Teenage Childbearing and the Welfare State

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Very Preliminary Version!

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Abstract

Teenage birth rates differ significantly across developed countries. They are higher in countries with high income inequality and low intergenerational income mobility. We develop an economic theory of parental investments and risky sexual behavior of teenagers. The model is calibrated to match the stylized facts about income inequality, intergenerational mobility, and sexual behavior of teenagers in the United States. We then impose Norwegian taxes and education spendings on the baseline model. The Norwegian welfare state institutions go a long way in explaining the differences in teenage birth rates between the United States and Norway.

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Key Words: Teenage Birth Rates, Income Inequality, Intergenerational Mobility, Progressive Taxation, Education.

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[†]All errors are the sole responsibility of the authors.

1 Introduction

Preventing teenage childbearing is a priority among policy makers in the United States. Federal policies such as abstinence-only programs and comprehensive sex education had limited, if not close to no effect on reducing the teenage birth rate. Kearney and Levine (2012) argue that high teenage birth rates are a consequence of deeper, underlying social and economic problems. In a companion paper they show that inequality at the lower part of the income distribution can explain a sizable fraction of the variation of the teenage birth rates across the United States (Kearney and Levine, (2014). However, studies that quantify the role of teenage childbearing for the future income levels of the teenage mothers find no evidence of such (negative) effects (Hotz et al., 2005).

We base our study on evidence that across developed countries teenage birth rates are positively correlated with inequality and child poverty and negatively correlated with intergenerational income mobility[1]. This implies that countries with high income inequality and low intergenerational mobility of income and status have higher teenage birth rates. The negative correlation between inequality and intergenerational mobility across countries is documented by Corak(2006; 2013) and was referred to by Krueger (2012) as "The Great Gatsby Curve". Moving up the curve implies that as a society becomes more unequal, individual opportunities become more limited, and intergenerational mobility declines. Therefore, teenagers tend to have more births. Cross-country differences in inequality and intergenerational mobility can be attributed to some of the welfare state institutions such as redistribution through taxation and intergenerational redistribution through public education (Guvenen et al., 2014; Holter, 2014; Herrington, 2014).

We develop an overlapping generation model of risky teenage sexual behavior and human capital investment, in which parents invest in the human capital of their offspring and teenagers choose whether to be sexually active or not at the risk of giving birth to a baby. Female teenagers weigh the utility gain from sexual intercourse against the human capital loss of having a baby. Based on this trade-off, they determine if they want to be sexually initiated and if so, how much effort they want to invest in preventing a teen birth. We calibrate the model to match stylized facts about inequality, intergenerational income mobility, teenage births and teenage sexual initiation rates for the United States at the beginning of the twenty-first century. For this purpose, we use estimates of the average income tax function and public expenditure on education from US data.

In a quantitative experiment we examine how teenage childbearing reacts to changes in the

[1] See Section 2 for details.

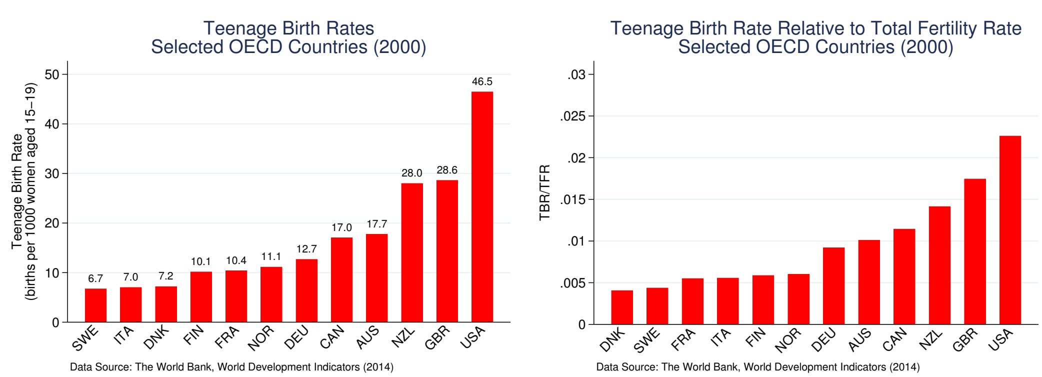
income tax progressivity and the structure of public education expenditures. Our results show that imposing the Norwegian tax progressivity reduces teenage birth rates in the US by around 7%. Imposing the Norwegian public education expenditure, on the other hand, reduces the US teenage birth rate by approximately 38%.

The paper proceeds as follows. In Section 2 we review the related literature. In Section 3 we provide cross-country evidence on the link between income inequality, intergenerational income mobility and teenage childbearing, and in Section 4 we present our economic model of teenage childbearing. We discuss our calibration strategy in Section 5 and explain the quantitative experiments in Section 6. In the final section we draw conclusions and present directions for future research.

2 Stylized Facts

Teenage birth rates differ significantly across developed countries. They range from 7 births per 1000 teenage females in Sweden, Italy and Denmark to 11-17 births in Norway, Germany and Canada and to more than 46 births in the United States (Figure 1). The *teenage birth rate* represents the number of births per 1000 women ages 15-19, as reported by the World Bank in the World Development Indicators. Even controlling for the total fertility rate the picture does not change. The differences between the US and especially the Scandinavian countries are hard to explain because they occur in countries with similar levels of economic development and similar attitudes towards teenage sexual behavior.

Figure 1: Teenage Birth Rates Across OECD Countries

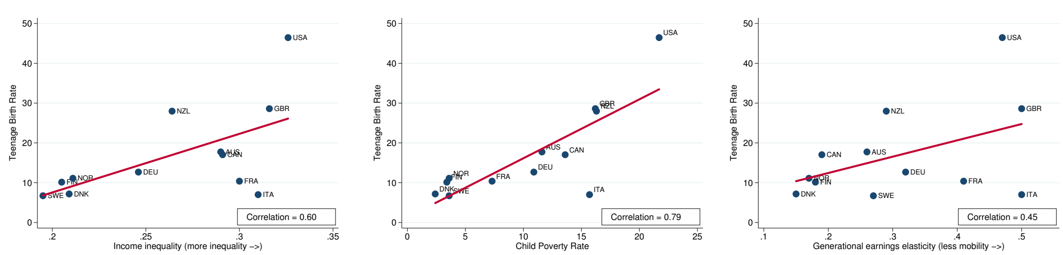


To the extent that high income inequality, in particular a pronounced lower tail of the income distribution, is an evidence of lack of economic opportunities for a large fraction of the population, one would expect that inequality and teenage birth rates are correlated. This conjecture turns to be true in a cross-country context (Figure 2a). Moreover, there is positive correlation between child poverty and teenage birth rates across OECD countries (Figure 2b). Thus, it is natural to think that limited and predetermined economic opportunities stem from the lack of adequate investments in the human capital of children. These poor investments in children are due to the limited resources available to parents (high poverty rates and income inequality) and, therefore, translate into lower intergenerational mobility in a society. Figure 2c shows that indeed intergenerational mobility is negatively correlated with teenage childbearing across countries.

