Did Improvements in Household Technology Cause the Baby Boom? Evidence from Electrification, Appliance Diffusion, and the Amish

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Abstract: More than a half century after its peak, the baby boom's causes remain a puzzle. A novel argument posits that rapid changes in household technology from 1940 to 1960 account for this large increase in fertility. We present new empirical evidence that is inconsistent with this claim. Rapid advances in household technology began long before 1940 while fertility declined, and differences and changes in appliance ownership and electrification in U.S. counties are negatively correlated with fertility rates from 1940 to 1960. Finally, the Amish, a group strictly limiting the use of modern technologies, experienced a coincident and sizable baby boom.

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1. Introduction

After at least 100 years of secular decline, births per 1,000 women (ages 15 to 44) in the United States increased by more than 50 percent between 1939 and 1957 (see figure 1). This remarkable departure from longer-term trends, often called the "baby boom," was not a short-lived, statistical aberration reflecting postponed births from the Depression or World War II. Rather, it stretched over two decades and was driven by earlier marriage and childbearing, shorter birth intervals, and increases in completed childbearing (Ryder 1980, Rogers and O'Connell 1984).[1] These features of the American baby boom present a fascinating challenge to scholars, especially because the rise in fertility took place against a backdrop of increasing income, urbanization, educational attainment, and women's labor force participation—all trends typically associated with *declining* fertility. More than a half century after its peak, the ultimate causes of the baby boom remain one of the twentieth century's great puzzles.

A recent article by Greenwood, Seshadri, and Vandenbroucke (2005, henceforth GSV) proposes a novel neoclassical explanation of the baby boom. Using an overlapping-generations model that integrates fertility decisions, advances in household technology, and changes in wage rates, they simulate both the secular decline in U.S. fertility, which is driven by rising wages (consistent with a rising opportunity cost of childrearing), and the baby boom, which is driven by a burst in the productivity of household technology between 1940 and 1960. In their words, "…technological advance in the household sector, due to the introduction of electricity and the development of associated household products such as appliances and frozen foods, reduced the need for labor in the child-rearing process. This lowered the cost of having children and should have caused an increase in fertility, other things equal. This led to the baby boom" (185). Thus, economic theory elegantly solves the puzzle of the baby boom, while also accommodating and explaining the long-run decline in fertility.

If correct, this household-technology centered explanation of the baby boom is a great achievement for fertility models that highlight changes in technology and prices. It also represents a formidable challenge to arguments from Richard Easterlin's point of view, which

[1] Completed cohort fertility is plotted with period fertility in figure 1. Women born during the 1930s, the mothers of the "baby boomers," had completed fertility rates as high as women born in the late nineteenth century.

emphasize an independent and causal role for changes in preferences (Easterlin 1961, 1980; Fernandez 2007).[2] Indeed, the ascendance of the household-technology centered explanation of the baby boom would entail a fundamental shift in standard narratives of American demographic history (see *inter alia* Montgomery and Trussell 1986, Haines 2006).

Our analysis subjects this important hypothesis to closer historical, empirical, and theoretical scrutiny. First, we examine the historical validity of key assumptions that underpin GSV's quantitative simulation and conclude that the central claim of an exceptional and sudden "burst" of household productivity relative to productivity growth in other sectors between 1940 and 1960 is questionable. Second, newly-encoded county-level information on household technology, combined with existing county-level census data on fertility and other household characteristics, provides further evidence that is inconsistent with the household-productivity hypothesis. This is true of both cross-sectional and first-differenced, regression-adjusted estimates of the relationship between fertility rates and the diffusion of electrical service and modern appliances. Moreover, individual-level data on completed fertility reveal no evidence that women who had greater exposure to electrical service in early adulthood had more children, even after conditioning on education, race, and state and cohort fixed effects. Finally, we document that the Old Order Amish, a group that limited its use of modern appliances on religious grounds, had a baby boom that began at nearly the same time, lasted just as long, and was approximately as large as the baby boom in the rest of the U.S. population.

Our findings and conclusions are consistent with economic theory as long as the *quantity* of children is not restricted to be a normal good or consumers are allowed to value other home-produced goods. We demonstrate that incorporating other household commodities into the utility function and allowing their prices to fall with improvements in household technology produces a theoretically ambiguous relationship between the number of children and technological progress in the household. In sum, this paper's historical and econometric

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[2] Easterlin emphasizes the importance of a cohort's perceived "earnings potential" relative to its "material aspirations." Children who grew up in the Depression, for example, may have formed material aspirations that were far exceeded by their actual experience as young adults in the later 1940s and 1950s, and they may have responded to their surprisingly good fortune by having more children. See Macunovich (1998) for a review of the empirical literature that the Easterlin hypothesis spawned. See Doepke, Hazan, and Maoz (2008) for an even more recent view based on World War II's effect on women's labor force experience.

evidence calls scholars to look beyond the diffusion of modern household technology for the causes of the U.S. baby boom.

2. A Simple Framework for Understanding the Impact of Household Technology

The GSV model of fertility yields an unambiguous prediction that the number of children rises when the productivity of household technology increases. This result provides the theoretical basis for the claim that a burst of household technology caused the baby boom. This section demonstrates that relaxing critical assumptions changes this unambiguous theoretical result to an ambiguous one.

Without loss of generality, consider a static framework where households maximize utility, $U(N,Z)$, defined over the number of children, N, and a composite non-child commodity, Z.[3] The price of the non-child composite is normalized to 1, and the price of children, p_N, is a shadow price (or marginal cost of a child) and defined relative to the price of Z. As in the GSV framework, we assume that p_N falls as progress is made in household technology, which is represented in the exogenous parameter A.[4]

In this framework, the demand for children is a function of the relative price and income, I; that is, $N = N(p_N, I)$. Using the Slutsky equation and the assumption that the relative price of N falls with A, the impact of technological progress in the household on the demand for children should be nonnegative,

$$(1) \qquad \frac{dN(p_N,I)}{dA} = \frac{\partial N}{\partial p_N}\cdot\frac{\partial p_N}{\partial A} = \left[\frac{\partial N^C}{\partial p_N} - \frac{\partial N}{\partial I}N(p_N,I)\right]\frac{\partial p_N}{\partial A} \geq 0,$$

where $\frac{\partial N^C}{\partial p_N}$ is the compensated price effect. Consistent with the properties of the Slutsky matrix, the own-price effect should be nonpositive, $\frac{\partial N^C}{\partial p_N} \leq 0$. Moreover, the income effect should be

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[3] The implications of the GSV model for childbearing remain in the one-period case, because they assume that childbearing decisions occur only in the first period of adulthood. We additionally assume that U is continuous and represents a locally nonsatiated and strictly convex preference relation.

[4] To this end, GSV employ a simple production function for children, $N = Al^{\theta}$, where l is the amount of labor input and $0 < \theta < 1$.

nonnegative, $\frac{\partial N}{\partial I} \geq 0$, if children are a normal good.[5] These properties combined with the assumption that household technological progress lowers the relative price of children, $\frac{\partial p_N}{\partial A} < 0$ lead to a straightforward result: both substitution and income effects encourage the production of more children when household productivity rises. The simple intuition from this general formulation is exactly what drives the results in the basic GSV model.[6]

One potential problem with the assumption that child quantity is a normal good is that empirical studies find that the number of children tends to fall with income.[7] Becker (1960) argues that one important reason for this is that increases in income may induce much larger increases in child quality than child quantity. Becker and Lewis (1973) and Willis (1973) formalize this argument by introducing a nonlinear budget constraint, in which the shadow prices of quality and quantity are jointly and endogenously determined. The well-known result, and therefore not demonstrated here, is that nonlinearities in these models' budget constraints allow the number of children to fall as income increases.

Another critical assumption in this formulation is that an increase in household productivity does not alter the relative price of other consumption goods. To see the importance of this, consider the addition of another good, H, to the model, and assume that its shadow price, p_H, falls with A as well.[8] Some examples of the goods in H might include listening to music (produced with a combination of time and a record player or radio); cleaning one's home or clothing (produced with time and a washing machine or other appliances); or making or ironing one's clothes (produced with time and a sewing machine or iron). Alternatively, H might be conceptualized as "child quality" as considered in Becker (1960), Becker and Lewis (1973), and Willis (1973), if child quality includes commodities like healthy meals, which may require fresh produce or meat to be refrigerated, or dance lessons, which could require automobile transportation to schools or studios. Following the notation and logic of (1), we now have

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[5] This assumption is considered in several paragraphs.
[6] The specific example is shown in the theory appendix to this paper. See also GSV's section I (185) and section IV (194), which considers an extension of their model that incorporates child quality.
[7] This well-known empirical regularity has been documented using inter-temporal and cross-sectional variation in observed income (Becker 1991, Hotz et al. 1996).
[8] This could be achieved by using a parallel non-child, home goods production function, $H = Ah^{\beta}$, where h is the amount of labor used and $0 < \beta < 1$.

$$(2) \qquad \frac{dN(p_N,p_H,I)}{dA} = \left[\frac{\partial N^C}{\partial p_N} - \frac{\partial N}{\partial I}N(p_N,p_H,I)\right]\frac{\partial p_N}{\partial A} + \left[\frac{\partial N^C}{\partial p_H} - \frac{\partial N}{\partial I}H(p_N,p_H,I)\right]\frac{\partial p_H}{\partial A}.$$

In this case the sign of the second term is theoretically ambiguous. For instance, if N and H are gross substitutes (implying that $\frac{\partial N^C}{\partial p_H} - \frac{\partial N}{\partial I}H(p_N,p_H,I) \geq 0$), then the sign of the second term would be nonpositive (because $\frac{\partial p_H}{\partial A} < 0$ by assumption). The addition of a potentially substitutable, home-produced commodity, H, and the relaxation of the assumption that children are a normal good allow for the possibility that the number of children might *increase or decrease* in response to an increase in A.

