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Abstract

This paper studies a politico-economic dynamic general equilibrium model to quantify the importance of endogenous fertility in explaining the generosity of redistribution and education policies in the U.S. Policies are endogenised as outcomes of majority voting. I find that accounting for endogenous fertility is essential for strong performance of the model in matching the levels of both transfers and education subsidies in the U.S. economy. The predictions of the model regarding a cross-section of U.S. states are used to verify the plausibility of fertility decision responses to policies and, consequently, to support the credibility of this result.

JEL Codes: D72, E62, H52, I24, I38, J13.

Keywords: Voting, Endogenous fertility, Redistribution, Education.

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1 Introduction

In modern societies, including the U.S, in which birth control is widely used, the number of children becomes an individual choice, which is very likely to be affected by public policies. Even though empirical and theoretical studies demonstrate that fertility decisions indeed interact with redistribution and education policies in non-negligible ways, the existing literature on determinants of public policies apparently abstracts from endogenous fertility.[1]

This paper fills this gap by demonstrating that endogenous fertility is an important determinant of redistribution and education policies and is one of few studies performing a quantitative analysis of public policies.[2] Specifically, relying on a novel politico-economic extension of a standard framework in the style of Barro & Becker (1989), this paper finds that majority-voting equilibrium transfers and education subsidies predicted by this model are quite close to the U.S. data (5.5% and 2.9% of GDP in the model versus 5.4% and 2.5% of GDP in the data). However, when endogenous fertility is eliminated from the model, equilibrium transfers and education subsidies increase dramatically - to 8.3% and 4.7% of GDP, respectively.

Endogenous fertility is important because it makes transfers and education subsidies more costly for two reasons. First, both types of policies positively affect fertility differentials between low and high income individuals, because income and substitution effects act in the same direction for high income as opposed to low income parents. Increases in fertility differentials lead to higher shares of low productive individuals and, consequently, to less resources available to finance public policies. Therefore, equilibrium tax rates increase. Second, both policies positively affect the average number of children, leading to declines in aggregate la-

[1] A wide range of empirical studies finds that expansion of transfers leads to non-negligible increases in birth rates in the U.S. (Georgellis & Wall, 1992; Whittington et al., 1990) and other developed countries (Bjorklund, 2006, Sweden; Ermisch, 1998, UK). Additionally, De la Croix & Doepke (2009) demonstrate theoretically that voting on public education interacts with fertility decisions. The predictions of their theory are consistent with the data on U.S. states and cross-country evidence.

[2] One of the most celebrated studies in this area is Krusell & Rios-Rull's (1999) paper.

bor supply and growth of total expenditures on education subsidies. Both factors contribute to increases in equilibrium tax rates. Therefore, a median voter would choose less generous transfers and education subsidies, which turn out to be much closer to the U.S. data than in the absence of endogenous fertility.

The implications of the model regarding a cross-section of U.S. states are used to validate the framework and circumvent the lack of empirical evidence on the elasticities of fertilities with respect to public policies. Taken redistribution policies as given, the model replicates the variations and levels of education subsidies, average numbers of children, and fertility differentials across U.S. states quite closely.[3] This confirms the plausibility of the model and, consequently, the credibility of the main result, which highlights the importance of endogenous fertility for high performance of the model in explaining the levels of public expenditures in the U.S. The remainder of this study is organised as follows. Section 2 discusses related literature, section 3 presents the model and section 4 introduces calibration. Section 5 describes the results including evaluation of the model's ability to replicate the levels of public expenditures observed in the U.S. data, and presents model validation based on data from a cross-section of U.S. states.

2 Related Literature

The contribution of this paper is twofold. First, it demonstrates that a politico-economic extension of a standard model with endogenous fertility in the style of Barro & Becker (1989), in which redistribution and education subsidisation policies are determined by majority voting, goes a long way to explain the levels of both types of public expenditures in the U.S. Notably, the assumption of endogenous fertility is quantitatively important for this result. Second, the study builds a quantitative theory connecting transfers, public education provision, intergenerational persistence of earnings, and endogenous fertility in the U.S.

[3] Since the greatest part of transfers are financed from federal budget, redistribution policy is assumed to be exogenous at the state level.