To measure inequality, we use the *Gini coefficient* based on equivalenced household disposable income, after taxes and transfers as reported by OECD. Income refers to cash income, regularly received over the year: earnings, self-employed income, capital income, public transfers, and household taxes. The value of the Gini coefficient ranges between 0, in the case of "perfect equality" (i.e. each share of the population gets the same share of income), and 1, in the case of "perfect inequality" (i.e. all income goes to the individual with the highest income). Data is reported for mid-1980s. The *generational earnings elasticity* measures the percentage of parental earnings advantage passed on to the children. Higher values indicate less income mobile societies, whereas lower values indicate high generational earnings mobility. The reported father-son earnings elasticities are compiled and calculated by Corak (2013) and refer roughly to the 1990s. The *child poverty rate* represents the percentage of children living in households with incomes below 50% of national median income and refers to time points around the year 2000. We employ the data from UNICEF (2005).

Figure 2: Teenage Childbearing, Inequality, Poverty and Integenerational Mobility

(a) Income Inequality (b) Child Poverty (c) Intergenerational Mobility



The facts suggest that teenage birth rates are higher in countries with greater income inequality and slow intergenerational mobility of income: as a society becomes more unequal, individual opportunities are limited, and intergenerational mobility goes down. Therefore, teenagers tend to have more births.

At a micro level we observe a higher number of teenage births at the lower end of the income distribution. We use the 2006-2010 NSFG dataset to compute the distribution of sexual initiation rates and teenage birth rates across the parental income distributions. We use information on whether the teen respondents ever had sex (variable "rhadsex") and whether they ever had a live birth (variable "hasbabes"). We summarize then these variable over the total income of the respondent's family (variable "totincr"). Total income is reported in intervals. In order to reduce the sensitivity of misreported family income we regroup the respondents into income groups based on income quantiles. In particular, the lowest four quantiles contain 17.5% of respondents and the highest quantile contains the remaining 30%. We choose this particular classification because of the size of the income groups in the NSFG data and because this classification produces the smoothest teenage birth- and initiation rate distributions. Table1 shows that female teenagers at the lower end of the parental income distribution have higher sexual initiation rates and higher teenage birth rates (columns 2 and 3). When intergenerational mobility is low (as it is in US), a teenager is likely to have in the future the same economic situation as the parents. As a consequence, poor teenagers have then little incentives to make an effort and avoid a teenage birth.

We use the information from the NSFG to estimate our theoretical model. Because the data on teenage births is not fully consistent with our model structure we adjust it in two ways. First, we make it comparable to aggregate data on teenage births from the World Bank. We do this by adjusting the mean of the teenage birth distribution to the teenage birth rate provided by the World Bank. This adjustment is needed to make our estimation results comparable to the Norwegian teenage birth rate. Second, in our model every woman has a child, whereas in reality in most countries women have on average more than one child. Consequently, we adjust the teenage birth rate for the total fertility rate.The third column of Table 1 provides the adjusted teenage birth rates.

Table 1: Sexual Initiation and Teenage Birth Rates by Income Quantiles

Income Quantiles	Sexual Initiation Rate	Teenage Births Rates	Adj. Teenage Birth Rate
Q1	53.22%	14.73 %	4.07%
Q2	41.45%	7.05%	1.95%
Q3	41.46%	6.92%	1.91%
Q4	42.62%	5.95%	1.64%
Q5	39.91%	2.03%	0.56%

We argue that crucial factors, that generate the cross-country differences in inequality and intergenerational mobility, are attributes of the welfare state such as cross-sectional redistribution through taxation and intergenerational redistribution through public education. We have chosen Norway as a counterfactual because of data availability. In comparison to the US, Norway has a more progressive tax system (see Holter, 2014) and a different distribution of public expenditures across individuals (Herrington, 2014). Figure 3 plots the distribution of public education expenditure across the median income of counties in the US and municipalities in Norway. We employ public expenditure data for the US from the National Center for Education Statistics Common Core of Data through the the Elementary/Secondary Information System (ELSi) application. We use the variable "total current expenditures on instruction per student" at county level and plot it against the median household income as reported by the 2006-2010 American Community Survey 5-Year Estimates. For Norway we use data from the Statistics Norway website through the StatBank application. We plot the "net operating expenditure on teaching at primary and lower- and upper-secondary level" (Tables 04684 and 06939) at a municipality level against the median gross income for residents 17 years and older (Table 05854). The circles in the scatter plots are proportional to the number of students in each county or municipality, respectively, and the regression lines are weighted by the number of students. Our results are similar to those obtained by Herrington (2014) who does the same exercise but at a school district level. We observe that public expenditure per student is positively correlated with the mean household income in the US, whereas in Norway the opposite pattern occurs. To the extent that higher public investment translates into higher human capital accumulation and, accordingly, into higher future income, targeting educational expenditure towards economic disadvantaged pupils may result into fewer teenage births because they have now an opportunity to escape poverty.

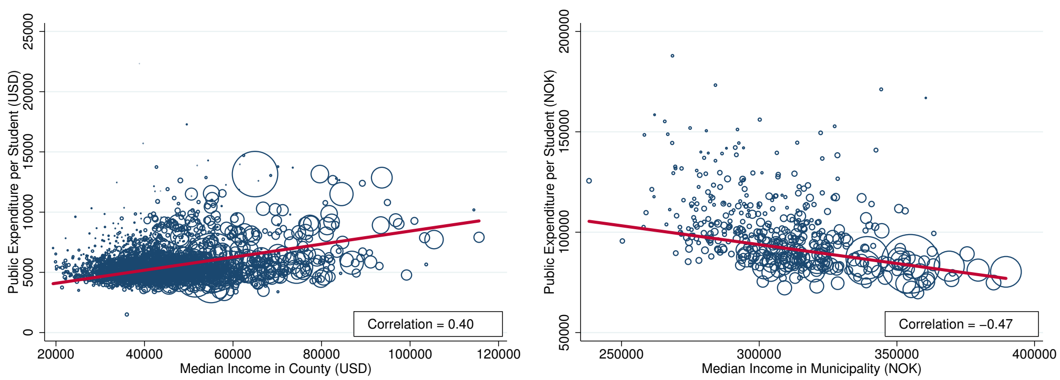


Figure 3: Public Education Expenditure

3 Economic Environment

Consider an overlapping generations economy populated by a unit continuum of females who live for two periods. In the first period females are teenagers, and in the second period, they are parents. Households consist of a mother and a daughter. A female gives birth to a child exactly once. Population is therefore constant. The child is born *either* when the mother is in her teens or at the start of adulthood. We assume that a teenage birth occurs just before the teenager becomes an adult. Consequently, the child is raised by the mother when she is an adult independently of the the timing of the birth.