The point of this simple analysis is to show that—independent of specific functional form assumptions— basic economic theory predicts that advances in household technology may lead to a rise or *fall* in the number of children born. In summary, both the sign and the magnitude of the impact of rapid advances in household technology on child quantity depends upon whether child quantity is a normal good and how the shadow prices of other consumption commodities, such as home-produced goods or child quality, are affected. Finally, even if the number of children did increase on net with advances in household technology, reductions in the price of other home-produced goods and, perhaps, substitution toward child quality (away from quantity) would temper the magnitude of this positive fertility response, making it a less likely candidate to account for the enormous increase in fertility rates during the baby boom.

The next sections examine whether changes in appliance ownership and electrification between 1940 and 1960 were sufficiently large and correlated with fertility changes to represent an empirically plausible explanation of the U.S. baby boom.

3. The Diffusion of Household Technology in the First Half of the Twentieth Century

The main evidence supporting the household-productivity hypothesis is a calibration exercise, which can mimic the actual time-series of the U.S. fertility rate up to 1960, including the baby boom (GSV 2005: 189-193). The calibrated model's key parameter is household productivity, but its time path is neither measured directly nor easy to compute using available data. Instead, values of the household productivity parameter that best fit the fertility time series are selected within a constrained minimization problem, where household productivity is constrained to be constant from 1800 to 1940 and from 1960 to 1990. 1940 to 1960 is the only period in which household productivity is allowed to accelerate. The imposition of these constraints is intended to correspond to a "burst of technological progress in the household sector" between 1940 and 1960 (GSV 2005: 183, 191). When combined with the model's assumptions that dictate a positive fertility response (discussed above), this sudden increase in household productivity yields the baby boom.[9]

This burst of household technological progress at mid-century, however, is historically questionable. Scholarship on the history of home production reveals significant technological progress that long predates the baby boom. For example, improvements in stoves and the distribution of processed foods, including canned goods, refrigerated and preserved meat, and ready-to-eat cereals, transformed meal preparation during the nineteenth and early twentieth centuries (Giedion 1948, Strasser 1982, Cowan 1983).[10] Indoor running water, a time-saving improvement rivaled by few others, became increasingly common in cities in the late 1800s and proliferated thereafter. Sewing machines diffused widely after 1850 (Godley 2001). Christine Frederick's widely circulated writings (1912) on how to improve efficiency in household work were published decades before the baby boom and were a continuation of a literature that dates to the mid-nineteenth century work of Catharine Beecher (1841).[11]

For quantitative evidence on the speed of technological progress in the household, we focus on the diffusion of household technologies.[12] Rather than combining separate series into an index, figure 2 plots them separately to highlight the timing of diffusion for different

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[9] Three parameters determine fertility trends in the GSV model (2005: 205): (1) the state of household technology, (2) the market wage rate, and (3) the time price of home production technology. (1) and (3) are inherently difficult to measure. In the GSV calibration, the state of household technology is inferred as described above and the time price of new technology is simply set to zero for all periods (2005: 191 fn). This means that changes in (1) and (2) are primarily responsible for the timeseries generated in the calibration exercise. We concentrate on measures of appliance diffusion and electrification because these are the hallmarks of twentieth-century change in household production techniques, and they are specifically cited as the instruments that reduced the need for labor in the child-rearing process (185 and section V).

[10] Cowan writes, "By the turn of the century, canned goods were a standard feature of the American diet: women's magazines contained advertisements for them on nearly every page, standard recipes routinely called for them, and the weekly food expenditures of even the poorest urban families regularly included them" (1983: 73).

[11] Some of these early developments are also cited in GSV's description of the history.

[12] We have found little, quality-adjusted information on national price changes for the pre-1947 period and focus, therefore, on the actual diffusion of technology to households. Another issue that arises with price data is that the magnitudes of household responses to changes in price are difficult to quantify. Using information on ownership rather than price has the advantage of reflecting actual changes in behavior.

technologies. These series provide no support for the idea that advances in household technology accelerated from 1940 to 1960, let alone that advances were negligible beforehand. The pre-1940 diffusion of modern conveniences was significant and rivaled the changes that unfolded between 1940 and 1960. In 1890, only 24 percent of homes had running water and 13 percent had flush toilets; only 3 percent of homes had electrical service in 1900, and essentially none had mechanical refrigerators, washing machines, or vacuum cleaners (Lebergott 1993: 101, 102, 113). By 1940—before the baby boom—the census reported that approximately 70 percent of households had running water, 60 percent had a private flush toilet, 79 percent had electrical lighting (and nearly as many had electric irons),[13] 44 percent had mechanical refrigerators, 54 percent had gas or electric stoves (rather than wood, coal, or kerosene), and 42 percent had central heating (Brunsman and Lowery 1943). We estimate that between 40 and 50 percent had power-driven washing machines in 1940.[14]

The overwhelming impression from figure 2 is that a strong trend of household technological change preceded the baby boom by at least three decades. Contrary to the hypothesized positive link between modern appliances and fertility, the U.S. fertility rate *declined* sharply in the context of rapid increases in home production technology between 1910 and 1940. Then, as home production technologies continued to improve (but as domestic help became increasingly expensive), this relationship reversed and fertility increased sharply from 1940 to 1960.[15]

The calibrated model's assumption that the acceleration in the advance of household

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[13] Lebergott estimates that 65 percent of homes owned electric irons in 1932, whereas about 68 percent had electrical lighting in 1930 (1976: 280, 288).

[14] The higher estimate (48 percent) is from multiplying figures for clothes washer ownership in 1940 among "wired" households (61 percent) from Bowden and Offer (1994: 745) by the proportion of occupied dwellings with electrical lighting (79 percent) from the U.S. Census (as reported in Brunsman and Lowery 1943: 91). The lower estimate (43 percent) is from using an alternative measure of "wired" houses (71 percent) from Bowden and Offer (1994).

[15] George Stigler noted that "in 1939 there were as many domestic servants as employees of the railroads, coal mines, and automobile industry combined" (1946: 2). But as the baby boom began, the proportion of the labor force working in domestic service fell by over 40 percent. Because this shift was accompanied by an increase in the wages of female domestic servants relative to other occupations (such as manufacturing operatives or clerical workers), Bailey and Collins (2006) argue that the pattern reflects increasing demand for women's labor in other sectors, as opposed to decreasing demand for household service. Along these lines, Cowan suggests that "Twentieth-century housewives may have wished to trade in their vacuum cleaners for a 'good old-fashioned maid', but could not do it because the good old-fashioned maids preferred positions on the assembly lines to positions in the parlor" (1983: 126). These trends would tend to increase, rather than decrease, the shadow price associated with childrearing during the baby boom.

production technology slowed in 1960 may also be inconsistent with history. After 1960, automatic dishwashers, clothes dryers, air-conditioning, and microwaves were recasting patterns of housework yet again (Cox and Alm 1997: 22). Moreover, television entertainment and expanding pre-school and kindergarten programs may have lessened children's demands on parents' time and energy.[16] We do not focus on this in our discussion, however, because GSV emphasize the calibrated model's ability to explain the baby boom between 1940 and 1960 and acknowledge that it fails to match the post-1960 baby bust.

In sum, these facts present difficult challenges for the household-technology centered explanation of the baby boom. A sudden and unprecedented acceleration in household productivity between 1940 and 1960 is essential for the calibration exercise to produce a baby boom, yet history questions this characterization of technological change and, instead, suggests a much longer period of transition. During much of this transition, fertility rates declined rapidly. In light of these time-series patterns, we turn to more disaggregated evidence to test the model's central, causal claim that modern appliances positively affected fertility levels after 1940.[17]

4. Appliance Ownership and the General Fertility Rate

This section uses a newly-compiled, county-level panel dataset for the United States to subject the household-technology hypothesis to direct empirical scrutiny. This analysis is akin to a set of unadjusted, cross-national correlations presented in GSV, but our dataset is much larger, contains more covariates and, therefore, has several advantages.[18]

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[16] Approximately 43 percent of 5-6 year olds were enrolled in school in 1940, but 81 percent were enrolled in 1960 (Goldin 2006: 2-406). From 1941 to 1961, the average public school student attended 12 additional days of school (2-411).

[17] The GSV simulation faces another serious critique, which is not discussed in detail in this paper. The results predict a large decline in time spent in household production, which GSV point out is consistent with the Lebergott (1993) estimates. However, Ramey and Francis (2006) and Ramey (2008) report that Lebergott's estimates are due to a mistake in reading the primary data source. In addition, the claim does not square with a large literature on household-level time-use studies, which suggests that there were small (if any) declines in time spent on housework before the mid-1960s (see, inter alia, Vanek 1974, Cowan 1983, Bryant 1996, Ramey and Francis 2006, Ramey 2008). In short, the GSV simulation predicts a large change in time use that apparently did not actually occur.

