Online Appendix for “Do Highly Educated Women Choose Smaller Families?”

Moshe Hazan Hosny Zoabi

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A Model's Extensions

Here we extend the basic model presented in the main text of the paper. We consider two separate extensions. The first extension is conducted to show that our model can account for the positive correlation between a mothers education and time spent with children observed in the data. The second extension incorporates husbands into our unitary household framework. The husbands time is optimally allocated between child-raising and labor supply. It turns out that including husbands and assuming positive assortative matching does not qualitatively change any of our results.

A.1 Mother-Teacher Complementarity in Human Capital Acquisition

The model analyzed in the main text is consistent with data about time allocated to the labor market and to home production (excluding childcare). However, it also suggests that a mother's time allocated to raising children decreases with the mother's education. This is because the increasing part of the U-shaped fertility pattern in our model is obtained from the availability of market services, which are relatively cheap for highly educated mothers. As discussed in the Introduction, Guryan et al. (2008) found that a mother's time allocated to childcare increases with the mother's education. As also discussed in the Introduction, however, Guryan et al. defined childcare as the sum of four primary time use components: “basic”, “educational”, “recreational”, and “travel”. Clearly, the educational and recreational components and part of the travel component are an investment in the children's quality, a component which, in our model, is bought in the market.

Ramey and Ramey (2010) reconcile the seemingly paradoxical allocation of time, according to which mothers with a higher opportunity cost of time spend more, rather than less time, with their children despite the availability of market substitutes. They argue that as slots in elite postsecondary institutions have become scarcer, parents responded by investing more in their children's quality so that they appear more desirable to college admissions officers. Since more educated parents spend more time on child quality as well as more income on market goods and services related to the child's quality it implies that parental time and market goods and services are strong complements in the production of the children's quality.

To capture this idea, we extend our model by assuming that a child's quality requires not only education bought in schools but also parental time. Thus, consistent with our notation, let child's education be

$$e_i = \left[(t^e_{SC})^\zeta + (t^e_M)^\zeta\right]^{1/\zeta}, \tag{A1}$$

where t^e_{SC} and t^e_M are the time invested in education provided by the school and parent, respectively; and $\zeta \in (-\infty, 0)$.[1]

To convey our idea with a simple example, we assume that there is perfect complementarity between school time and parental time invested in children's education. Formally we assume that $\zeta = -\infty$ and (A1) becomes $e_i = \min\{(t^e_{SC}), (t^e_M)\}$. This implies that at the optimum, for any unit of time provided by the school, a similar unit is provided by the parent in order to produce a unit of education:

$$e_i = t^e_{SC} = t^e_M, \tag{A2}$$

and the cost of education, equation (4), becomes:

$$TC^e_i = n_i p_e e_i = n_i(\bar{h} + h_i)e_i. \tag{A3}$$

Given this new price for quality of children in equation (A3), the price of quantity of children and consumption in equations (8) and (11), respectively, the solution to maxi-

[1] One may argue that more educated mothers and teachers are better able to produce educated children through tutoring. Formally, we can modify (A1) to: $e_i = \left[\bar{h}(t^e_{SC})^\zeta + h_i(t^e_M)^\zeta\right]^{1/\zeta}$, which yields the following cost function: $TC^e_i = n_i p_e e_i = n_i(\bar{h} + h_i)^{1-\frac{1}{\zeta}} e_i$. As will soon become apparent as ζ approaching $-\infty$, this solution coincides with the solution shown in equation (A3). More generally, for a sufficiently small ζ, the qualitative results presented in this section hold under this modification.

mizing (1) subject to the budget constraint, (2) becomes:

$$e_i = \frac{\theta \varphi \underline{h}^{1-\phi} h_i^{\phi} - \eta(\bar{h} + h_i)}{(\bar{h} + h_i)(1-\theta)}, \tag{A4}$$

$$n_i = \frac{h_i(1-\theta)}{2(\varphi \underline{h}^{1-\phi} h_i^{\phi} - \eta(\bar{h} + h_i))}. \tag{A5}$$