The basic setup here is that parents invest in their offspring's human capital, while teenagers decide on whether to engage in sex. If so, they face the risk of having a teenage birth. Teenage childbearing has a negative effect on human capital accumulation of the teenager and human capital determines future income. Sexually active teenagers can exert effort to reduce the risk of having an unwanted birth. Birth control is costly but it diminishes the odds of a teenage birth. Once teenagers become parents, in their turn, decide how much to invest into their offspring's human capital. This process perpetuates through time.

Teenagers derive utility from being sexually active and they care about their income as parents. Teenagers weight the potential cost of having a teenage birth against the utility they receive from being sexually active when deciding whether they want to have sex or not. Furthermore, if they become sexually active, they choose a level of birth control by comparing its utility cost versus its benefit in terms of higher future income.

Parents derive utility from consumption and are altruistic towards their daughters in the sense that they value their child's future income. Parents divide their income between household consumption and investments in the human capital of their offspring. In doing so, parents take into account how their daughters will respond to the investment decision in terms of sexual initiation and birth control effort.

The economy features a government which collects an income tax and spends resources on the human capital development of teenagers. The fiscal and education policies of the government are exogenously given.

3.1 Teenagers

Teenagers live with their parents and receive human capital investment b from them. The government spends g on each teenager's education. The public and private investments are inputs in the production of human capital of the teenagers.

Teenagers receive a sex taste shock ξ. They make a decision of whether to be sexually active summarized by the indicator function s. If $s = 1$, the teenager is sexually active, whereas $s = 0$ implies sexual abstinence. Active teenagers can exercise birth control effort $e \in [0, \infty)$, which comes at a utility cost modeled by the differentiable, increasing and convex cost function $c(e)$. The odds of teenage birth for an initiated teenager are given by the probability function $\Xi(e, b)$ which is differentiable in both arguments. The probability of a teenage birth is decreasing in birth control effort e and private investments b. Teenagers learn about sex from their parents. In particular, their attitudes towards contraception and their overall sex education is strongly influenced by the parents. We capture this influence by including private investment b directly into the probability function $\Xi(e, b)$. Empirical studies show that public sex education had only very limited influence on teenage childbearing Sabia (2006). Therefore, we assume that g has no direct effect on the probability of having a teenage birth. The occurrence of a teenage birth is summarized by the indicator function

$$y = \begin{cases} 1, & \text{with probability } \Xi(e, b) \\ 0, & \text{with probability } 1 - \Xi(e, b) \end{cases} .$$

It takes the value 1 if a teenage birth occurs, and 0 otherwise.

Human Capital and Income

Human capital stock h' is determined by[2]

$$\mathbf{h}(b, g, y, \epsilon') = \exp(\epsilon')(1 + (b^\pi + g^\pi)^{1/\pi})^{\theta_0(1-\theta_1 y)}. \tag{1}$$

The inputs are private and public investments b and g. The degree of substitutability between these inputs is given by the parameter π. The production function has non-increasing returns to scale, i.e. $\theta_0 \in (0, 1]$. A teenage birth can disrupt human capital accumulation. This is portrayed by the parameter θ_1. Whenever a teenager experiences a birth, that is, $y = 1$, the produced stock of human capital decreases for given investment levels b and g. Moreover, the cost of teenage childbearing

[2] Variables reflecting the future of the teenager which are not known at the time of the decision making are indexed by prime. h' denotes the human capital stock of the future household of the teenager when she becomes a parent.

in terms of lost human capital is increasing in investments. This implies that teenagers with high investment levels would be more attentive to the consequences of teenage sex which is in line with the cross-sectional evidence presented in Table 1[3]. The production function (1) describes the creation of the household's stock of human capital and accounts for patterns of assortative mating and non-tangible investments in the human capital of the children. The parameter θ_1 captures not only the direct cost of teenage birth on the mother's skill formation but also the decline in her marriage perspectives in terms of spousal labor market skills (Fernández et al., 2005). The ability shock ϵ' reflects non-tangible investments not captured by the production technology. Ability is thus transferred imperfectly from parents to children according to the autoregressive process

$$\epsilon' = \psi\epsilon + \nu,$$

where $v \sim N(0, \sigma_\nu^2)$ is the innovation term. The heritability parameter ψ is positive but strictly smaller than one. Denote the conditional distribution function of ϵ' stemming from the specification above as $E(\epsilon'|\epsilon)$.

Future household income a' is a function of human capital stock,

$$\log(a') = \mu + \rho \log(h'). \tag{2}$$

The parameter ρ reflects the market return on human capital, while μ is a shift parameter of the average income.[4]

The human capital production technology and the income process defined by equations (1) and (2) define the teenager's next period gross household income a' as a function of investments b and g, the realization of the ability shock ϵ', and the presence of a teenage birth y. We denote this relationship as

$$a' = \mathbf{a}'(b, g, \epsilon', y).$$

The government collects an income tax in this economy. The tax schedule is a function of income and is given by $\tau(a)$. Consequently, next periods disposable income, denoted by $\widetilde{a}'$ can be expressed as

$$\widetilde{a}' = \widetilde{\mathbf{a}}'(b, g, \epsilon', y) = (1 - \tau(\mathbf{a}'(b, g, \epsilon', y)))\mathbf{a}'(b, g, \epsilon', y).$$

[3]We add the constant = 1 in equation (1) for two reasons. First, this technical assumption ensures that at any level of investment there is a cost of having a teen birth in terms of producing human capital, and second, it allows us to interpret teenager's ability $\exp(\epsilon')$ as the realized teenagers human capital stock in case of no human capital investment $(b = g = 0)$.

[4]Our parametrization strategy for the empirical implementation of the model relies on the normalization of average household income in the economy to one. This brings about a transparent interpretation of our results since all quantities in the quantitative exercises are expressed in terms of average income.