[18] GSV graphically compare (on one axis) baby-boom magnitude or the year-of-boom onset and (on the other axis) income per capita in 1950 in 18 OECD countries or an index of appliance ownership in 6 countries (2005: 201-202). The interpretation of the GDP per capita comparisons hinges on the idea that households in rich countries were more likely to own labor-saving appliances. Of course, this correlation is also consistent with the fundamentally different interpretation of Easterlin (1980) and is vulnerable to omitted variable biases.

To create this dataset, we entered county-level appliance ownership counts from the census volumes for the 1940 to 1960 period.[19] We supplemented these data with publicly-available, county-level economic and demographic information collected by Michael Haines (2004). Every county with available information (excluding those in Hawaii and Alaska) is in our dataset, yielding approximately 3,000 county-level observations per decade. Our proxy for the general fertility rate is the number of infants (under age one) per 1,000 women of ages 15 to 44. The level of household technology is measured as the proportion of housing units with refrigerators, washing machines, modern stoves (e.g., fueled by electricity or gas, rather than coal, wood, or kerosene), and electrical service. The census data provide a geographically detailed view of the diffusion of modern appliances during the baby-boom period, but the census did not collect information on every appliance in each year. Electrical service and refrigerators were reported in 1940 and 1950, washing machines only in 1960, and cooking fuel (an indicator of modern stoves) in 1940, 1950, and 1960. Additional information about variable definitions and the construction of our measures appears in the data appendix.

Table 1 reports means and standard deviations for the household technology variables and the number of infants per 1,000 women ages 15 to 44. The diffusion of electrical service and modern appliances was widespread, as reflected in the large increases in average rates of appliance ownership, but the levels and changes in appliance ownership were highly uneven across counties. For instance, the increase in electrical service (1940 to 1950) ranges from 8.0 percentage points at the 10th percentile to 49.8 at the 90th percentile, and the rise in modern stoves (1940 to 1960) ranges from 35.2 percentage points at the 10th percentile to 84.9 at the 90th percentile. A pervasive-but-uneven pattern of increase is also evident in the general fertility rate. From 1940 to 1960, more than 95 percent of counties recorded a rise in infants per 1,000 women age 15 to 44, and the average ratio increased from 80 to 120. Over the same period, changes in the ratio ranged from 11.3 at the 10th percentile to 66.1 at the 90th percentile.

Our analysis exploits the intertemporal and geographic variation in these measures to describe the relationship between fertility and the state of household technology while accounting for other relevant demographic and economic characteristics in the following linear

[19] Consistent data on household appliances are unavailable in the micro-level IPUMS samples.

regression framework,

(3) $$F_{js} = \tau A_j + \boldsymbol{\beta X}_j + \sum_{k=1}^{49} \gamma_k 1(s = k)_k + \varepsilon_{js} \ ,$$

where *F* is the fertility rate in county *j* and state *s, A* is our measure of the state of household technology, and *1( )* is a state dummy variable. To account for county-level characteristics that may affect both fertility rates and the state of household technology, $\boldsymbol{X}$ includes median years of schooling for those over age 24, log of median property value for owner-occupied housing, log of median family income (in 1950 and 1960 only due to data constraints), racial composition, measures of local economic development (the proportion working in agriculture, the proportion working in manufacturing, the urban proportion of the county's current population, and log population density), and a correlate of the opportunity cost of childrearing (the proportion of women in the labor force). Testing whether $\tau > 0$ is one way to evaluate statistically the hypothesized positive association between household technology and fertility.

Table 2 reports least-squares estimates of τ separately for 1940, 1950 and 1960. Each point estimate is from a separate, unweighted regression of the general fertility rate on appliance ownership.[20] Heteroskedasticity-robust standard errors are corrected for correlation within states and presented in brackets below each estimate. The specification in column 1 includes no covariates or fixed effects, and the unadjusted correlation between fertility and appliance ownership (refrigerators, modern stoves, and washing machines) is strongly negative. This is consistent with the observation that the level of workers' labor market productivity is positively correlated with appliance ownership and negatively correlated with fertility (as in the GSV model). To reduce the scope for this source of omitted variable bias, column 2 includes state fixed effects and column 3 adds the full set of county-level demographic and economic covariates described above. Identifying τ from within-state variation in appliance ownership and fertility (column 2) tends to increase the magnitude of the point estimates slightly. Adding controls for county-level characteristics (column 3) results in point estimates that are considerably smaller in magnitude, but none of the six is positive and statistically significant. Moreover, the largest point estimate (0.068 on washing machines in 1960) in conjunction with a

[20] Results from quantile regressions at the median, which are less sensitive to outliers than OLS, yield results that are qualitatively similar to the OLS estimates reported in tables 2, 3 and 4.

30 percentage point increase in washing machine ownership (the change in national average in figure 2) implies an increase of 2.0 infants per 1,000 women ages 15 to 44. Even using the upper bound of the 95 percent confidence interval implies an increase of only 6.2 infants. Because the baby boom entailed an increase of about 45 infants per 1,000 women, the magnitude of this relatively large point estimate, even at the outer reaches of its confidence interval, is not consistent with the hypothesis that appliance diffusion caused the baby boom.

One problem with the cross-sectional regressions is that *unobserved* differences in factors that influence both appliance ownership and fertility outcomes, such as unobserved differences in labor market opportunities for women, might bias estimates of τ downward.[21] With this in mind, we use the following first-differenced specification to eliminate time-invariant, unobservable county-level differences,

(4) $$\Delta F_{js} = \tau^D \Delta A_{js} + \widetilde{\boldsymbol{\beta}} \Delta \boldsymbol{X}_{js} + \sum_{k=1}^{49} \tilde{\gamma}_k 1(s = k)_k + u_{js},$$

where Δ denotes county-level changes in the variable over a 10 or 20 year period (either from 1940 to 1950, 1950 to 1960, or 1940 to 1960), and the remaining notation is as previously described. In this specification, observed, time-varying county characteristics (including changes in women's labor market participation rates) are captured in $\Delta\boldsymbol{X}$;[22] and the effects of unobserved, fixed differences are differenced out by design. Finally, state fixed effects now absorb unobserved *changes* at the state level, such as changes in perceived prosperity, policy, or other relevant conditions that may otherwise bias the point estimates. In effect, county-level, unobservable shocks that are correlated with changes in appliance ownership and fertility are the primary source of potential bias for the coefficient of interest.[23]

Table 3 reports unweighted, least-squares estimates of τ^D for pairs of census years with information on the same appliance measures (1940 to 1950, 1950 to 1960, or 1940 to 1960). The

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[21] We concentrate on potential bias against the GSV hypothesis, but one can also imagine scenarios in which the coefficient is positively biased in favor of the GSV hypothesis (e.g., reverse causality would lead families with more children to buy more appliances to keep up with added housework).

[22] Because median family income is unobservable in 1940, differenced regressions with 1940 cannot include the change in log median family income as a control variable. However, it can be included in panel C of table 3 (1950-60 difference), in which case it slightly strengthens the negative coefficient (-0.053, s.e. = 0.055).

[23] Omitting the control variable for observed changes in women's labor market participation has a small effect on the coefficients of interest in table 3. This suggests that the scope for bias from unobservable changes in women's market opportunities is small relative to the size of the coefficient one would need to account for the baby boom.

sequence of specifications across columns corresponds to those in table 2. As before, heteroskedasticity-robust standard errors are computed and corrected for correlation within states for all specifications reported. The unadjusted correlations in appliance and fertility changes are negative (column 1). When we account for observable changes in county-level covariates (including women's labor-force participation), unobservable state-level changes, and time-invariant county-level unobservable characteristics (column 3), the coefficient estimates are still negative.[24] If anything, the first-differenced regressions provide evidence that counties with greater growth in appliance ownership experienced smaller changes in their fertility rate. In light of the theoretical framework presented in section 2, these results are consistent with appliances enabling the substitution toward child quality or other home produced goods.

5. Electricity, the General Fertility Rate, and Completed Fertility

A potential concern with the appliance regressions in tables 2 and 3 is that appliance ownership might be a poor measure of the "state of household technology." From the perspective of households, access to electrical service may be a better indicator of access to current technology than ownership of specific appliances: few families that had electrical service available to them declined to have lights (or electric irons), whereas the decision to purchase specific, large consumer durable goods might have reflected a variety of household-level differences in preferences, prices, and plans. Another advantage of using electrical service is that it is a relatively homogenous and easily comparable product across locations and time.

Our data on county-level electrification come from the published volumes of the Census of Housing in 1950 and from the Haines (2004) county files for 1940.[25] Panels A and B of table

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[24] For brevity, we omit one set of results (1940-50 change in modern stoves) in which the estimate in column 3 is positive but statistically insignificant (0.082, s.e. 0.052). As before, this estimate is too small to account for a substantial portion of the baby boom. It should also be considered in light of the 1940 to 1960 (panel B) and the 1950 to 1960 (panel C) regressions which exhibit negative point estimates.

