Rochester Center for Economic Research

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Working Paper No. 561
February 2011

University of Rochester

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February 2011

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Abstract

Bailey and Collins (forth.) argue that Greenwood, Seshadri and Vandenbroucke (2005)'s hypothesis that the baby boom was partly due to a burst of productivity in the household sector is not supported by evidence. This conclusion is based upon regression results showing that appliance ownership is negatively correlated with fertility. They also argue that the Amish, who limit the use of modern technology, had a baby boom. First, it is demonstrated that a negative correlation between appliance ownership and fertility can arise naturally in Greenwood et al.'s model. Second, evidence is presented casting doubt upon the presumed technological phobia of the Amish.

Keywords: Amish, appliances, baby boom, Bailey and Collins, fertility, model laboratory, Monte Carlo simulations, regressions

1 Introduction

Greenwood, Seshadri and Vandenbroucke (2005) hypothesize that the baby boom was partly due to a burst of productivity in the household sector. The idea is that the introduction of appliances (for example dryers, refrigerators and washing machines) and new products (such as frozen and packaged foods and infant formula) reduced the cost of having children. Equally important was the home economics movement, that introduced the principles of scientific management into the home. Albanesi and Olivetti (2010) argue that advances in obstetrics and pediatric medicine had much the same effect. By lowering the cost of having children, such forces promoted fertility.[1]

Bailey and Collins (forth.) argue that this hypothesis is not supported by evidence. They make two points. First, they report results of regressions showing that appliance ownership is negatively correlated with measures of fertility. According to them, GSV's theory warrants a positive correlation. Second, they argue that the Amish, who limit the use of modern technology, had a baby boom. They conclude that it could not have been caused by technological progress, another point against GSV's theory. These points are addressed in order. Section 2 demonstrates that BC's empirical strategy is not well designed. Therefore, it does not deliver a suitable test of GSV's hypothesis. Section 3 presents evidence casting doubts on the well-accepted notion that the Amish are "anti-technology."

2 Quantitative Strategy

BC's strategy is to regress fertility on adoption rates, controlling for income and other variables. This is done for a set of U.S. counties. They assert that the GSV theory of the baby boom implies a positive coefficient of adoption on fertility. A negative coefficient is found. This is interpreted as evidence against the theory.

BC are, in fact, misinterpreting their results. The negative correlation they find between the adoption rate for appliances and fertility is perfectly consistent with GSV's model. This is shown below by constructing a simple example that illustrates how fertility and the adoption of appliances are determined. The idea is that technological adoption differs by income. Richer people will tend to adopt electricity and appliances earlier than poorer ones. They will also have lower levels of fertility than poorer people. So, a regression may associate low levels of fertility with the adoption of appliances, if the rich adopt first. Two Monte Carlo experiments are conducted running the BC's regressions on simulated data generated from a simplified version of GSV's model. They yield the same negative correlations that BC find. If such regressions don't perform

[1] The baby boom is now an active area of research in macroeconomics. For example, Doepke, Hazan and Maoz (2007) and Jones and Schoonbroodt (2011) analyze the impact of World War II and the Great Depression on the baby boom. Their hypotheses are not mutually exclusive with the one discussed here.

well in a dust-free model laboratory it is hard to understand why they should be expected to work well in the real world. The idea that regression equations can be "tested" on simulated data drawn from economic models is not new in macroeconomics. An early example is Baxter and Jermann (1999), who examine tests of the permanent income hypothesis. A more recent one is Chari, Kehoe and McGrattan (2008) who study the use of VARs.

The constructed example is realistic in that it displays a secular decline in fertility that is briefly interrupted by a baby boom. It is important to stress that as logical matter all that is needed is a counter example to the hypothesis that the GSV model implies a positive relationship between fertility and adoption in a regression of the form run by BC; i.e., there is *no* need for the example to be realistic to disprove the hypothesis, as any logician knows.

2.1 A Simple Model

Suppose that individuals live for one period of time. Individuals earn the wage w_i, which differs by income class i. They have preferences over consumption, c_i, and the number of kids, n_i, represented by

$$U(c_i, n_i) = \phi \frac{c_i^{1-\eta}}{1-\eta} + (1-\phi) n_i, \quad \text{with } \phi \in (0,1) \text{ and } \eta > 0.$$

There are two available household technologies. The first is free and implies a time cost q for raising children. The second costs e units of the consumption good and implies a time cost $z < q$. The budget constraints for users and nonusers are

$$\begin{aligned} c_i + q w_i n_i &= w_i, && \text{for nonusers,} \\ c_i + z w_i n_i &= w_i - e, && \text{for users.} \end{aligned}$$