Sexual Initiation and Birth Control

A teenager derives utilityξ from being sexually active. If she forgoes this pleasure and stays sexually abstinent, her instantaneous utility level is normalized to zero. Teenagers value their expected disposable income as adults. The preferences of teenagers are given by

$$(1-\delta)(\xi - c(e))s + \delta \mathbf{E} \log(\widetilde{a}'),$$

where δ is the utility weight on the expected future disposable income. The first term of the expression above describes the net utility derived out of sex. The cost of birth control effort, $c(e)$ is subtracted from the the utility of sex ξ. The utility term of future disposable income is assumed to be logarithmic. Future disposable income is not determined at the time the teenager makes her decision about sexual initiation and birth control. In this sense, sexual activity is risky because it may decrease the level of after-tax income if a teen birth is realized. This gives an incentive to sexually active teenagers to exert birth control effort.

Teenager's Decision Making

Consider a teenager who is sexually initiated and makes a decision on the level of birth control. A sexually active teenager who receives investments b and g, has parents of ability ϵ, and a sex taste ξ, faces the following problem,

$$\begin{aligned} \widetilde{V}^1(b,g,\epsilon,\xi) = \max_{e\geq 0} & (1-\delta)(\xi - c(e)) \\ & + \delta \int_{\mathcal{E}} \Big\{ \Xi(e,b) \log(\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{1}) \\ & + (1-\Xi(e,b)) \log(\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{0})) \Big\} dE(\epsilon'|\epsilon). \end{aligned} \tag{3}$$

The teenager has to choose an optimal level of birth control e. In doing so, she maximizes the weighted sum of her instantaneous utility of from sex and the expected utility out of her disposable household income in the future. The expected utility out of future income is formally expressed in the second and third lines of problem (3). If the teenager has a level of birth control effort e, with probability $\Xi(e,b)$ she would have a teenage birth and consequently her future disposable income would be given by the function $\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{1})$. With the complementary probability $1-\Xi(e,b)$ the teenager will manage to avoid a teen birth and the future level of disposable income would be given by $\widetilde{\mathbf{a}}'(b, g, \epsilon', \mathbf{0})$. To arrive at the final expression for the expected utility out of future income above, one needs to integrate over all possible realizations of the teenager's ability ϵ' using the conditional distribution function $E(\epsilon'|\epsilon)$. Denote the decision rule of the initiated teenager with respect to birth control as $\mathbf{e}(b, g, \epsilon)$.

Now think about a teenager who contemplates sexual initiation. We define the indirect utility function of an abstinent teenager as

$$\widetilde{V}^0(b, g, \epsilon) = \delta \int_{\mathcal{E}} \log(\widetilde{\mathbf{a}}'(b, g, \epsilon', \mathbf{0}) dE(\epsilon'|\epsilon).$$

The utility level in the case of sexual abstinence is normalized to zero. Therefore, the indirect utility function for the abstinent teenager is the expected utility out of future disposable income with respect to ability ϵ'.

The teenager will engage in sex whenever the value of being sexually initiated is higher than the value of being abstinent. The initiation problem is formalized as

$$V(b, g, \epsilon, \xi) = \max_{s \in \{0,1\}} \{(1 - s) \underbrace{\tilde{V}^0(b, g, \epsilon)}_{\text{Abstinence}} + s \underbrace{\tilde{V}^1(b, g, \epsilon, \xi)}_{\text{Sex}}\} \tag{4}$$

and the corresponding decision rule is given by

$$\mathbf{s}(b, g, \epsilon, \xi) = \begin{cases} 1 \text{ if } & \tilde{V}^1(b, g, \epsilon, \xi) \geq \tilde{V}^0(b, g, \epsilon) \\ 0 \text{ if } & \tilde{V}^1(b, g, \epsilon, \xi) < \tilde{V}^0(b, g, \epsilon) \end{cases}.$$

Teenagers are indifferent between sexual initiation and abstinence if the realization of the sex taste shock $\xi^\star$ is such that $\tilde{V}^1(b, g, \epsilon, \xi^\star) = \tilde{V}^0(b, g, \epsilon)$. Teenagers with a taste for sex below $\xi^\star$ would be abstinent, while teenagers with a taste shock above it would be sexually active. The threshold value of the sex taste shock $\xi^\star = \xi^\star(b, g, \epsilon)$ can be represented as an implicit function of parent's ability ϵ, as well as private b and public g investment in human capital.[5]

3.2 Parents

Each parent is paired with a teenager in a household. Adults value current household consumption, c, and are paternalistic towards their offspring in the sense that they care about the future expected

[5]Probably a footnote which explains why we need this function in the remainder of the analysis.

disposable income $\tilde{a}'$ of the child (Doepke and Zilibotti, 2014). The preferences of parents are given by

$$(1-\alpha)\log(c) + \alpha\mathbf{E}\log(\widetilde{a}'),$$

where α is the degree of paternalism of parents. Future income of teenagers is not determined at the time of decision making of parents, thus the expectation operator in the expression above.

Parent's Decision Making

The parent observes public education expenditures g to her teenager. The ability of the parent ϵ is also known. She has a household income a and decides how to allocate it between household consumption, c, and the investment in human capital production of their offspring, b. The parent knows how human capital investment b influences her offspring's decisions about sexual initiation, $\mathbf{s}(b,g,\epsilon,\xi)$, and birth control, $\mathbf{e}(b,g,\epsilon)$. She takes into account the teenager's decision rules when making the investment decision. However, the parent does not know the preferences of the teenager over sex, ξ. Also, at the time parental decisions are made, the level of ability,ϵ', or the realization of the potential birth to the teenager, y, is not yet known.

The parent's decision problem is given by

$$\begin{aligned}
W(a,g,\epsilon) = &\max_{b\in[0,(1-\tau(a))a]}(1-\alpha)\log(c) \\
&+\alpha\int_{\mathcal{X}}\int_{\mathcal{E}}\Big\{(1-\mathbf{s}(b,g,\epsilon,\xi))\log(\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{0})) \\
&+\mathbf{s}(b,g,\epsilon,\xi)\Xi(\mathbf{e}(b,g,\epsilon),b)\log(\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{1})) \\
&+\mathbf{s}(b,g,\epsilon,\xi)(1-\Xi(\mathbf{e}(b,g,\epsilon),b))\log(\widetilde{\mathbf{a}}'(b,g,\epsilon',\mathbf{0}))\Big\}dE(\epsilon'|\epsilon)dF(\xi)
\end{aligned} \tag{5}$$