[25] The census does not report electric lighting in 1960, presumably because it was nearly universal. In 1960 more than 98 percent of homes had electrical service (United States Department of Commerce 1975). It is also important to note that the *county-level electrification rate is a relevant but invalid instrument* for appliance ownership. Although it is true that electric lighting was strongly, positively correlated with the level of refrigerator and modern stove ownership in 1940, electrification is also highly correlated with a host of other county-level measures of economic development. Therefore, electrification does not provide a valid instrument for estimating the causal effect of appliance ownership on fertility.

4 report estimates from separate, unweighted, least-squares regressions using equation 3, and panel C reports estimates from a regression of the *change* in the fertility rate on the change in electrical service between 1940 and 1950 using equation 4. Overall, the cross-sectional and first-differenced results provide no evidence of a positive relationship between electrification and fertility. In fact, the point estimates indicate that electrification is significantly and negatively correlated with county fertility rates even after accounting for economic and demographic differences and changes in column 3. Taken together, the results provide no suggestive evidence consistent with improvements in household technology causing the baby boom. As suggested before, it appears that whatever caused the baby boom worked against secular economic forces that tended to reduce U.S. fertility rates over this period.

A separate matter of concern is that changes in period fertility rates might not adequately reflect changes in *completed* fertility, the key outcome variable in the GSV model. Although period rates are used as evidence by GSV and period and completed fertility are highly correlated (see figure 1), we have assembled a new dataset that allows for a test based on cohorts' completed fertility rates. These completed fertility rates are constructed from the Integrated Public Use Microdata Series (IPUMS, Ruggles et al. 2008) for women ages 41 to 60 aggregated into birth-state and year-of-birth cells. We link estimates of completed fertility with newly-entered data from archived issues of the Edison Electrical Institute's *Statistical Bulletin*, which contain annual, state-level information on the number of residential electrical service customers from 1925 to 1960. With this information, each woman can be assigned an "electrical service exposure index" based on her year of birth and state of birth, which is the average ratio of electric customers over total households in that state during the time in which the woman would have been at the peak of her childbearing years (ages 15 to 29).[26] This index is a rough measure

[26] We divided the EEI customer counts by the Census of Housing counts of families (1920 and 1930) or occupied dwelling units (1940-1960) in each state to estimate the proportion of families with electrical service. We interpolated the housing counts between census dates. This choice of denominator is consistent with the housing unit counts in *Historical Statistics of the United States* (2006). See Kenneth Snowden's discussion (volume 4: 4-500 and 4-501): "Before 1940 the census enumerated 'families' and not housing unit[s]…. However, the two concepts are closely related: a census family was defined in 1930 as a single person living alone, a small group of unrelated persons sharing living accommodations, or, more normally, a group of related persons who live together as one household. Despite differences in terminology, therefore, the basic notion of a family, dwelling unit, or housing unit has provided essentially comparable measures of the residential housing stock since 1890."

of the probability of having access to electricity during the main years of family formation.[27] It corresponds to the spirit of the GSV model, which assumes that households make decisions about the number of children in the first period of adulthood based upon the current "state of household technology." The limitation of this definition, given the available data, is that the index can only be constructed for women born from 1910 (ages 15 to 29 from 1925 to 1939) to 1931 (ages 15 to 29 from 1946 to 1960). As a result, the final sample consists of women born in the coterminous U.S. between 1910 and 1931 in the 1960 to 1990 IPUMS.[28]

The positive correlation between completed fertility and advances in household technology can be tested by exploiting variation in the timing of electrification in women's state of birth using the following linear regression framework,

$$N_{yb} = \delta EXP_{yb} + \boldsymbol{\gamma X}_{yb} + \sum_{k=1}^{46} \mu_k 1(b = k) \quad + \sum_{j=1911}^{1931} \theta_j 1(j = y) \quad + \varepsilon_{yb} \ , \qquad (5)$$

where *y* denotes the birth cohort (inferred from age and year of observation) and *b* denotes the state of birth;[29] *N* is the mean self-reported number of children ever born (excluding miscarriages and still-births); *EXP* is the "exposure to electricity" index; and μ_k and θ_j capture year-of-birth invariant differences across birth states and state-of-birth invariant differences across birth cohorts, respectively. The set of demographic controls is limited, because measures of income, place of residence, and other life circumstances at the time of observation in 1960 to 1990 are poor proxies for circumstances in early adulthood. As a result, $\boldsymbol{X}$ includes a constant and characteristics that should vary little over the life-course but are strongly correlated with differences in lifetime income and socio-economic status: the proportion of the cohort that is "nonwhite"; mean educational attainment; and, in one specification, the mean of husbands' educational attainment and proportion of husbands who are nonwhite, which are only observed for women residing with their husbands at the time of the census. Table 5 presents population weighted least-squares estimates from specifications that add fixed effects and control variables sequentially. Heteroskedasticity-robust standard errors are corrected for correlation within states

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[27] The median age of last birth for these cohorts was approximately 29.

[28] Completed fertility peaked around the birth cohorts of 1935. Our birth cohorts cover most of the increase in completed fertility for the cohorts born between 1920 and 1935 as well as 10 years of cohorts prior to the increase.

[29] In the EEI data, Maryland and Washington DC customers are always counted together, and North Carolina and South Carolina customers are often counted together. For consistency we have used these larger units of aggregation for all years, which yields 47 birth state groups.

and are reported in parentheses beneath the point estimates. Column 1 presents the unadjusted correlation between children-ever-born and exposure to electricity. Column 2 adds state- and year-of-birth fixed effects. Column 3 includes controls for the woman's race and education level, and column 4 includes her husband's education level (this reduces the sample to women who are currently married at the time of observation). We prefer the specifications that include birth-state and birth-year fixed effects (columns 2 to 4), as they rely upon within-state variation in the speed of electrification to estimate δ. In contrast to the hypothesized positive link between the state of household technology and completed fertility, cohorts born into states with higher rates of electrification in their early adult years had fewer children on average. Regardless of specification, the inclusion of covariates has a negligible impact on the magnitude of the point estimates of interest. Overall, the estimates in table 5 provide compelling evidence that the "state of household technology," as embodied in electrification, is not positively associated with completed fertility.

In summary, empirical tests using disaggregated data with the best available measures of appliance ownership, electrification, and the general fertility rate provide no evidence that advances in household technology caused the baby boom. After controlling for a host of observable characteristics and fixed effects, the point estimates are negative or small in magnitude (table 2, 3, and 4). Moreover, the negative relationship between exposure to electricity in young adulthood and completed fertility—the closest empirical test of the mechanism proposed in GSV's model—also fails to support the claim that advances in household technology caused the baby boom (table 5).

6. Outen the Lights: The Amish Baby Boom

A final test of the household-productivity hypothesis investigates fertility change among a group that limited its use of modern household conveniences and generally refused to adopt appliances powered by electricity: the Old Order Amish.[30] In 1963 sociologist John Hostetler wrote, "Custom is regional and therefore not strictly uniform. The most universal of all Amish

[30] The Amish began settling in Pennsylvania in the early 1700s and later settled in parts of Ohio, New York, Indiana, Illinois, and Ontario. For background on the Amish, see Hostetler (1963) or Nolt (1992).

norms across the United States and Canada are the following: no electricity, telephones, central-heating systems, automobiles, or tractors with pneumatic tires…" (61). Although he also notes that some Amish had started to use gas-powered kitchen and farm equipment (305), it is clear that the Amish uptake of modern appliances was very limited and late in comparison to the U.S. farm and general populations.[31] If rapid improvements in the "state of household technology" were the main cause of the midcentury baby boom, and the Amish were not "treated" with these improvements, then one would expect an absence of the baby boom among the Amish. In this sense, Amish demographic history provides an independent test of the household-technology centered explanation of the baby boom.

Using information on the language spoken at home (Pennsylvania Dutch) in the 1980 and 1990 IPUMS (the only census years with information on language spoken at home and children ever born), we document changes in completed fertility among the Amish. The 5 percent 1980 and 1990 IPUMS samples contain information on 1,915 women ages 35 to 85 at the time of observation who spoke Pennsylvania Dutch at home. It is likely that most women speaking Pennsylvania Dutch at home in the late twentieth century were Amish, but we cannot observe religion directly in the census data and, therefore, we call this sample the "likely Amish." In addition, we generate a sample of "likely Old Order Amish" by excluding respondents who had telephones in their residence in 1980 or 1990.[32] This conservative approach also excludes women who followed the practices of the Old Order Amish during the 1940 to 1960 period (i.e., did not adopt new home production technologies) but who subsequently acquired a phone. This additional filter yields even smaller sample sizes (see data appendix table 1) and, therefore, the completed fertility of likely Old Order Amish can only be tracked in the census data for the most recent birth cohorts. For comparison groups, we create samples of ever-married women in the same birth cohorts who were residing on farms in Indiana, Ohio, and Pennsylvania (states with the largest Amish populations) and U.S. women not residing on farms. Unfortunately, the 2000

[31] Hostetler explains, "The social organization of the Amish community has little facility for dealing with change. The general effort to preserve the old and degrade the new is so pervasive that change must occur slowly…" (1963: 306).