Notice that as in the basic model, the economic forces that are behind the U-shaped fertility pattern and the increasing relationship between parental education and children's education are still at work: the decreasing part in fertility is due to a lower share of income that is allocated for quantity and the increasing part is due to the greater use of babysitter services as parental education increases. Likewise, children's education is positively affected by the price of quantity relative to the price of quality. However, the price of quality is now increasing with the parent's education and, therefore, some additional conditions are necessary. Secondly, the positive relationship between parental education and children's education along with the complementarity between parental time and schooling time in producing a child's education implies that the time invested by parents also increases with the parents' education. Finally, the steepness of the relationship between parental education and parental time spent on children's education can be sufficiently high enough that it dominates the reduction in parental time allocated to raising children induced by the existence of market substitutes such as babysitters and childcare. In this case, the total time spent by parents on children increases with parental education. Deriving analytical conditions under which the total time spent on children is increasing with the mother's education is complicated, however, and, consequently, we illustrate the ability of the model to account for this empirical fact, while maintaining all of the desired results of the model using a numerical example.

Specifically, Figure A1 shows that fertility is U-shaped as a function of the mother's education and that the children's education can increase with the mother's education, even when the marginal cost of education is increasing with the mother's education. The figure also shows that the sum of time devoted to both quantity and quality by the mother, that is the total time allocated to childcare, is increasing with the mother's education. Finally, labor supply is increasing with the mother's education. Notice that the margin that allows parents to spend more time with their children and supply more hours to the labor market is the availability of housekeeping services, a service which

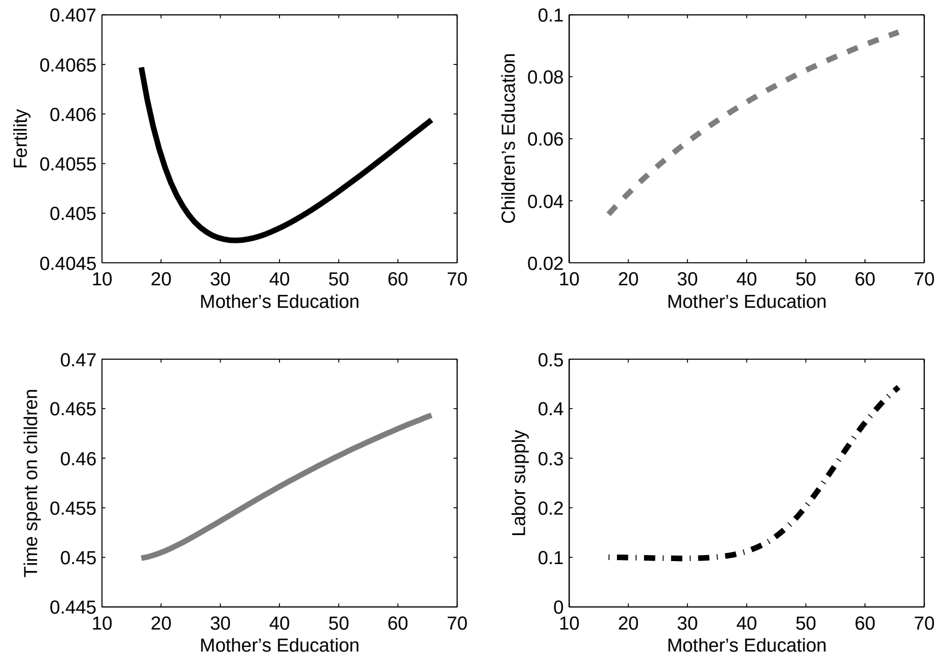

Fig. A1: *Numerical Example: fertility, children's education, mother's time spent of childcare and labor supply. Parameter values:* $\hat{h} = 16.67, \underline{h} = 25, \bar{h} = 50, \alpha = 0.9, \theta = 0.15, \phi = 0.985, \sigma = 0.9, \eta = 0.0105$.

highly educated mothers use more than mothers with lesser education.

A.2 A Two-Person Household

Here we extend our household to include not only mothers but also fathers. Generally, we would like to check the robustness of our results for including husbands into the household decision problem. Particularly, we would like to examine the extent to which husbands of more educated wives could substitute for their wives in raising children.