subject to

$$(1-\tau(a))a = c + b.$$

The parent has to choose an optimal levels of household consumption, c, and the investment in the human capital of the teenager, b. In doing so, she needs to maximize weighted sum of the utility out of consumption and the expected utility out of the disposable income of the teenager when she becomes an adult parent herself. Th expected utility out of the income of the teenager in the future is expressed on the second, third, and forth lines of problem (5). For a particular mix of investments, b and g, parental ability, ϵ, and sex taste, ξ, the teenager may decide to stay sexually abstinent, i.e. $\mathbf{s}(b, g, \epsilon, \xi) = 0$. In this case, her future income will be given by $\widetilde{\mathbf{a}}'(b, g, \epsilon', \mathbf{0})$. This is the case depicted on the second line of the problem. However, if the teenager becomes sexually active, $\mathbf{s}(b, g, \epsilon, \xi) = 1$, she faces a teenage birth with probability $\Xi(\mathbf{e}(b, g, \epsilon), b)$. In this case her disposable income is given by $\widetilde{\mathbf{a}}'(b, g, \epsilon', \mathbf{1})$. Of course, with certain probability $(1 - \Xi(\mathbf{e}(b, g, \epsilon), b))$ she might avoid giving birth while a teenager. In this case, her disposable income in the future will be given by $\widetilde{\mathbf{a}}'(b, g, \epsilon', \mathbf{0})$. To form the final expression for the expected utility to the parent out of the future income of the teenager, one needs to integrate over all possible realizations of the ability, ϵ', and the taste for sex, ξ. The decision rule of the parent on investing in the human capital of her child is $\mathbf{b}(a, g, \epsilon)$.

3.3 Equilibrium

The equilibrium in this economy is characterized by a stationary income distribution associated with optimal behavior of parents and teenagers. To characterize the stationary income distribution, first define the following function,

$$\mathbf{1}(a', a, g, \epsilon, \epsilon', y') = \begin{cases} 1 & \text{if } a' = \mathbf{a}'(\mathbf{b}(a, g, \epsilon), g, \epsilon', y') \\ 0 & \text{otherwise} \end{cases}.$$

The function above takes the value of one if a teenager with ability level ϵ', teenage birth status summarized by y', and government expenditure g, ends up having an income level a', given that her parental income and ability are a and ϵ. It takes the value of zero otherwise. Next, construct a transition probability function,

$$P(a'|a) = \int_{\mathcal{X}} \int_{\mathcal{E}} \int_{\mathcal{E}} \int_{\mathcal{G}} \mathbf{1}(a', a, g, \epsilon, \epsilon', y') dG(g|a) dE(\epsilon'|\epsilon) d\widetilde{E}(\epsilon) dF(\xi),$$

which computes the probability of a teenager of attaining income level a' conditional on having a parental income level a. Based on that, define the stationary distribution function of income as

$$\mathcal{A}(a') = \int_{\mathcal{A}} P(a'|a) d\mathcal{A}(a). \tag{6}$$

Definition. A ***stationary equilibrium*** consists of a given distribution function for government expenditure conditional on income, $G(g|a)$, a set of indirect utility functions for teenagers, $\widetilde{V}^1(b, g, \epsilon, \xi)$,

$\widetilde{V}^0(b, g, \epsilon)$, $V(b, g, \epsilon, \xi)$, and for parents, $W(a, g, \epsilon)$, decision rules for sexual initiation, $\mathbf{s}(b, g, \epsilon, \xi)$, birth control effort, $\mathbf{e}(b, g, \epsilon)$, and investments in children, $\mathbf{b}(a, g, \epsilon)$, and a stationary income distribution $A(a)$, such that:

1. The function $\widetilde{V}^1(b, g, \epsilon, \xi)$ solves the teenager's decision problem on the level of birth control effort (3), and $\mathbf{e}(b, g, \epsilon)$ is the corresponding decision rule.

2. The function$V(b, g, \epsilon, \xi)$ solves the teenager's decision problem on sexual initiation (4), taking as given functions $\widetilde{V}^1(b, g, \epsilon, \xi)$ and $\widetilde{V}^0(b, g, \epsilon)$, and $\mathbf{s}(b, g, \epsilon, \xi)$ is the corresponding decision rule.

3. The function $W(a, g, \epsilon)$ solves the parent's decision problem (5), taking as given the teenager decision rule for sexual initiation, $\mathbf{s}(b, g, \epsilon, \xi)$, and for birth control effort, $\mathbf{e}(b, g, \epsilon)$, defined by problems (3 and 4), and $\mathbf{b}(a, g, \epsilon)$ is the corresponding decision rule.

4. The stationary distribution $\mathcal{A}(a)$ solves(6), taking as given the distribution function $G(g|a)$ and the decision rules $\mathbf{e}(b, g, \epsilon)$, $\mathbf{s}(b, g, \epsilon, \xi)$ and $\mathbf{b}(a, g, \epsilon)$.

4 Fitting the Model to the Data

The model developed here will be fit to the U.S. data for the time period 2006-2010. Governmental policy in the model is exogenously given. Therefore, the parameters of the income tax schedule and the public education expenditure process can be set independently from the other targets on the basis of a priori information. The remaining parameters will be fitted using a simulated method of moments estimation procedure. Important dimensions in which the model is matched to the data are: (i) the teenage birth rates and sex initiation rates across the parental household labor income distribution, (ii) household labor income distribution, (iii) consumption share in income and average wage reductions associated with a teenage birth, and (iv) intergenerational patterns of income mobility.

4.1 A Priori Information

Tax schedule

Tax progressivity affects the incentives of parents to invest in the human capital of their teenagers. Therefore, the tax system affects, indirectly, the sexual decision-making process of the teenagers, namely whether to get sexually initiated or not, and if so, the optimal effort exerted to avoid having a baby. We follow the literature (Herrington, 2014; Guvenen et al., 2014; Holter, 2014) and define the average net income tax function as

$$\tau(a) = \lambda_0 + \lambda_1 a + \lambda_2 a^{\lambda_3},$$

where a denotes annual individual earnings divided by the average annual earnings in the country.

In other approaches the average tax rate is modeled using a more simple functional form with only two parameters: $\tau(a) = 1 - \lambda_1 a^{-\lambda_2}$ (Benabou, 2002; Heathcote et al., 2014; Holter et al., 2014; Guner et al., 2014). Another two-parameter specification is the log income one:$\tau(a) = \alpha + \beta \log(a)$ (Guner et al., 2012; Eeckhout and Guner, 2015). To calibrate our model we employ the parameter estimates as computed by Herrington (2014). We employ Herrington's estimates because he provides average net income tax functions using only data for households with children both for both the US and Norway. Table 2 shows the results of his non-linear least squares regression.

Table 2: Tax Functions.

	United States	Norway
λ_0	0.434	1.106
λ_1	0.003	-0.002
λ_2	-0.321	-0.921
λ_3	-0.719	-0.190
R^2	0.993	0.998

Herrington (2014) estimates the tax functions using data from the 2010 edition of the OECD publication Taxing Wages. The OECD dataset constructs average tax rates covering not only central and local government taxes, but also social security contributions and government transfers to the households. For very low earnings the average tax rate might be negative, which means that the households receive government transfers exceeding their income tax bill.