The optimal consumption and fertility decisions for an individual of income class i are given by:

$$\begin{aligned} c_i^n &= w_i - q w_i n_i^n, && \text{for nonusers,} \\ n_i^n &= 1/q - [\phi/(1-\phi)]^{1/\eta} (q w_i)^{(1-\eta)/\eta}, && \\ c_i^u &= w_i - e - z w_i n_i^u, && \text{for users,} \\ n_i^u &= (w_i - e)/(z w_i) - [\phi/(1-\phi)]^{1/\eta} (z w_i)^{(1-\eta)/\eta}, && \end{aligned}$$

where the superscript u (n) denotes the decision for a (non) user. The adoption decision is summarized by

$$a_i = \begin{cases} 1, & \text{if } U(c_i^u, n_i^u) > U(c_i^n, n_i^n), \quad \text{user,} \\ 0, & \text{if } U(c_i^u, n_i^u) \leq U(c_i^n, n_i^n), \quad \text{nonuser.} \end{cases}$$

The following example illustrates how the above model can generate a secular decline in fertility that is punctuated by a baby boom, the latter due to the adoption of a labor-saving household technology. In the example, there are three types of individuals, viz, "poor," "middle-income," and "rich". Their wages grow at 2 percent a year. The price of appliances starts off very high and remains so for 100 years. It then proceeds to decline at 2 percent a year.

Example: Parameterization	
Tastes	$\eta = 0.7, \phi = 0.6$
Technology	$q = 0.18, z = 0.16$
Initial Wages	$w_1 = 0.5, w_2 = 1.5, w_3 = 2.5$
Growth in Wages	$w_i(t) = w_i^{1.02(t-1800)}$, for $t > 1800$
Initial Price	$e = 6$
Growth in Price	$e(t) = \begin{cases} e, & \text{for } t \leq 1900, \\ e^{0.98(t-1900)}, & \text{for } t > 1900 \end{cases}$

Figure 1 shows the time path of fertility for these individuals. Fertility displays a secular decline for all income classes due to rising wages. Observe that richer individuals tend to have lower fertility, both in the cross section and the time series, a fact firmly established in Jones and Tertilt (2008). This is because the opportunity cost of having children is increasing in the wage rate. Notice also that richer individuals adopt the new technology earlier. At the time of adoption there is a jump in fertility because the new technology reduces the time cost of raising children.

2.2 Bailey and Collins' First Regression

To test the above theory, BC run a cross-sectional regression of the form:

$$n_j = \text{constant} + \tau a_j + \beta y_j + \varepsilon, \text{ with } \varepsilon \sim N(0, \sigma),$$

where n_j is fertility in county j, a_j is the county's rate of adoption for appliances, and y_j is per-capita income. They postulate that the theory implies that τ should be positive.

A Monte Carlo experiment can be conducted to test this regression on simulated data generated from the model. To do this, assume that there are $J = 2,000$ counties indexed by j and that each county is populated by $N = 2,000$ individuals indexed by i. In each county j draw individual i's wage, w_{ij}, for $i = 1, \ldots, N$, from a lognormal distribution. Specifically, let $\ln w_{ij} \sim N(\bar{w}_j, 0.6)$. Note that each county j has its own mean level of wages, $\bar{w}_j$. Let this mean also be lognormally distributed. In particular, $\ln \bar{w}_j \sim N(1, 0.1)$. These numbers are chosen so that the coefficient of variation of wages is in line with the U.S. data. In particular, in the Monte Carlo experiment considered here the coefficient of variation of w_{ij} is 0.65. Kopecky (Table 3, forth.) reports that the coefficient of variation in earnings, from Census data, is between 0.65 and 0.74. Take the price for the new technology to be given by $e = 1$.

For each individual generate the following data points for fertility, adoption and income:

$$n_{ij} = \begin{cases} (w_{ij} - e)/(zw_{ij}) - [\phi/(1-\phi)]^{1/\eta} (zw_{ij})^{(1-\eta)/\eta}, & \text{if user,} \\ 1/q - [\phi/(1-\phi)]^{1/\eta} (qw_{ij})^{(1-\eta)/\eta}, & \text{if nonuser,} \end{cases}$$

$$a_{ij} = \begin{cases} 1, & \text{if } U\left(c_{ij}^u, n_{ij}^u\right) > U\left(c_{ij}^n, n_{ij}^n\right), \quad \text{user,} \\ 0, & \text{if } U\left(c_{ij}^u, n_{ij}^u\right) \leq U\left(c_{ij}^n, n_{ij}^n\right), \quad \text{nonuser.} \end{cases}$$

$$y_{ij} = \begin{cases} w_{ij}\left(1 - zn_{ij}\right), & \text{if user,} \\ w_{ij}\left(1 - qn_{ij}\right), & \text{if nonuser,} \end{cases}$$

where

$$\begin{array}{ll} c_{ij} + qw_{ij}n_{ij} = w_{ij}, & \text{for nonusers,} \\ c_{ij} + zw_{ij}n_{ij} = w_{ij} - e, & \text{for users.} \end{array}$$