Formally, our household budget constraint given in (2) becomes

$$h_i + h_s = p_{ci}c_i + p_{ni}n_i + n_i p_{ei}e_i, \tag{A6}$$

where h_s is the human capital of the spouse (husband). We assume that husbands can also raise children and thus modify (5) to become

$$n = (t_M^n)^{\phi}(t_s^n)^{\lambda}(t_B^n)^{1-\phi-\lambda}, \qquad \phi, \lambda > 0\,;\; \phi + \lambda < 1,$$

where t_s^n is the time spent by the husband in raising children. Consequently, the cost function of raising n children becomes

$$TC^n(n, \underline{h}, h^i, h_s) = \min_{t_M^n, t_s^n, t_B^n} \{t_M^n h_i + t_s^n h_s + t_B^n \underline{h} : n = (t_M^n)^{\phi}(t_s^n)^{\lambda}(t_B^n)^{1-\phi-\lambda}\}.$$

The optimal levels of t_M^n, t_s^n and t_B^n are:

$$t_M^n = \frac{\phi^{1-\phi}}{\lambda^{\lambda}(1-\phi-\lambda)^{1-\phi-\lambda}} \frac{h_s^{\lambda}\underline{h}^{1-\phi-\lambda}}{h_i^{1-\phi}} n, \tag{A7}$$

$$t_s^n = \frac{\lambda^{1-\lambda}}{\phi^{\phi}(1-\phi-\lambda)^{1-\phi-\lambda}} \frac{h_i^{\phi}\underline{h}^{1-\phi-\lambda}}{h_s^{1-\lambda}} n \tag{A8}$$

and

$$t_B^n = \frac{(1-\phi-\lambda)^{\phi+\lambda}}{\lambda^{\lambda}\phi^{\phi}} \frac{h_i^{\phi}h_s^{\lambda}}{\underline{h}^{\phi+\lambda}} n. \tag{A9}$$

Dividing (A7) by (A8) we get $t_M^n/t_s^n = (\phi/\lambda) \cdot (h_s/h_i)$. This reflects the substitutability between the spouses as a result of changes in relative opportunity cost of time. Notice that an increase in h_j, $j = \{i, s, B\}$ leads to a decrease in j's time spent on childcare and to an increase in the time spent on childcare by $-j$. Cherchye et al. (2012) found similar results in a collective model in which each spouse allocates his or her time to work, leisure, home production, and childcare.

A stylized fact of the marriage market is assortative matching on socioeconomic backgrounds such as parental wealth (Charles et al. 2013) and spousal education (Pencavel 1998). To keep our model simple, we abstract from the marriage market and assume that h_i and h_s are positively correlated. An extreme example would compare two couples whose h_i and h_s is the same up to a multiplicative constant. As evident from the above discussion, the ratio of time spent on raising children would be the same between the two couples. However, as apparent from (A9), the richer couple would allocate less time for raising children and purchase more babysitting services. More generally, without making strong assumptions about the distributions of h_i and h_s and how exactly women and men are matched, our model cannot say much about the relationship between women's human capital and the time spent on childcare of mothers vis-a-vis the fathers. Nevertheless, a positive correlation between h_i and h_s is sufficient to ensure that mothers with higher human capital will purchase more babysitting services. In Section 4.2 we provide direct evidence on purchases of childcare services and show that it monotonically increases with mothers' education.

Equations (A7), (A8) and (A9) can be combined to yield the cost function:

$$TC^n(n, \underline{h}, h^i) = p_{ni}n = \pi \underline{h}^{1-\phi-\lambda} h_i^{\phi} h_s^{\lambda} n, \tag{A10}$$

where $\pi \equiv (\phi^{\phi}\lambda^{\lambda}(1-\phi-\lambda)^{1-\phi-\lambda})^{-1}$.

Notice that when λ approaches zero, (A7), (A9) and (A10) collapse to (6), (7) and (8), respectively.

Incorporating the new price of quantity, p_{ni} into the household's optimization problem yields

$$e_i = \frac{\theta \pi \underline{h}^{1-\phi-\lambda} h_i^{\phi} h_s^{\lambda} - \eta \bar{h}}{\bar{h}(1-\theta)}, \tag{A11}$$

$$n_i = \frac{(h_i + h_s)(1-\theta)}{2(\pi \underline{h}^{1-\phi-\lambda} h_i^{\phi} h_s^{\lambda} - \eta \bar{h})}, \tag{A12}$$

Notice that equations (A11) and (A12) reveal that the human capital of both spouses appears in a similar manner in the optimal solution of e_i and n_i. Thus, the inclusion of the husbands does not change the qualitative solution of the model. As in the basic model, education monotonically increases with mothers' human capital, but now it also increases with the fathers' human capital. Similarly, the U-shaped fertility pattern is preserved with respect to the mothers' human capital. Finally, assuming assortative matching, the U-shaped pattern is preserved when comparing couples with different human capital.

