South Africa.) The magnitude of the Solow effect depends on the weight of reproducible capital in the production function. For example, Weil (2005, Chapter 4) shows that for a conventional Solow model with a capital weight of 1/3, reducing population growth from 4% to zero (which would be a very large reduction) raises steady state output per worker by 34%.

Reduced pressure on fixed natural resources

The Solow effect depends on the growth rate of the workforce. A second classical channel by which population affects output depends on the size of the labor force relative to a fixed stock of natural resources. This is, of course, the Malthusian channel. The resources in question can either be non-renewable (oil) or renewable (soil fertility, ground water, etc.) How increases in the ratio of workers to natural resources will translate into declines in output per worker depends on how the resources enter the production function. For example, as the land/labor ratio falls, farmers can switch to labor-intensive cultivation techniques, and so output per worker may not fall by much as the number of workers rises. By contrast, in the case of a resource like oil, the total flow of rents is invariant to the number of workers in the country, so rents per worker are just inversely proportional to the number of workers.

In the preliminary analysis presented above, we simply allow for land to have a fixed share (10%) in an aggregate production function. We are currently extending this technique by using data from the World Bank on shares of natural capital in national income at the country level. There is enormous heterogeneity in the importance of resources. Consider the countries of particular interest to the MacArthur Foundation. According to the World Bank (2006, figure 4.1) in Nigeria over the period 1970-2000, resource rents as a fraction of GDP averaged 32%! In Mexico, the figure was 8%, and in India only 3.5%. (These figures only apply to income flows, and don't include implicit rent on owned land, use of unpriced resources like groundwater, etc.) Another approach is to compare natural capital (capitalized value of subsoil resources, farm and pasture land, etc.) to produced physical capital, on a per capita basis. Values are below ((World Bank, 2006, Appendix 2)

	Natural	Produced
India	$1,928	$1,154
Mexico	$8,493	$18, 959
Nigeria	$4,040	$667

Effects on saving and investment

In addition to the effect of reduced fertility in raising output per worker because of slower labor force growth (the Solow effect discussed above), there is a second channel from demographics to capital per worker. Specifically, fertility reduction will induce a change in the age structure of the population, and since different age-groups tend to save at different rates (in particular, middle-aged workers save more than the young or the old), this will also change aggregate savings-rates. The classical prediction of the life-cycle hypothesis (LCH) is that reducing the number of children will first increase savings rates and later depress them, as the incoming working cohorts are small relative to the older (now dissaving) and larger cohorts. However, Deaton and Paxson (2000), using data from Taiwan and Thailand, show that these effects, although they can be quantitatively large, can be difficult to sign *a priori*: they estimate opposite effects in Thailand and Taiwan. For instance, in Thailand, where survival rates to old age are relatively low, the dissaving effect might be correspondingly small and so a reduction in population growth might actually *raise* saving, even in the long run. There is as yet relatively little knowledge of life-cycle savings effects in Africa, and we intend to explore these more fully in our work.

Whether the "demographic gift" of temporarily low overall dependency translates into higher saving, and in turn into higher economic growth, depends on a country's institutional structure. Future work will address the issue of how to incorporate this effect into our simulation model.

Effects on human capital accumulation

Declines in fertility over the course of the demographic transition are generally accompanied by increased investment in human capital of children, although the extent to which this "quality-quantity" substitution, as opposed to changes in child mortality, availability of contraception, and gender roles, is the driving force in fertility reduction is actively debated. It is certainly the case that an exogenous intervention that reduces fertility will loosen household budget constraints (and similarly loosen the budget constraints of governments that provide schooling) and allow for the possibility of greater investment in children's education. Joshi and Schultz (2006) find that a family planning intervention in Matlab, Bangladesh that reduced the TFR by 15% also raised the education of boys by .54 standard deviations. Given an estimate of the effect of fertility reduction on educational investment in children, we can then apply standard ("Mincerian") estimates of the returns to schooling, and using our model trace through the effects on output of the entry of more educated workers into the labor force. An important issue to keep track of will be the interaction of increments to schooling that might arise from lower fertility with the institutional structure of the economy: if as argued by Pritchett (2001), the economy makes no use of educated workers, then increments to education will not raise output.

Another form of human capital which can be increased by fertility reduction is health. Joshi and Schultz (2006) report that the family planning intervention reduced under-5 mortality, although they do not find significant effects on the measured health of surviving children. Improvements in worker health can be translated into productivity using the techniques described in Weil (forthcoming).

Age structure of the labor force

Slower population growth implies an increase in the average age of the workers. In the developed country context, this may be a bad thing, as older workers will soon outnumber younger ones, possibly leading to a flattening in the lifetime wage profile. Developing country labor forces are overwhelmingly young, so the more important effect will be a "seasoning" of the labor force, as average experience rises. We use estimates of the return to experience as follows. For a worker with x years of experience, we set labor input (relative to a worker with no experience) as

$$h = \exp(\phi x + \varphi x^2)$$

We use values of $\phi = 0.0495$ and $\varphi = -.0007$, based on the evidence from Bils and Klenow (2000) on the average return to experience in a sample of 48 countries.

Effects on population composition

Thus far, we have been considering an intervention that reduced TFR proportionally throughout the population. However, experience of actual fertility transitions shows that they take place at different speeds in different parts of the income and/or education distribution. Specifically, families in lower income and education groups lag in reducing their fertility. This means that there is a composition effect associated with fertility reductions, in which the fraction of the population made up of children of the poor/low education rises. This can in turn affect the measured level of output per capita, even if average income is growing at the same rate in each income/education group. Whether a particular intervention to reduce fertility will also have a differential effect by economic class is a more open question. We hope to examine this issue by looking at measures of unmet need for contraception broken down by income/education group, and also by looking at the experience of countries where there have been rapid reductions in fertility.