Note that adoption, a_{ij}, fertility, n_{ij}, and income, y_{ij}, are *all* simultaneously determined endogenous variables. From this individual-level data, county-wide averages can be constructed. Specially, let

$$n_j = N^{-1}\sum_{i=1}^{N} n_{ij}, a_j = N^{-1}\sum_{i=1}^{N} a_{ij}, \text{ and } y_j = N^{-1}\sum_{i=1}^{N} y_{ij}.$$

Now the above regression can be estimated using model-generated cross-sectional county-level data. The estimation yields $\hat{\tau} = -0.69$.

To gather intuition about this result, contemplate Figure 1 again. Is it true that individuals who adopted the time-saving technology have higher fertility than those who did not? Not necessarily. Focus on the year 1940. The rich (circles) have adopted the technology and their fertility increased as a result, but yet it remains below that of the poor (diamonds) who has not yet adopted the technology. Such observation is consistent with a negative correlation between adoption and fertility. Observe also that the first intersection between the poor and middle-income classes fertility (squares) occurs in the 1940s. At this moment the poor have not adopted while the middle-income class has. Yet, their fertility is the same: a zero correlation.

2.3 Bailey and Collins' Second Regression

BC argue that the issue raised above can be dealt with by regressing differenced variables. In particular, they now run a regression of the form

$$\Delta n_j = \text{constant} + \tau\Delta a_j + \beta\Delta y_j + \varepsilon, \text{ with } \varepsilon \sim N(0, \sigma).$$

Consider, then, redoing the above experiment. Add another time period to the earlier analysis and let w_{ij} increase by 20 percent (i.e., 2% per year for 10 years) for each individual i in each county j, and let e decrease by 50 percent. Compute n'_j, a'_j and y'_j, or the new values for fertility, adoption and income in county j, and build $\Delta n_j = n'_j - n_j$, $\Delta a_j = a'_j - a_j$ and $\Delta y_j = y'_j - y_j$. Estimating this equation on model-generated data yields $\hat{\tau} = -0.24$. So, this does not cure the problem.

2.4 Upshot

These examples show that GSV's model is not appropriately "tested" by regressions such as those used by BC. Regressions of these types are not implied by the model proposed in GSV on many grounds: they are linear while the GSV model is not; they are based on static and incomplete theorizing about fertility alone, whereas in GSV's model forward-looking people solve complicated dynamic optimization problems involving both adoption and fertility, where current and future wages and prices will matter; finally, they overlook the endogeneity of both adoption and income. A long time ago, Koopmans (1947, p. 161) railed against "measurement without theory":

> "The various choices as to what to 'look for,' what economic phenomena to observe, and what measure to define and compute, are made with a minimum of assistance from theoretical conceptions or hypothesis regarding the nature of the economic processes by which the variables studied are generated."

By dispensing with theoretical guidance it is easy to misinterpret the results from empirical measurement, in this case the observed correlation between fertility and adoption rates.

3 The Amish

BC present data on Amish fertility. According to them, the Amish also experienced a baby boom. BC assert that the Amish do not use modern labor-saving technologies in their households. Certainly, this is conventional wisdom. It is suspect, though. An expert on Amish culture, D. B. Kraybill (2001, p. 295), relates the following on this matter:

> "Consider some of the household changes in the last fifty years. Amish women no longer wash clothes in hand-operated machines. They use washing machines powered by hydraulic pressure or gasoline engines. Gas refrigerators have replaced iceboxes, indoor flush toilets have replaced outdoor privies, hydraulic water pumps have replaced windmills, and gas water heaters have replaced the fire under wrought-iron kettles. Modern bathtubs have superseded old metal tubs. Kerosene lanterns have given way to gas lights. Wood-fired cookstoves have yielded to modern gas ranges. Hardwood floors and no-wax vinyl have replaced linoleum and rag carpets. Spray starch, detergents, paper towels, instant pudding, and instant coffee have eased household chores. Permanent-press fabrics have lifted the burden of incessant ironing. Although canning still predominates, some foods are preserved by freezing. Air-powered sewing machines are replacing treadle machines. Battery-powered mixers do the job of hand-operated egg beaters,and air-powered food processors have replaced hand grinders."