B Additional Regression Results

In this section we display a number of additional regression results as a check of the robustness of the main results presented in the paper. Table A1 displays regression results analogous to those in Table 1 using probit regression. The results are qualitatively and quantitatively similar to the linear probability results displayed in the main text.

Table A2 addresses two potential problems in the results presented in Table 2, where we regress a dummy indicating the occurrence of a birth on the average labor cost in the child daycare services industry, relative to a woman's wage. First, the fact that wages are observed only for working women raises a selection bias problem. Secondly, the wage we observe may be endogenous to the decision to have a baby. For example, the hourly wage during the year a woman gives birth may be lower than her wage in other years because of a weaker attachment to the labor market or poorer health due to the pregnancy.

Each column in Table A2 repeats the specification in Column 7 of Table 2, but uses a different measure for w_{ist} to overcome the selection bias and endogeneity problems. Mulligan and Rubinstein (2008) found that selection into the female workforce was positive since the 1990s. Accordingly, we correct for the selection bias problem by assigning a lower wage for non-working women than for working women, conditional on their characteristics. To overcome the endogeneity problem, we predict wages for all women using a standard Mincerian regression. The regressors are years of schooling dummies, age dummies, and state dummies. We estimate the parameters of the wage regression for each year separately because returns to characteristics, such as female experience, have changed over the period 1983-2012 (Olivetti 2006).

In Column 1 in Table A2 we take care of the endogeneity of wages by using predicted wages for all women. The coefficient on the relative cost of childcare is very close to the one obtained in Column 7 in Table 2. In Column 2 of Table A2 we use wages for women who reported positive labor income and the predicted wages for women who did not report labor income. The coefficient of the relative cost of child care is negative and highly significant, although it is somewhat smaller. In Column 3 we take care of the selection bias problem by predicting wages for women who did not report labor income using a 25^{th} quantile regression, while using wages for women who report labor income.[2] As can be seen, the coefficient on the relative cost of childcare is negative, highly significant, and almost identical to the coefficient in Column 2. Finally, in Column 4 we take care of the selection bias and endogeneity problem. We do so by predicting wages using a median regression for women who report positive labor income while predicting wages

[2] We use the same regressors and estimate the parameters of the wage regression for each year separately.

Table A1

The association between giving a birth and women's education: 2001-11

	(1)	(2)	(3)	(4)	(5)	(6)
High School Graduates	0.206***	-0.012	-0.149***	-0.149***	-0.156***	
	(0.015)	(0.011)	(0.013)	(0.013)	(0.013)	
Some College	0.240***	0.021	-0.186***	-0.189***	-0.199***	
	(0.015)	(0.012)	(0.015)	(0.015)	(0.014)	
College Graduates	0.366***	0.080***	-0.119***	-0.122***	-0.134***	
	(0.016)	(0.013)	(0.018)	(0.018)	(0.017)	
Advanced Degrees	0.423***	0.106***	0.009	0.005	-0.008	
	(0.018)	(0.011)	(0.017)	(0.017)	(0.016)	
Number of children	0.015***	-0.099***	-0.072***	-0.073***	-0.074***	-0.168***
	(0.004)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
Female earnings: Q1						-0.171***
						(0.010)
Female earnings: Q2						-0.355***
						(0.012)
Female earnings: Q3						-0.376***
						(0.009)
Female earnings: Q4						-0.282***
						(0.008)
Spouse earnings						0.116***
						(0.007)
Other income						0.014*
						(0.007)
Martial Status	No	Yes	Yes	Yes	Yes	–
Age	No	No	Yes	Yes	Yes	Yes
Year	No	No	No	Yes	Yes	Yes
State	No	No	No	No	Yes	Yes
Obs.	4,046,532	4,046,532	4,046,532	4,046,532	4,046,532	2,166,054

NOTE. Probit models. Women aged 15-50. All models are weighted by ACS sampling weights. The main regressors in Columns 1-5 are education dummies and the omitted group is high school dropouts. Column 6 focuses instead on female earnings. The omitted group is women without labor income and Q1-4 corresponds to the four quartiles of the earnings distribution. Robust standard errors adjusted for heteroscedasticity are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

for non-working women using a 25th quantile regression. The coefficient on the relative cost of child care is negative, highly significant, and very close to the coefficients in Columns 2 and 3.