Public Education Expenditures

Public education expenditures also influence teenagers' human capital accumulation and consequently their decisions on sexual initiation and optimal effort. Figure 3 in Section 2 shows that, both in Norway and the US, public education expenditures g tend to change with median income of counties. While public education expenditures in the US tend to be higher in counties with high median income, the opposite pattern is observed in Norway. Even though the correlation of public education expenditures and median income is statistically significant in both countries, we observe many different public education expenditure levels at each income level. In order to capture the overall correlation between median income and public education expenditures on the one hand, and the variance of public education expenditures on the other hand, we assume that public expenditure is a random variable, distributed according to $g \sim G(g|a)$.

We use data on the mean and median income, as well as public education expenditures of the individual counties in the US (2006-2010 American Community Survey 5-Year Estimates and the National Center for Education Statistics Common Core of Data) and Norway (Statistics Norway) to estimate the distribution $G(g|a)$ by semi-parametric methods. We assume that the county level income distribution is log-normal. The mean and the median of the counties' income distribution identify the parameters of the log-normal income distribution for every county. Using these county-level income distributions and the pupil population of the counties we can simulate a country-wide income distribution. We pair the draws in the simulation with the respective counties' public education expenditures to create a sample of incomes and related public education expenditures. Then we separate the simulated country-wide income distribution into centiles and compute the empirical CDF of the related public education expenditures in each of the centiles.

In the simulated model parents draw from these empirical distribution functions before they make their decisions. In particular, they draw from the empirical CDF that is associated with their income.

Returns to Human Capital

Following Solon (2004), the parameter ρ has an intuitive interpretation as the labor-market return to human capital. Hanushek et al. (2013) provide estimates for these returns to capital. They use numeracy skills from the PIAAC survey as a proxy for human capital to compute labor-market returns to human capital for a broad set of countries. Because they estimate semi-elasticities we have to adjust their estimates to obtain the elasticity of income with respect to human capital. In particular, their estimates $\hat{\rho}$ are related to ρ in the following way

$$\rho = \frac{\mu_h}{\sigma_h}\hat{\rho},$$

where μ_h is the sample mean and $\sigma_h$is the sample variance of the human capital measure used by Hanushek et al. (2013). Using their estimates and the sample mean and variance of numeracy skills in the US, we set ρ to a value of 1.236.

4.2 Endogenous Parameters

We distinguish three groups of endogenous parameters that are matched to different data moments: parameters related to teenage birth- and initiation rates, parameters recovering parents consumption decision for different income levels and parameters pinning down the income distribution.

Table 3: Parameters calibrated endogenously.

Parameter	**Description**	**Value**
ζ	Sex taste shock	2.500
α	Parents utility weight	0.6957
δ	Teenagers utility weight	0.7658
ω_0	Cost of effort	0.0450
ω_1	Cost of effort	2.5865
ω_2	Cost of Effort	0.6900
γ_0	Prob teen birth	0.3298
γ_1	Prob teen birth	3.9805
γ_2	Prob teen birth	0.2587
ψ	Persistence of ability	0.1740
σ_ν	Variance of ability shock	0.5619
θ_0	Human capital curvature	0.8900
θ_1	Human capital cost of teenage birth	0.9721
μ	Income Intercept	-0.61
π	Elasticity of substitution: b & g	1.000
ρ	Return to human capital	1.236

Teenage Birth Rates and Initiation Rates

The NSFG data set provides information on sexual initiation and the occurrence of a teenage birth together with information on parental income. As described in Section 2 we adjust the teenage birth rates obtained from the NSFG to make them consistent with aggregate data. We use the information supplied by the NSFG and construct teenage birth- and sexual initiation rates for different income groups. Table 1 shows that, both, teenage birth rates and sexual initiation rates decrease with parents income.

In our model teenagers decide if they want to get initiated by comparing the value of their sex taste shock ξ with a threshold $\xi^{\star}(b, g, \epsilon)$. If the realization of the taste shock is below the threshold, the teenagers remain abstinent. We assume that the sex taste shock follows an exponential distribution: $\xi \sim \exp(\zeta)$, with parameter ζ. The parameter ζ determines the mean of the sex taste shock distribution and therefore its value is recovered by the average initiation rate of the teenagers. The higher the mean of the distribution the more teenagers find their realization of the tax shock being above the threshold.

The distributions of teenage childbearing and sex initiation across parents' income are pinned down by the interaction of the utility weights α and δ, the returns to scale in human capital production θ_0, the probability function $\Xi(e, b)$ and the effort cost function $c(e)$. We assume the following functional forms for the probability function

$$\Xi(e, b) = \gamma_0 \exp(-\gamma_1 e - \gamma_2 b\, e)$$

and for the effort cost function

$$c(e) = \exp(\omega_0 e^{\omega_1}) - \omega_2.$$

The reasoning behind the identification of the above parameters is that the utility weights determine how much parents invest on average and how much effort teenager's exert on average. Furthermore, the higher the value of θ_0 the higher is the expected value of teenagers' next period after tax income. This implies that a higher θ_0 corresponds to higher investment, higher effort and a lower threshold value. Consequently teenage birth rates and sex initiation rates are lower on average when $\theta_0$is high. Finally, the form and parametrization of $\Xi(e, b)$ and $c(e)$ are responsible for the shape of the teenage birth- and sex initiation distribution across parent's income.

Whether teenage childbearing is costly in terms of a mother's future earnings is still a controversy in the literature. We follow Fletcher and Wolfe (2009) who use teenagers that had a late miscarriage as the relevant comparison group to compute the income loss suffered by teenage mothers. Fletcher and Wolfe (2009) use data from ADHEALTH to compute average income for teenage mothers and teenagers having a late miscarriage. We use their numbers and estimate the income loss of having a teenage birth to be of approximately 17%.[6] We use this estimate to recover the value of θ_1, that governs the cost of teenage childbearing in the model.

[6]Note that income is computed for young women. This implies that our estimate of the income cost of teenage childbearing is a lower bound estimate, because over the life-cycle most probably tend to become larger. REWRITE!!!

Income Distribution

The remaining three parameters μ, σ_ν and ψ can be identified using data on the income distribution and intergenerational mobility. We normalize mean income in our model to one, by adjusting μaccordingly. The value of σ_ν pins down the variance of the income distribution and we use the Gini coefficient for the US as target. Finally, intergenerational income mobility allows us to recover the persistence of the ability process ψ.