The first contribution makes the current study close to theoretical and quantitative political economy literature. There is a wide range of theoretical studies analysing determinants of redistribution and education policies. As opposed to this paper, most theoretical studies focus on factors related to individuals' perceptions and preferences, which are typically very difficult to quantify. For instance, Piketty (1995) shows that preferences for redistribution depend on individual histories of productivities. Benabou & Ok (2001) suggest that demand for redistribution is influenced by individuals' perceptions of upward mobility. Alesina & Angeletos (2005) demonstrate that individual choices of redistribution policies might be also affected by individuals' ability to distinguish between the "luck" and "effort" components of income. Additionally, the choice of public provision of education may depend on community income (Fernandez & Rogerson, 1998). Agents may also support public provision of education due to positive externalities related to accumulation of human capital (Benabou, 1996). The studies listed above endogenise either redistribution or education policies. Bernasconi & Profeta (2012) and Ono (2016) are among the few papers integrating both types of policies. The quantitative analysis presented in this study, which also integrates both policies, may be seen as complimentary to these theoretical papers.

One of the most influential quantitative studies in this area is Krusell & Rios-Rull (1999). Similarly to their work, this paper analyses a dynamic framework and investigates whether the level of redistribution observed in U.S. data could be rationalised as an outcome of politico-economic equilibrium. However, beyond endogenous fertility, the fundamental assumption of this paper, which distinguishes it from Krusell & Rios-Rull, is uncertainty driven by ability shocks. Consequently, the costs-benefit comparison motive of demand for redistribution in the style of Meltzer & Richard (1981) is augmented by parental willingness to insure their children against negative ability shocks.

The main contribution of this work to the politico-economic literature discussed above is its consideration of endogenous fertility. The literature in this area is scarce. One example is a study by De la Croix & Doepke (2009), who connect private education and voting on public funding for schooling with endogenous fertility. This paper abstracts from the choices between public and private schools, but extends the setup analysed in their study to a dynamic dynastic framework in which both education and redistribution policies are endogenous and determined through majority voting.

The second contribution relates this paper to a wide range of studies devoted to theoretical and quantitative modelling of redistribution and education policies and their interaction with intergenerational correlation of earnings and income inequality. Restuccia & Urrutia (2004), Sephardi & Yuki (2004), Erosa & Koreshkova (2007) and Krueger & Ludwig (2013) are examples of papers in this area. Most of these studies evaluate the roles of redistribution and education policies separately, while this study integrates both policies, similarly to Krueger & Ludwig. Additionally, this paper contributes to this strand of literature by endogenising fertility. The literature in this area is scarce: De la Croix & Doepke (2003,2004), Moav (2005) and Fan & Zhang (2013) are among the few examples of theoretical studies in this domain. This paper extends frameworks developed in these papers to a dynamic dynastic setting with stochastic abilities.

The example of quantitative study in this area is Knowles (1999a,1999b). Similarly to this paper, Knowles develops a general equilibrium model in which both decisions on the human capital of children and fertilities are endogenous. This study extends the work of Knowles by considering public provision of education and endogenising education and redistribution policies through majority voting.

3 Model

This section begins with the description of the economic environment and a definition of equilibrium assuming that education and redistribution policies are exogenous. Then the concept of politico-economic equilibrium is formulated.

The methodology in this work builds on Barro & Becker (1989) and Alvarez (1999), who introduce endogenous fertility and human capital formation into a dynamic dynastic model and Knowles (1999a), who extends this basic framework to a general equilibrium setting. This paper further extends the methodology developed in these studies by introducing education policy and endogenising both redistribution and education policies as outcomes of politico-economic equilibrium.

3.1 The economic environment. Exogenous policies

Consider a two-period overlapping-generation dynastic model populated by an infinite number of individuals. Agents live for two periods corresponding to 0-25 and 26-50 years in a real economy. All decisions in the model are taken by parents who decide on the number of their children, their investments in the education of each child, and consumption. There is a government in the economy that proportionally taxes incomes and uses tax revenue to finance transfers, education subsidies and exogenous government expenditures. The distribution of transfers across income groups is exogenous and replicates the combination of direct and means-tested benefits in the U.S. economy.

3.1.1 Education and human capital

This study focuses on a primary education (corresponding to K-12 in the U.S.) and for simplicity abstracts from college education. This simplification is motivated by the fact that expenditures on primary education are likely to be more important for fertility decisions than expenditures on college, which take place later after child birth. Additionally, as demonstrated by Keane & Wolpin (1997), around 90% of the variance in lifetime utility is determined by the heterogeneity of skills acquired by the age of 16, prior to entering college. The human capital production technology takes the following form:

$$h' = z'[h^{\kappa}(\theta + e)^{1-\kappa}]^{\eta}$$

where $0 < \kappa, \eta < 1$, h' denotes the human capital of the child, z' is iid ability shock for the child, h is parental human capital, θ is public provision of primary education, e is private spending on primary education.