C Estimating Fertility Rates Using Age of Youngest Child

In Section 2.3 in the main text, we estimate hybrid fertility rates for 1980, 1990 and 2000 using age-specific fertility rates that were inferred from the age of youngest own child in household. Here we show the reliability of this measure in the ACS data which contains the response to both questions. The correlation between the resulting two sets of estimates for the age-specific fertility rates is larger than 0.99 for all five educational groups. However, the age-specific fertility rates based on the age of the youngest own child in the household are systematically lower than those presented in Figure 1. More importantly, the gap between the series is larger at younger ages. Although we do not have a good explanation for this phenomenon, this problem is less severe when we estimate the hybrid measure of fertility. Figure A2 presents two estimates of hybrid fertility rates for the period 2001-2011. The estimate labeled "hybrid based on fertyr" is the one reported in Figure 3, while the estimate labeled "hybrid based on yngch" is the estimate based on the age of the youngest own child in the household. As can be seen from the figure, there exists a gap between the two series but it is almost constant across the educational groups.

Table A2

The association between giving a birth and childcare relative cost: 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)
Childcare relative cost	-0.035***	-0.024***	-0.023***	-0.020***
	(0.002)	(0.001)	(0.001)	(0.002)
Number of children	-0.018***	-0.019***	-0.018***	-0.018***
	(0.001)	(0.001)	(0.001)	(0.001)
Total Personal Income	-0.061***	-0.089***	-0.095***	-0.063***
	(0.003)	(0.004)	(0.004)	(0.003)
Total Personal Income^2	0.016***	0.020***	0.022***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
Spouse's Wage	0.519***	0.499***	0.543***	0.627***
	(0.037)	(0.035)	(0.035)	(0.034)
Obs.	418,347	418,347	418,347	418,347
R^2	0.079	0.080	0.079	0.078

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. Childcare relative cost is the log of the average wage in the child daycare services, varied at the state-year level, relative to the woman's wage. Column (1) uses predicted wages for all women. Column (2) uses own wages for women who reported positive wages and predicted wages for those who did not. Column (3) uses own wages for women who reported positive wage and predicted wages from a 25^{th} quantile regression for those who did not. Column (4) uses predicted wages from a median regression for working women and from a 25^{th} quantile regression for those who did not. All models include age, year, and state dummies. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. See note to Table 2 for further details.

Table A3

The association between giving a birth and childcare relative cost: 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1983-85	1986-88	1989-91	1992-94	1995-97	1998-00	2001-03	2004-06	2007-09	2010-12
Childcare relative cost	-0.021***	-0.017**	-0.027***	-0.017***	-0.025***	-0.025***	-0.034***	-0.035***	-0.038***	-0.025***
	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.002)	(0.005)	(0.004)	(0.005)
Number of children	-0.018***	-0.019***	-0.019***	-0.018***	-0.017***	-0.018***	-0.014***	-0.020***	-0.021***	-0.020***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Total Personal Income	-0.178***	-0.144***	-0.145***	-0.127***	-0.076***	-0.068***	-0.081***	-0.069***	-0.066***	-0.028**
	(0.017)	(0.011)	(0.012)	(0.018)	(0.008)	(0.010)	(0.007)	(0.009)	(0.009)	(0.008)
Total Personal Income^2	0.147***	0.107***	0.104***	0.124***	0.030***	0.021***	0.022***	0.016***	0.020***	0.005**
	(0.021)	(0.014)	(0.017)	(0.024)	(0.005)	(0.005)	(0.002)	(0.003)	(0.003)	(0.002)
Spouses' wage	0.354**	0.697***	0.331*	0.874***	0.690***	0.671***	0.384***	0.398***	0.404***	0.425***
	(0.113)	(0.110)	(0.143)	(0.138)	(0.099)	(0.133)	(0.073)	(0.095)	(0.096)	(0.100)
Obs.	40,058	40,094	40,645	39,695	35,173	31,445	55,444	50,287	45,764	40,974
R^2	0.074	0.075	0.076	0.074	0.078	0.077	0.073	0.092	0.097	0.095

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. All models include age, year, and state dummies. Wages are predicted from a median regression for working women and from a 25th quantile regression for those who do not. All models include age, year and state dummies. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A4

The association between giving a birth and women's education: 2001-11. 15 states with infertility insurance laws