Elasticity between b & g

There is one important parameter that can not be identified from the data. This parameter is the elasticity of substitution between private and public human capital investment π. Although there is a intuitive interpretation for public human capital investment as public education expenditures, there is no such clear interpretation for its private counterpart. In our model private human capital investment intends to capture not only monetary investments, but also time spent with children, which is hard to measure in the data. Therefore we follow Holter (2014) and Herrington (2014) and assume that the two investments are perfect substitutes.

Estimation Method

We estimate the fourteen endogenous parameters of the model with an over identified simulated method of moments approach. We minimize the squared difference of the 19 simulated moments and the corresponding counterparts in the data. We define $\Theta = \{\zeta, \alpha, \delta, \omega_0, \omega_1\omega_2, \gamma_0, \gamma_1, \gamma_2, \theta_0, \theta_1, \mu, \psi, \sigma_\nu\}$ and compute the percentage deviation of the model moments $\hat{m}_i(\Theta)$ from the data moments m_i, $g_i(\Theta) = \frac{m_i - \hat{m}_i(\Theta)}{m_i}$. Let $g(\Theta) = (g_1(\Theta), ..., g_{19}(\Theta))$ be the vector of the percentage deviation of the model moments from the data moments and let

$$\begin{aligned} \hat{\Theta}_j = \min_{\Theta} g(\Theta)' g(\Theta) \\ \text{s.t. } \mathbb{E}\{a\} = 1 \end{aligned} \tag{7}$$

be the minimization problem. The constraint is added because we solve the model using the assumption that mean income is one. We minimize equation 7 for multiple realizations of the random processes. The mean of the J estimated parameter vectors provides our estimate $\hat{\Theta} = \frac{1}{J}\sum_{j=1}^{J} \hat{\Theta}_j$ and the estimated parameters' variances are obtained by $\sigma^2_{\hat{\Theta}} = \frac{1}{J-1}\sum_{j=1}^{J}(\hat{\Theta} - \hat{\Theta}_j)^2$. Table 3 summarizes the results and provides the standard errors of the estimates.

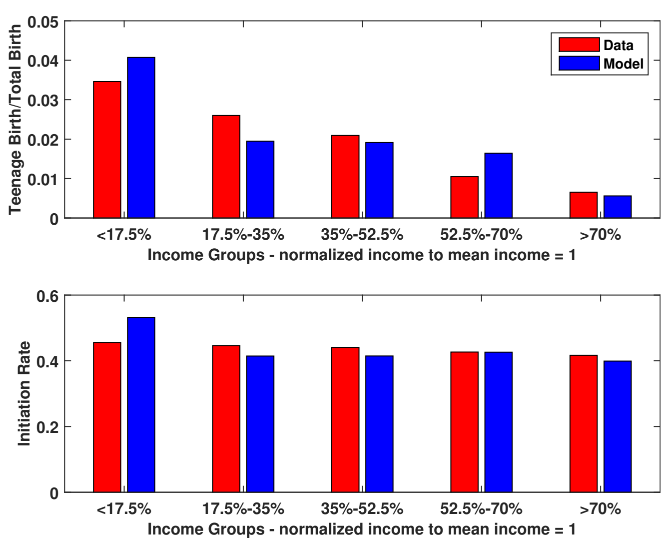
4.3 Model Fit

Before we use the model to conduct our policy experiments we show that our model replicates the relevant features of the US economy and explain the mechanisms driving our results. Table 4 presents model moments and their empirical counterparts. The table shows that the model performs relatively good in replicating the income distribution, intergenerational income mobility and average teen birth- and sexual initiation rates of the US. The model is also able to replicate the distribution of teenage birth rates and sexual initiation rates across income groups. Figure 4 shows the resulting model distribution and the empirical distribution obtained from the NSFG (2006-2010).

Table 4: Model Fit.

	Data	Baseline Model
Teenage Birth Rate	1.84%	1.81%
Initiation Rate	43.25%	43.47%
Income loss of teenbirth	17.3%	17.4%
Gini Coefficient	0.424	0.422
Intergenerational Persistence	0.408	0.405
Mean Income	1	1

Figure 4: Model Fit.



5 Quantitative Experiment

The question of this paper is to examine to what extent taxation and public education expenditures can explain differences in teenage birth rates across countries. In order to asses this question we introduce the Norwegian tax schedule and Norwegian public education expenditures into the model calibrated to the US. Differences in teenage birth rates between the baseline calibration and the counterfactual experiments can then be attributed to differences in the analyzed welfare state institutions. In the first counterfactual experiment we generate a counterfactual tax schedule characterized by average US taxes and Norwegian progressivity[7]. This counterfactual tax schedule is then imposed on the baseline model. The second counterfactual experiment asks what happens to teenage birth rates if the US adopts Norwegian public education expenditures. Thus we impose the Norwegian distribution of public education expenditures on the baseline model and resolve it. In a third experiment we ask the question what happens to teenage birth rates if we introduce both, the tax schedule and public education expenditures in the baseline model.

Table 5 shows the teenage birth rate, the initiation rate and mean income for the baseline model and all three experiments. In the experiments we also adjust the parameter μsuch that mean income is still at one. We need this adjustment to make the experiments comparable to the baseline model. Otherwise possible wealth effects due to the changed environment would overstate the importance of the analyzed welfare state institutions for changes in the teenage birth rate. The corresponding values of $\mu$are stated in the last row of Table 5

Table 5: Experiments

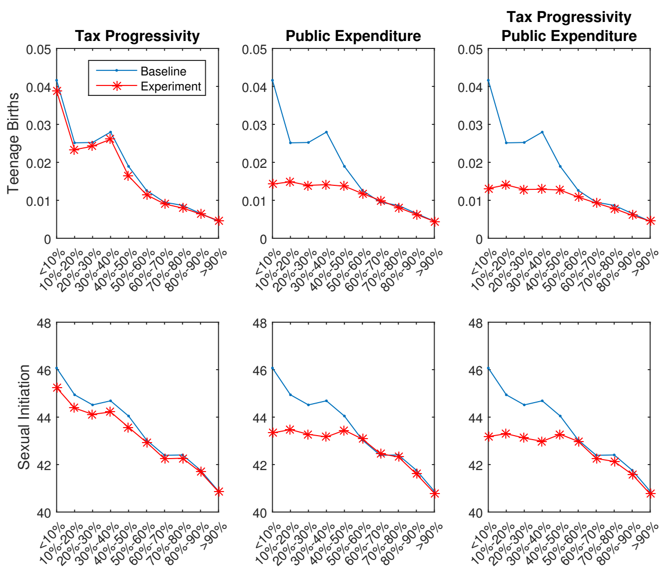
	Baseline Model	Tax Progressivity	Public Education	Tax Progressivity & Public Education
Teenage Birth Rate	1.81%	1.68%	1.11%	1.04%
Initiation Rate	43.47%	43.15%	42.70%	42.56%
Mean Income	1.000	1.000	1.000	1.000
μ	-0.611	-0.5913	-0.6252	-0.6072