Figure 2 shows an Amish kitchen, sometime *prior* to 1989. The presence of lights (perhaps from a gas generator), a refrigerator, and range can be seen immediately. Less apparent is the fact the kitchen is arranged in a modern, rationalized, time-saving manner, as evidenced by the built-in wood cabinets, continuous counter tops, and modern sink. Such a picture perfectly illustrates the following quote from GSV (p. 197):

> "Take the kitchen, for example. The kitchen of the 1800s was characterized by a large table and isolated dresser. An organized kitchen with continuous working surfaces and built-in cabinets began to appear in the 1930s, after a period of slow evolution. In the 1940s, the kitchen became connected with the dining room and other living areas, ending the housewife's isolation."

Such innovations, while hard to quantify, did save time. Often they can be seemingly small. For example, GSV discuss how Christine Frederick, an early advocate of applying the principals of scientific management to the home,

> "discovered that dishwashing could be accomplished more efficiently by placing drainboards on the left, using deeper sinks, and connecting a rinsing hose to the hot-water outlet; she estimated that this saved 15 minutes per dinner."

In fact, today, in some areas the Amish are on the forefront of technology adoption. Holmes county, OH, hosts the largest Amish community in the world. About 80% of the Amish living there use solar power. Apparently, the Amish's main concern about the use of electricity is its connection with a publicly shared grid, which reduces independence from the outside world. This can be avoided through the use of diesel generators, windmills, and, in modern times, solar panels. To conclude, while there is some truth in the conventional wisdom about the Amish being technophobic, the true story is much more nuanced. To the extent that they adopted labor-saving practices in the home one would expect that they should also experience a baby boom. It is interesting to note that conventional wisdom also believes that the Amish do not use any form of birth control. The presence of an Amish baby boom casts doubt on this too (unless one believes that Amish women became more fecund during this period).

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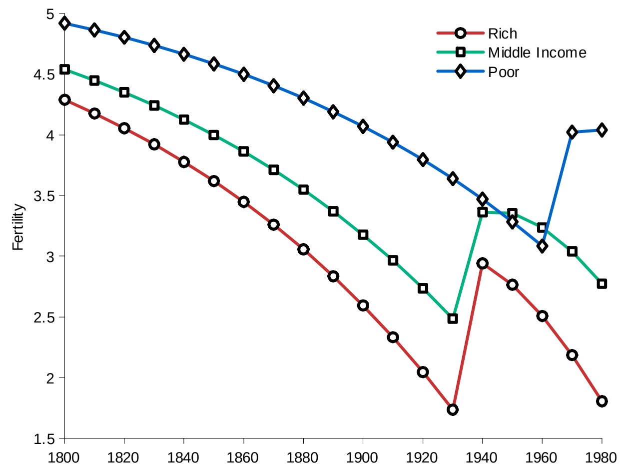

Figure 1: Baby boom and baby bust. The simulation starts in 1800. Wages grow at 2 percent annually. Appliance prices are constant until 1900, and then decline at 2 percent a year.

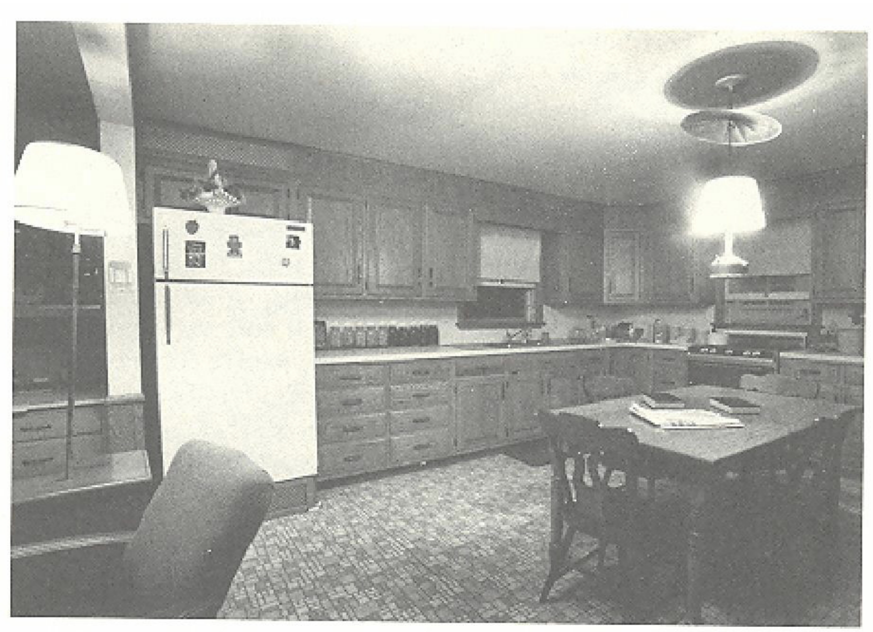

Figure 2: An Amish kitchen sometime prior to 1989. Source: Kraybill (1989, p. 17)