	(1)	(2)	(3)	(4)	(5)	(6)
	birth	birth	birth	birth	birth	birth
High School Graduates	0.017***	-0.002	-0.010***	-0.011***	-0.011***	
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	
Some College	0.019***	0.001	-0.012***	-0.013***	-0.013***	
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	
College Graduates	0.032***	0.008**	-0.006	-0.007	-0.008*	
	(0.003)	(0.002)	(0.004)	(0.004)	(0.003)	
Advanced Degrees	0.043***	0.015***	0.008*	0.007*	0.006	
	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	
Number of children	0.001	-0.015***	-0.012***	-0.012***	-0.012***	-0.020***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Female earnings: Q1						-0.015***
						(0.001)
Female earnings: Q2						-0.034***
						(0.003)
Female earnings: Q3						-0.037***
						(0.002)
Female earnings: Q4						-0.028***
						(0.001)
Spouse earnings						0.012***
						(0.001)
Other income						0.003***
						(0.000)
Martial Status	No	Yes	Yes	Yes	Yes	–
Age	No	No	Yes	Yes	Yes	Yes
Year	No	No	No	Yes	Yes	Yes
State	No	No	No	No	Yes	Yes
Obs.	1,454,325	1,454,325	1,454,325	1,454,325	1,454,325	758,938
R^2	0.004	0.027	0.072	0.072	0.072	0.086

Note: Linear probability models. Women aged 15-50 in the 15 states with infertility insurance laws. All models are weighted by ACS sampling weights. The main regressors in Columns 1-5 are education dummies and the omitted group is high school dropouts. Column 6 focuses instead on female earnings. The omitted group is women without labor income and Q1-4 corresponds to the four quartiles of the earnings distribution. Robust standard errors adjusted for heteroscedasticity are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

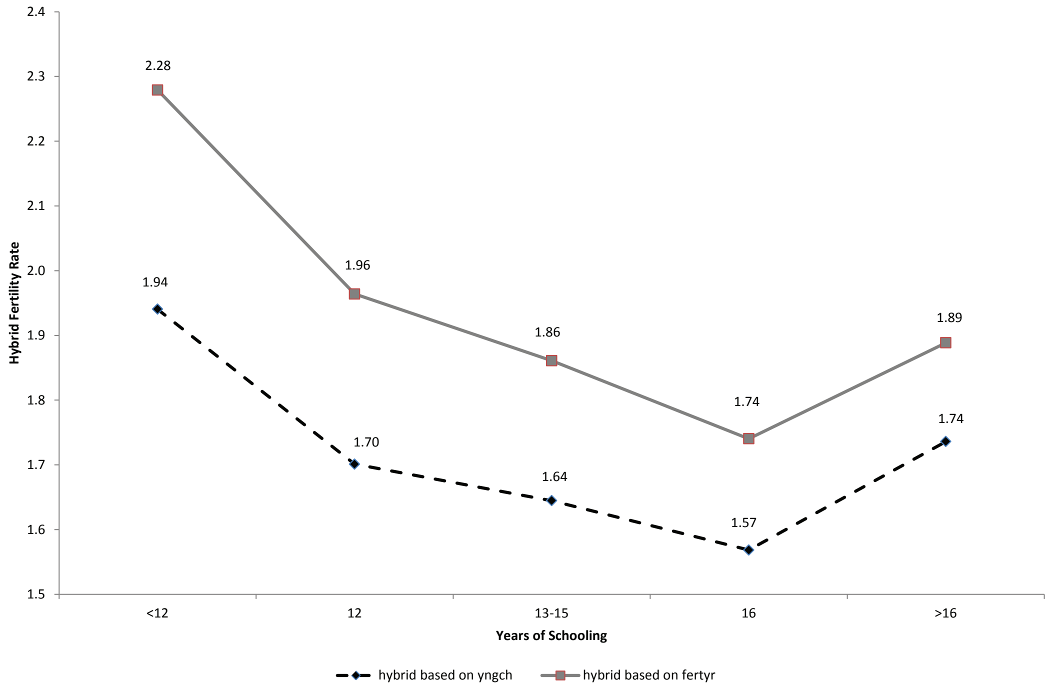

Fig. A2: *Two estimates for Hybrid Fertility Rate, 2001-2011. The hybrid fertility rate sums up the number of children ever born to women at age* a *and the age-specific-fertility rates from age* $a + 1$ *to 49. We assume* $a = 24$*. Authors' calculations using the American Community Survey.*

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