[32] The Old Order Amish remain more conservative than some other Anabaptist groups who may also speak Pennsylvania Dutch. See Kraybill (1994) for discussion of splits within the Amish and differences across groups in appliance use in the 1990s in Holmes County, Ohio; see Umble (1994) for a discussion of phone use.

census did not ask about the number of children ever born, so the estimates for each of these groups only capture the upswing in fertility rates during the baby boom and very little of the baby bust.

Figure 3 plots the mean number of children ever born by birth cohort for these four groups. For each birth cohort, U.S. native, nonfarm residents have the lowest completed fertility rate, followed by women on farms in Indiana, Ohio, and Pennsylvania. The likely Amish women had higher levels of completed fertility than the non-farm population, as one might expect in an agrarian population. The likely Old Order Amish had the highest levels of completed fertility, having an average of almost two more children over their lifetimes. The key result of this analysis is that the fertility trends of the likely Amish track those in the two comparison groups quite closely. In a reversal of a long period of fertility decline, each of the groups in figure 3 – including the Amish – had large increases in completed fertility among the cohorts of women born after 1910. In the U.S. nonfarm sample and in the Indiana, Ohio and Pennsylvania farm sample, completed fertility increased by roughly one birth per woman from trough (1900-1909) to peak cohorts (1930-34). The likely Amish group had an increase of 0.75 births from 1910-19 to the peak 1935-39 cohort, and the likely Old Order Amish had an increase of 0.94 births from 1910-19 to the peak 1940-44 cohort (and a rise of 1.43 births between the 1890-1909 and 1940-44 cohorts). In short, the Amish had a baby boom that roughly began at the same time, lasted as long as, and matched the magnitude of the boom in the rest of the U.S. population.

These findings are not unique to the census data or due to problems with distinguishing the Amish population. Demographic studies of the Old Order Amish based on non-census sources (typically directories with genealogical information) corroborate these findings. Ericksen et al. (1979) compiled data from the four largest Amish settlements in the United States: Lancaster, Pennsylvania; Elkhart, Indiana; and Holmes and Geauga Counties, Ohio. Between the 1909-18 birth cohort of Amish women and the 1929-38 cohort, they document a decline in the proportion of childless women, a rise in age-specific marital fertility for 20-24 and 25-29 year olds, and a rise in cumulative marital fertility by about 0.6 children at age 35 (258-260). These findings correspond fairly closely to our census-based estimates. Markle and Pasco (1977) relied on the Indiana Amish Directory from 1971 to calculate period fertility rates.

Between 1935-39 and 1955-59, the average age at marriage for women in their sample fell from 22.8 to 20.8 years, and the average time between marriage and first birth declined. Between 1935-39 and 1960-64, they also document large increases in birthrates among women in their 20s (274, figure 1).[33] Most recently, Greska (2002) compiled data from a 1993 directory for the Amish settlement in Geauga, Ohio, including 1,337 women. Consistent with the studies above, he finds a dip in age at first marriage and age at first birth for the 1928-37 birth cohorts of women, and he finds a jump in fertility rates for women in their 20s from the 1928-37 birth cohorts relative to previous cohorts. Consistent with our estimates, he reports that the 1928-37 cohorts had a cumulative fertility rate that was 0.42 higher than the 1908-17 cohorts, and 0.49 higher than the 1918-27 cohorts (195-197). In summary, our census-based estimates are broadly consistent with an independent demographic literature, which also finds signs of a sizable increase in fertility among the Old Order Amish that is coincident with the general population's baby boom.

7. Conclusions

The mid-twentieth-century rise in fertility is a compelling puzzle not only because it was a dramatic departure from the previous 100 years of American demographic history, but also because it unfolded against a background of rising income, urbanization, educational attainment, infant health, and women's labor force participation—many of the factors that economists and demographers typically associate with *declining* fertility. Women who reached their childbearing years in the 1940s and 1950s (women born between 1920 and 1935) got married younger, bore their first child sooner, and had more children over their lifetimes than women born earlier in the century. Richard Easterlin's longstanding view of the baby boom (1961, 1980), which emphasizes the contrast between pre-war penury and post-war prosperity, has anchored the literature for decades, but there is no scholarly consensus about the baby boom's ultimate causes.

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[33] Markle and Pasco do not report the exact birthrate figures, but rather present a graph (1977: 274, figure 1). From their figure, we infer that the birthrate (divided by 1000) for women aged 20-24 increased from approximately 0.30 to 0.53, and for women 25-29 it increased from about 0.38 to 0.48. In earlier work, Smith (1960) studied the Amish in rural southeastern Pennsylvania. He also reports that birth spacing was significantly shorter for Amish women who married in the 1940s and 1950s compared to earlier cohorts (104).

Our goal in this paper is to provide a comprehensive evaluation of a novel household-productivity centered explanation of the baby boom (Greenwood, Seshadri, and Vandenbroucke 2005). This explanation uses the formal structure of modern, macroeconomic theory and calibration techniques to model the American baby boom within the context of the secular decline in fertility. Our analysis of a newly-compiled dataset for approximately 3,000 U.S. counties provides scant evidence that advances in household technology contributed to the baby boom. This does not appear to be an artifact of poor measurement of key variables such as the "state of household technology" or completed fertility. In fact, in a sample of over 900,000 women, within year-of-birth and state-of-birth cohort variation in exposure to electricity (a broad proxy for the "state of household technology") is *negatively* related to completed fertility, even after adjusting for differences in education and race (strong correlates of lifetime income). These findings are consistent with basic economic theory as long as child quantity is not assumed to be a normal good or advances of household technology are permitted to impact the demand for other home produced goods. One final piece of evidence is that the mid-century increase in fertility among the Amish suggests that the baby boom occurred among populations that were relatively unaffected by changes in electrification, modern appliances, the availability of frozen foods, and other advances in household technology. In combination with the paper's previous sections, which argue that neither theory nor history lend unqualified support for the household-productivity-centered view, this new empirical evidence calls scholars to look elsewhere for the baby boom's causes.

Although this paper concentrates on a single specific hypothesis, insights emerge that can inform broader research on demographic history and the baby boom. First, whatever factors explain the American baby boom must account for its occurrence in urban and rural areas, among different educational and racial groups, and in all regions. It was a remarkably pervasive event, and scholars should endeavor to explain the near simultaneity of baby booms in places and populations that varied widely in their social and economic circumstances. In this context, explanations centered on mass mobilization during World War II, on rapid suburbanization, or on changing norms and culture may not satisfactorily explain the nearly simultaneous occurrence of the baby boom among the Amish nor, perhaps, in several other countries. At the same time, we find that although the baby boom was widespread, the boom was not evenly spread, and the variation in changes in fertility invites analyses based on detailed cross-place and cross-household data. Both Easterlin's pioneering work and GSV's ambitious argument are based on national-level time-series patterns in the United States, but more disaggregated views may prove extremely valuable, and indeed necessary, for discerning among the many potential causes. In formulating new causal hypotheses, identifying "untreated" populations that provide effective falsification tests should prove useful. Based on the evidence we have seen, it seems unlikely that any monocausal explanation for the baby boom will suffice, but the question remains open.

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Table 1. Summary Statistics, U.S. County-Level Data

	1940	1950	1960
Infants per 1,000 women of age 15 to 44	79.9	105.6	120.1
	(17.4)	(17.5)	(20.2)
Proportion of housing units with electric lights	55.0	85.0	---
	(24.7)	(13.0)	
Proportion of housing units with a mechanical refrigerator	27.1	67.7	---
	(14.8)	(16.2)	
Proportion of housing units with a modern stove (using gas or electricity as fuel)	23.0	54.5	87.5
	(22.5)	(24.0)	(13.3)
Proportion of housing units with a power-driven washing machine	---	---	78.3
			(12.3)

Notes: The table reports unweighted averages across U.S. counties (excluding Hawaii and Alaska). Standard deviations are in parentheses. Counties that are omitted from table 2's regressions are also excluded in this table, but this has little effect on the reported figures. Sources: Infants per woman, proportion of homes with lights (in 1940), refrigerators, and washing machines are from Haines (2004). We compiled data on electric lighting in 1950 and stoves in all years from the published volumes of the Census of Housing (U.S. Department of Commerce 1943, 1953, 1963). See data appendix for more information about the dataset.