Interestingly, changing the tax progressivity or public education expenditures alters the initiation rates only marginally, whereas policy experiments have a pronounced effect on the teenage birth rate. Changes in the teenage birth rate, instead, are more sizable relative to our baseline calibration. This points out that teenagers adjust to different circumstances mainly by changing

[7] We follow Herrington (2014) in the way we generate the counterfactual tax schedule with Norwegian progressivity and average US tax rates.

their effort. Furthermore the results in Table 5 show that introducing Norwegian public education expenditures into our baseline economy has a stronger impact on the teenage birth rate. Compared to the tax experiment, which reduces the teenage birth rate by 7.2%, the introduction of Norwegian public education expenditures reduces the teenage birth rate by 38.7%. Finally, introducing both the tax schedule with Norwegian progressivity and Norwegian public education expenditure reduces the teenage birth rate even more. If we compare the teenage birth of only 0.45% in Norway with the our estimates, we observe that tax progressivity and public education expenditures together can account for more than 50% of the difference between the teenage birth rates in Norway and the US.

Figure 5: Experiments



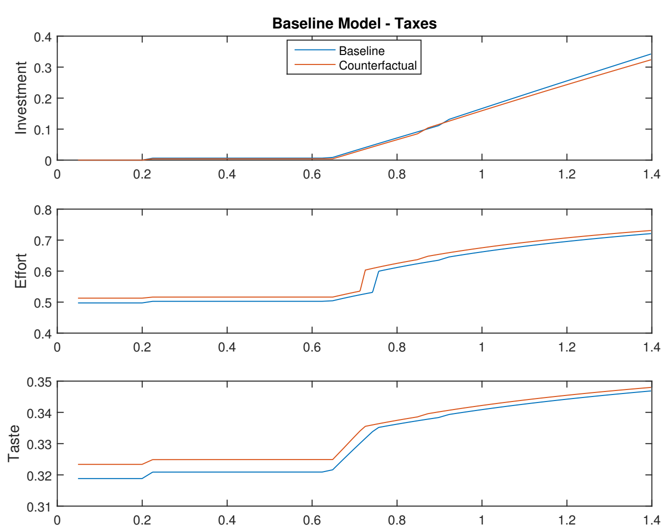
In Figure 5 we plot the teenage birth rates and initiation rates across centiles of the parental income distribution in the baseline calibration and the three experiments. The figure visualizes why public education expenditures have a stronger impact on the teenage birth rate in our model. Introducing Norwegian tax progressivity into the baseline model leads only to a marginal reduction of the teenage birth rate for the poor and no reduction in teenage childbearing among the rich. In contrast, Norwegian public education expenditures have a substantial impact on teenagers living in households with income below the median. In the next two subsection we explore the reasons for this heterogeneous outcome.

5.1 Tax Progressivity

In Figure 6 we plot the policy functions for investment, effort and the threshold for families with average ability, facing average public education expenditure and being in the first eight centiles of the parental income distribution. The first thing that stands out is that parent's investment decisions are only marginally changed by the introduction of a more progressive tax schedule. The parents invest even less in a world with more progressive taxes. The reason for this is that a stronger increase in taxes associated with a more progressive tax schedule reduces the return on human capital investment.

The policy functions of teenagers retain their shape when Norwegian tax progressivity is introduced into the baseline calibration, but shift upwards. This implies that on average teenagers exert more effort when initiated and are less likely to be initiated. But more interestingly than the upward shift is that the discrete jump in the policy function moves to the left. This discrete jump emerges because for some level of parental investment a teenage birth becomes more costly and therefore teenagers strongly increase their effort to prevent a teenage birth. With a more progressive tax system this level of parental human capital investment is lower because the tax burden is lower for families in the middle of the income distribution and consequently an expected gain in before tax income translates in higher after tax income for those families. Therefore the threshold investment level is smaller for teenagers living in a world with lower tax progressivity.

Figure 6: Policy Functions Tax Experiment

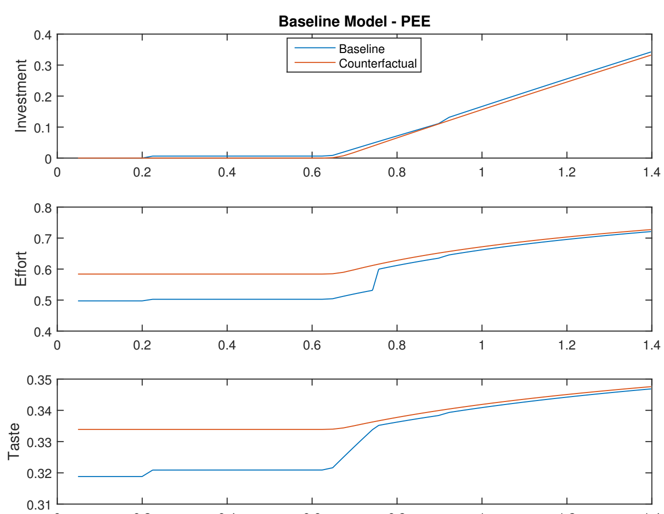


5.2 Public Education

Figure 7 plots again the policy functions for investment, effort and the threshold for families with average ability, facing average public education expenditure and being in the first eight centiles of the parental income distribution. But in this case the average public education expenditure levels differ between the baseline and the counterfactual model. As with the tax experiment, introducing Norwegian public education expenditures into the baseline model reduces the incentives to invest slightly. The reason in this case is that private and public education expenditures are perfect substitutes in this model and therefore parents invest less if the government invests more.

Even though public education expenditures have only a limited impact on the parent's behavior, teenagers respond more strongly to as change in public education policies. With Norwegian public education expenditures the average investment of the government is higher and this gives teenagers coming from poorer families an incentive to put in more effort to avoid a teenbirth. Because now their future human capital is less dependent on their parent's contribution to their education they try to avoid teenage childbearing.

Figure 7: Policy Functions Public Education Experiment



6 Conclusion

We develop a partial equilibrium model of human capital accumulation and teenage childbearing that is suited to explain differences in teenage birth rates across countries. We find that differences in welfare state institutions, in particular the income tax schedule and public education policies can explain up to 30% of the difference in teenage birth rates between the United States and Norway.

This result has important implications for public policies. Past policy interventions aiming to reduce teenage birth rates in the US focused on sex education, improved access to contraceptives or abstinence pledges. These policies proved to be ineffective in reducing teenage birth rates. Instead one should think on how to improve access and quality of public education for the poor to reduce teenage birth rates in the US.

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