Table 2. Cross-Sectional Regressions of Fertility on Appliances in U.S. Counties, 1940-1960

	Dependent Variable: General Fertility Rate		
	(1)	(2)	(3)
Panel A: 1940			
Percent with refrigerator	-0.689	-0.665	0.017
	[0.056]	[0.067]	[0.050]
Observations	3034	3034	3034
R-squared	0.34	0.50	0.63
Percent with modern stove	-0.427	-0.409	0.029
	[0.033]	[0.038]	[0.034]
Observations	3034	3034	3034
R-squared	0.30	0.48	0.63
Panel B: 1950			
Percent with refrigerator	-0.402	-0.483	-0.401
	[0.056]	[0.057]	[0.104]
Observations	3031	3031	3031
R-squared	0.14	0.38	0.48
Percent with modern stove	-0.193	-0.246	0.004
	[0.036]	[0.033]	[0.049]
Observations	3031	3031	3031
R-squared	0.07	0.35	0.47
Panel C: 1960			
Percent with washing machine	-0.132	-0.284	0.068
	[0.141]	[0.167]	[0.069]
Observations	3022	3022	3022
R-squared	0.01	0.29	0.44
Percent with modern stove	-0.230	-0.433	-0.309
	[0.105]	[0.081]	[0.113]
Observations	3022	3022	3022
R-squared	0.02	0.32	0.45
State fixed effects	No	Yes	Yes
Economic and demographic controls	No	No	Yes

Notes: Each point estimate is from a separate regression corresponding to equation 3. The dependent variable is the number of infants (under 1 year) per thousand women ages 15 to 44. A "modern stove" is defined to use electricity or gas (not wood, coal, or kerosene). The unit of observation is a county. Heteroskedasticity-robust standard errors have been corrected for correlation at the state level and are reported in brackets. The covariates in column 3 include the urban proportion of the county's population, log population density, nonwhite proportion of the county's population, proportion of employment in agriculture and manufacturing (separately), median years of schooling for those over age 24, log of median property value, and the proportion of women in the labor force. The 1950 and 1960 specifications also control for log median family income (this variable is unavailable in 1940). The urban variable generally measures the proportion of the population residing in incorporated places with more than 2,500 residents. The density measure is the log of residents per square mile. Nonwhite includes black and "other" racial categories. The proportion of workers employed in agricultural and manufacturing industries are expressed relative to total employment. The percent of women in the labor force is the ratio of all women in the labor force divided by the number of women over age 14. The median schooling variable in the 1940 table is for women, whereas in 1950 and 1960 it is for both men and women. Observations with missing values for any economic or demographic control variable are dropped to maintain a consistent sample across specifications. Sources: Data for refrigerators, washing machines, and covariates are from Haines (2004). Data on the type of cooking fuel, which are used to define "modern stoves," were entered from the published Census of Housing volumes (U.S. Department of Commerce 1943, 1953, 1963).

Table 3. Differenced Regressions of Fertility on Appliances in U.S. Counties, 1940-1960

	Dependent Variable: Change in General Fertility Rate		
	(1)	(2)	(3)
Panel A: Refrigerators 1940-50			
Δ Percent with refrigerator	-0.007	-0.214	-0.101
	[0.099]	[0.089]	[0.094]
Observations	3023	3023	3023
R-squared	0.00	0.20	0.28
Panel B: Modern stoves, 1940-60			
Δ Percent with modern stove	-0.231	-0.298	-0.088
	[0.052]	[0.047]	[0.049]
Observations	2990	2990	2990
R-squared	0.04	0.29	0.42
Panel C: Modern stoves, 1950-60			
Δ Percent with modern stove	-0.201	-0.185	-0.044
	[0.035]	[0.043]	[0.053]
Observations	2990	2990	2990
R-squared	0.04	0.16	0.24
State fixed effects	No	Yes	Yes
Economic and demographic controls	No	No	Yes

Notes: Each point estimate is from a separate regression corresponding to equation 4. The dependent variable is the change in the number of infants (under 1 year) per thousand women ages 15 to 44 between two census years at the county-level. Heteroskedasticity-robust standard errors have been corrected for correlation at the state level and are reported in brackets. The covariates in column 3 include the change in urban proportion of the county's population, the change in log population density, the change in nonwhite proportion of the county's population, the change in proportion of employment in agriculture and manufacturing (separately), the change in median years of schooling for those over age 24, the change in log of median property value, and the change in the proportion of women in the labor force. Urban, density, nonwhite, employment and labor force variables are defined as in table 2's notes. In this table, for better comparability with the variables available in 1950 and 1960 (which include both men and women), the schooling variable in 1940 is the average of the median schooling values for men and women. When necessary, observations with missing values are dropped to maintain a consistent sample across specifications.

Sources: Data for refrigerators, washing machines, and covariates are from Haines (2004). Data on the type of cooking fuel were entered from the published census volumes in each year as described in the data appendix.

Table 4. Regressions of Period Fertility on Electrical Service, 1940-1950

	Dependent Variable: General Fertility Rate		
	(1)	(2)	(3)
Panel A: Fertility cross section, 1940			
Percent with electric lights	-0.410	-0.515	-0.171
	[0.034]	[0.034]	[0.053]
Observations	3034	3034	3034
R-squared	0.34	0.55	0.64
Panel B: Fertility cross section, 1950			
Percent with electric lights	-0.506	-0.553	-0.375
	[0.072]	[0.047]	[0.083]
Observations	3031	3031	3031
R-squared	0.14	0.40	0.48
Panel C: Fertility change, 1940-1950			
Δ Percent with electric lights	-0.275	-0.327	-0.182
	[0.044]	[0.042]	[0.054]
Observations	3023	3023	3023
R-squared	0.08	0.24	0.29
State fixed effects	No	Yes	Yes
Economic and demographic controls	No	No	Yes

Notes and sources: See table 2. We compiled the data for electric lights in 1950 from the published volumes of the Census of Housing (U.S. Department of Commerce 1953); the 1940 electric light data are from Haines (2004).

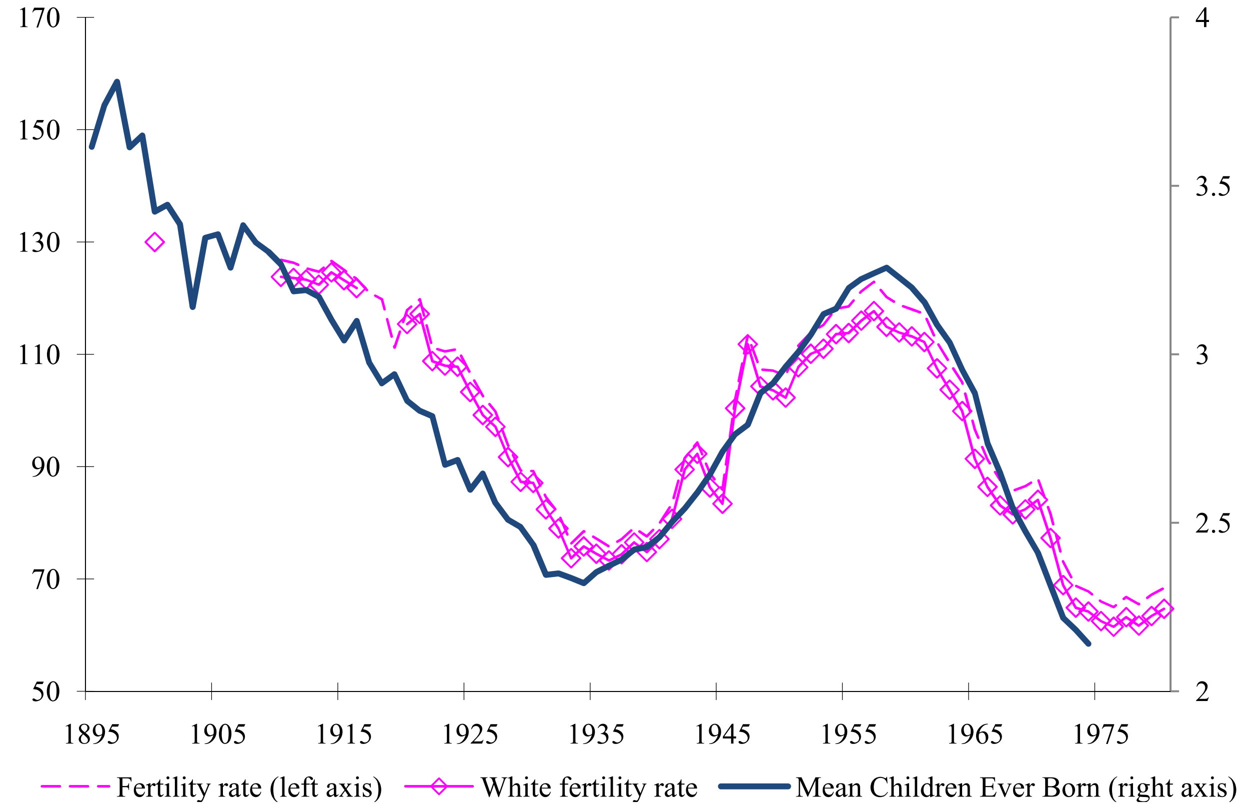
Table 5. Regressions of Children-Ever-Born on Exposure to Electrical Service

	Dependent Variable: Children Ever Born			
	(1)	(2)	(3)	(4)
Exposure to electricity x 100	-0.008	-0.008	-0.008	-0.008
	[0.002]	[0.002]	[0.002]	[0.002]
State of birth f.e.	No	Yes	Yes	Yes
Year of birth f.e.	No	Yes	Yes	Yes
Race and education	No	No	Yes	Yes
Husband's education	No	No	No	Yes
Observations	1034	1034	1034	1034
R-squared	0.877	0.880	0.880	0.881

Notes: The dependent variable is the mean self-reported children-ever-born to ever married women. Observations are birth state-birth year cells. Heteroskedasticity-robust standard errors have been corrected for correlation by birth state and are reported in brackets. The numerator for "mean exposure to electricity" in a given state-year cell is constructed from Edison Electrical Institute (EEI) *Statistical Bulletin* which contains annual state-level information on the number of residential electrical customers from 1925 to 1960. In the EEI data, Maryland and Washington DC customers are always counted together. North Carolina and South Carolina customers are often counted together. For consistency we have used these larger units of aggregation for all years. To calculate the denominator, we use the housing unit count from the census (interpolated between dates). "Exposure to electricity" is calculated as the mean of this proportion over the peak child-bearing years (15 to 29) for each year-of-birth and birth state cohort (and multiplied by 100). The sample includes women born from 1910 to 1931 (22 cohorts) and 47 geographic units for 1034 observations.

Sources: Edison Electric Institute *Statistical Bulletin* (various years) and 1960-1990 IPUMS (Ruggles et al. 2006).

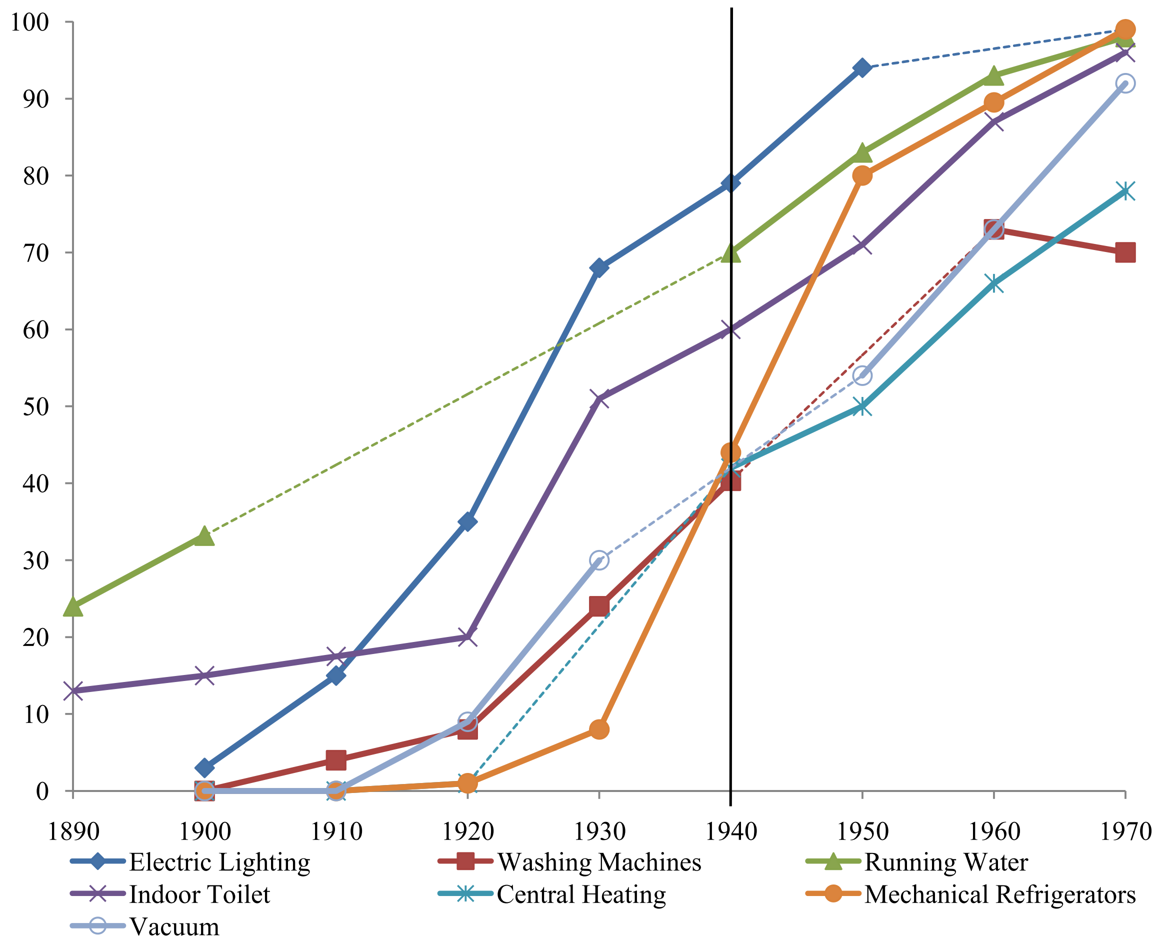
Figure 1. U.S. General Fertility Rate and Children Ever Born from 1895 to 1985



Notes: The outcome variables are the period fertility rate and the mean self-reported number of children by birth cohort. Birth cohorts are indexed to year of birth and increased by 25 years. For instance, the birth cohort of 1870 corresponds to the year 1895 on the graph's horizontal axis. Computations using the IPUMS use population weights.

Sources: Annual fertility rates are calculated using Historical Statistics, http://www.cdc.gov/nchs/data/statab/t001x01.pdf. The mean number of children ever born per woman is calculated using a sample of ever-married women ages 41 to 70 in the 1950, 1960, 1970, 1980 and 1990 IPUMS (Ruggles et al. 2008)

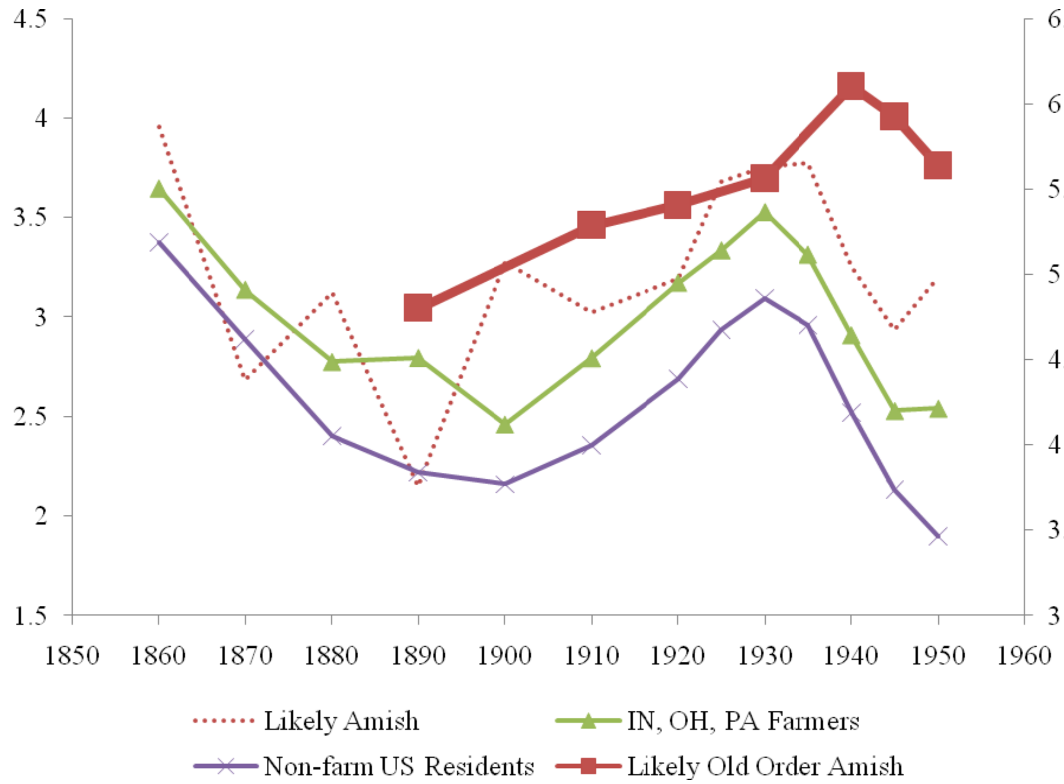
Figure 2. Proportion of Households with Modern Household Technology, 1890-1970



Note: Dashed lines indicate linear interpolation between data points.

Source: Lebergott (1976: 260-288).

Figure 3. Mean Children Born to Amish and Other Women Born from 1860-1954



Notes: The horizontal axis represents the birth-cohort of the women, which are grouped into five or ten-year categories to maintain informative samples sizes (see data Appendix for more information). The sample is comprised of ever-married women ages 35 to 85 at the time of observation. The “likely Amish” sample consists of women reporting that they speak Pennsylvania Dutch at home. The “likely Old Order Amish” sample is the subsample of the likely Amish who do not have phones in their residence (1980-1990 IPUMS). The “likely Old Order Amish” are plotted on the right vertical axis; the other series are plotted on the left vertical axis. See text and data appendix for more information.

Source: 1980-1990 *IPUMS* (Ruggles et al. 2008).

Theory Appendix

Consider a static version of the GSV model's maximization problem, where households enjoy utility from consuming children, N, and a composite of other goods purchased on the market, Z (price normalized to 1). Nonlabor income is given by I, and w is the market wage. Children are produced using some fraction of an individual's time and their shadow price is given by $p_N = \frac{w}{A}$. Thus, advances in household technology increase A and reduce the shadow price of children, p_N. In this framework, the household's problem can be written as

$$(A1) \qquad max_{Z,N}\left\{U(Z) + Q(N): Z + \frac{w}{A}N = w + I\right\},$$

and optimality implies that

$$(A2) \qquad Q'(N) = \frac{w}{A}U'(Z).$$

Under the common assumptions that $U''(Z) < 0$ and $Q''(N) < 0$, differentiating (*A2*) with respect to I (while holding the relative price of children fixed),

$$(A3) \qquad \frac{dN}{dI} = \frac{w}{A}U''(Z)\left[\left(\frac{w}{A}\right)^2 U''(Z) + Q''(N)\right]^{-1} > 0,$$

shows that this framework implicitly assumes that child quantity is a normal good. It follows from the logic in equation (1) of the paper that a change in the state of household technology, A, which induces a reinforcing substitution and (because children are a normal good) income effect, has an unambiguously positive impact on the number of children. This can be shown directly by differentiating (*A2*) and reorganizing,

$$(A4) \qquad \frac{dN}{dA} = -\frac{w}{A^2}\left[U'(Z) - \frac{w}{A}U''(Z)N\right]\left[\left(\frac{w}{A}\right)^2 U''(Z) + Q''(N)\right]^{-1} > 0.$$

Data Appendix

County-level data

Data for infants per woman aged 15 to 44 and for the proportions of homes with lights (in 1940), refrigerators (in 1940 and 1950), and washing machines (1960) are from the files compiled by Michael Haines (2004). Specifically, files "32: 1940 Census I", "33: 1940 Census II", and "70: 1947 County Data Book" provide demographic and economic data for 1940. Files "35: 1950 Census I", "36: 1950 Census II", "72: 1952 County Data Book" and "73: 1956 County Data Book" provide data for 1950. Files "39: 1960 Census II", "40: 1960 Census III", "74: 1962 County Data Book", and "75: 1967 County Data Book" provide data for 1960. In 1950 and 1960 the housing appliance data are based on subsamples of the full population.

We typed in the data for electric lights in 1950 and for cooking fuel in 1940, 1950, and 1960 from the published volumes of the *Census of Housing*, and combined that information with the data from Haines (2004) described above. For 1940, the cooking fuel figures are from Volume 2, Table 23 (for each state) of the *Census of Housing*. For 1950, the lighting and cooking fuel figures are from Volume 1, Table 27 (for each state) of the *Census of Housing*. For 1960, the cooking fuel figures are from Volume 1, Tables 16 and 29 of the *Census of Housing*.

The proportion of homes with "modern stoves" is the ratio of the number using electricity, utility gas, or bottled gas for the principal cooking fuel divided by the total number of units that report the cooking fuel variable; implicitly, we define those using wood, coal, kerosene, "other", or no fuel as "not modern." The "mechanical refrigerator" variable pertains to any type of refrigeration equipment powered by electricity, gas, kerosene, or gasoline; this is distinct from an "ice box." The "washing machine" variable that is reported in the Haines files for 1960 includes "automatic and semi-automatic" washing machines that wash, rinse, and damp dry the laundry; "washer-dryer combination" machines that wash, rinse, and fully dry the clothes in the same tub; and power-operated "wringer or spinner" machines.

We made the following adjustments to the data from Haines (2004):

- In 1940, the proportion of housing units with refrigerators in Raleigh County, West Virginia should be 41.8 percent, and the proportion in Washington, DC should be 79.1 percent. The median years of schooling for women and men in Cooke County, Texas should be 8.9 and 8.3 respectively. The county code for Warwick, Virginia is adjusted in 1940 to facilitate merger across datasets.

- In 1950, approximately 40 counties with missing values for refrigerators in the 1952 County Data Book (underlying the Haines data) are listed as zeros in the Haines files. We referred back to the original Census volumes to fill in the correct figures when possible, or to set the value to "missing" if unavailable in the Census (replacing zero). Separately, the proportion of housing units with refrigerators in Washington, DC should be 92.0.
- In 1960, the figure for washing machines in Lee County, Kentucky should be 73.2 percent according to the 1962 County and City Data Book. The median property value in Milam County, Texas should be $5,400.
- For 1930, we combined the counts for infants and women in Fulton, Milton, and Campbell counties in Georgia to be comparable with subsequent years (1930 fertility is used as a control variable in some regressions).
- Partial county entries for Yellowstone National Park are dropped from the analysis, as are counties/territories in Hawaii and Alaska.

Matching counties over time is imperfect due to occasional mergers and changes in boundaries. Excluding counties with reported changes of more than 5 square miles does not change the qualitative results from tables 3 and 4. The coefficient in panel A, column 3 (refrigerators, 1940-50) increases in magnitude from -0.101 (s.e.=0.094) to -0.121 (s.e.=0.091); the coefficient in panel B, column 3 (stoves 1940-1960) falls in magnitude from -0.088 (s.e.=0.049) to -0.076 (s.e.=0.050). The coefficient change for electric lighting (1940-50) in table 4 is from -0.182 to -0.187 (s.e.=0.054 in both cases).

In 1960, approximately 15 percent of counties have a bottom code for median property values of $5,000 in the census data. The results in the text are not sensitive to resetting these observations to $3,750 (75% of 5,000). In table 2, panel C, column 3, the coefficient on washing machines falls from 0.068 to 0.057 (s.e.=0.069 in both cases); the coefficient on modern stoves falls from -0.309 (s.e.=0.113) to -0.327 (s.e.=0.116). In table 3, panel B, column 3, the coefficient on modern stoves (1940-60) falls from -0.088 to -0.093 (s.e. = 0.50 in both cases); in panel C, column 3, the coefficient on modern stoves (1950-60) increases from -0.044 to -0.043

(s.e. = 0.053 in both cases).

State-level, annual electricity data

The numerator for the "mean exposure to electricity" variable is constructed from the Edison Electrical Institute (EEI) publication, *Statistical Bulletin*. The *Bulletin* provides annual state-level reports of the number of residential electrical customers from 1925 to 1960. In the EEI data, Maryland and Washington DC customers are always counted together. North Carolina and South Carolina customers are often counted together, and for consistency we used these larger units of aggregation for all years.

To calculate the denominator, we used the housing unit counts from the census, which we interpolated between dates with constant growth rates. Then, we divided the EEI customer counts by the Census of Housing counts of families (in 1920 and 1930) or occupied dwelling units (in 1940, 1950, and 1960) in each state to estimate the proportion of families with electrical service. The figures for the denominator are consistent with the housing unit counts in *Historical Statistics of the United States* (Carter et al., 2006). Kenneth Snowden discusses the comparability of housing count data across census years in Volume 4 of *Historical Statistics* (4-500 and 4-501): "Before 1940 the census enumerated "families" and not housing unit…. However, the two concepts are closely related: a census family was defined in 1930 as a single person living alone, a small group of unrelated persons sharing living accommodations, or, more normally, a group of related persons who live together as one household. Despite differences in terminology, therefore, the basic notion of a family, dwelling unit, or housing unit has provided essentially comparable measures of the residential housing stock since 1890."

On occasion, the ratio of residential customers from EEI to housing units from the Census slightly exceeds unity (in approximately 10 percent of state-year cells from 1925 to 1960). Nearly all such cases (84 percent) occur between 1950 and 1960 when the true rate of electrification is likely to be close to 100 percent for some states. We have left these values in place rather than making *ad hoc* adjustments to the underlying data.

Data Appendix Table 1: Summary Statistics for the Likely Amish Samples

Birth Cohort	Likely Amish	Likely Old Order Amish	Farm residents in IN, OH, PA	Non-farm U.S. residents
1860-69	3.957		3.648	3.379
	[23]		[141]	[6,204]
1870-79	2.686		3.139	2.891
	[35]		[331]	[12,410]
1880-89	3.121		2.777	2.406
	[33]		[471]	[15,878]
1890-99	2.151	4.801*	2.797	2.219
	[55]	[26]	[657]	[103,576]
1900-09	3.279		2.462	2.161
	[186]		[1,388]	[449,257]
1910-19	3.024	5.289	2.795	2.356
	[348]	[52]	[2,669]	[898,851]
1920-24	3.194	5.408	3.174	2.691
	[154]	[68]	[1,938]	[571,826]
1925-29	3.680		3.337	2.937
	[168]		[2,047]	[589,945]
1930-34	3.755	5.564	3.529	3.098
	[141]	[113]	[1,998]	[559,390]
1935-39	3.777		3.316	2.961
	[115]		[1,944]	[569,243]
1940-44	3.255	6.230	2.910	2.521
	[118]	[89]	[1,981]	[679,530]
1945-49	2.939	6.104	2.530	2.134
	[98]	[47]	[1,079]	[493,112]
1950-54	3.201	5.639	2.541	1.899
	[82]	[70]	[896]	[488,013]
Column total	3.194	5.639	2.980	2.533
	[1,556]	[465]	[17,540]	[5,437,235]

Notes: The table entries represent the mean number of children ever born, and the figures in brackets are the cell sample sizes. Birth cohorts are grouped into five or ten-year categories to maintain informative samples sizes. *The cohort labeled 1890-99 for the likely Old Order Amish corresponds to the 1890 to 1909 cohort. The younger cohorts of the likely Old Older Amish are grouped into ten year cohorts, so the cohorts labeled 1920-24 and 1930-34 correspond to the ten-year groupings 1920-29 and 1930-39, respectively. For sample definitions and source information, see text and figure 3 notes.