Following Restuccia & Urrutia (2004), I assume that public and private funding are perfect substitutes. Public provision of education θ corresponds to state and federal funding of public schools, while private expenditures are interpreted as local funding of primary education financed by local taxes. Consequently, each productivity type should be interpreted as a community of homogeneous agents who choose the amount of local funding of public schools along with number of children and consumption.

3.1.2 Individual problem

Individuals are referred to as children and adults in first and second periods of their lives. All decisions are made by adults. At the beginning of the second period, individuals enter adulthood and decide on the number of their children, investments in the education of each child, and consumption. The ability shock of child is revealed after decisions on the number of children and investments in the education of each child is made. Preferences are in the style of Barro & Becker (1989) with parental utility depending on current period consumption and the expected utility of each child, weighted by an increasing concave function of the number of children. Individual earnings are determined by human capital or productivity and time devoted to paid work.

For now, education subsidies θ_t and transfers T_t are exogenous. I keep time indexes for variables because public policies and, consequently, individual decisions may change over time. The dynamic programming formulation of individual problem is as follows:

$$V_t(h) = \max_{c_t, n_t, e_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \beta n_t^{\xi} E_{z'}[V_{t+1}(h')] \right\}$$

subject to

$$c_t + [g_t(i_t) + e_t]n_t \leq w_t h(1 - \phi n_t)(1 - \tau_t) + T_t(i_t/\bar{i}_t),$$

$$T_t(i_t/\bar{i}_t) = \lambda_{0t}\lambda(i_t/\bar{i}_t),$$

$$g_t(i_t) = \bar{g}(i_t),$$

$$h' = z'[h^{\kappa}(\theta_t + e_t)^{1-\kappa}]^{\eta}$$

where h is human capital or productivity, w_t is wage, $i_t = w_t h(1 - \phi n_t)$ is income, $\bar{i}_t$ is average income, τ_t is a labor income tax, T_t is transfers which depend on income according to parameter λ_{0t} and function $\lambda(i_t/\bar{i}_t)$ discussed in the calibration section below, z is iid ability shock, $\log(z) \in N(0, \sigma_z^2)$, c_t is the consumption of an adult individual, g_t is the cost of children in terms of goods, which depends on parental income according to function $\bar{g}(i_t)$ discussed in the calibration section below.

3.1.3 Production

A large number of firms rent effective labor from households in competitive markets. The production technology is determined by linear function: $Y_t = L_t$, where L_t is an aggregate effective labor supply.

3.2 Economic equilibrium

Let $\psi_t(h)$ denote the share of agents at time t with human capital $h \in H = [\underline{h}, \bar{h}]$.
The definition of recursive competitive equilibrium assumes that public policies are exogenous. Given an initial measure ψ_0 of individuals, a competitive equilibrium is a sequence of value functions and policy rules $\{V_t, c_t, e_t, n_t\}_{t=0}^{\infty}$, production plans $\{Y_t, L_t\}_{t=0}^{\infty}$, sequence of transfers, education subsidies and labor income taxes $\{T_t, \theta_t, \tau_t\}_{t=0}^{\infty}$, sequence of prices $\{w_t\}_{t=0}^{\infty}$ and sequence of measures $\{\psi_t\}_{t=1}^{\infty}$ such that:
1) given prices and government policies, $\{V_t, c_t, e_t, n_t\}_{t=0}^{\infty}$ solves the individual problem specified above;
2) prices $\{w_t\}_{t=0}^{\infty}$ are determined by the optimal behaviour of the representative firm;

3) the government budget is balanced in all periods t:

$$\int [T_t(i_t/\bar{i}_t) + \theta_t n_t] d\psi_t + E_t = \tau_t w_t L_t,$$

where $E_t = \delta Y_t$ are exogenous government expenditures, $0 < \delta < 1$;

4) markets clear in all periods t:

a) market of goods: $Y_t = \int \big[c_t + [g_t(i_t) + e_t + \theta_t] n_t\big] d\psi_t + E_t$;

b) labor market: $L_t = \int \big[h(1 - \phi n_t)\big] d\psi_t$;

5) $\psi_{t+1} = G_t^{\psi}(\psi_t)$, where G_t^{ψ} is a law of motion for measures of individuals, which is determined by households' decision rules and a stochastic process for abilities z. The explicit definition of the law of motion for measures is as follows. For all subsets $B \in H$ the Markov transition function at time t is defined as

$$P_t(h, B) = \begin{cases} p(z'), & \text{if } h'(z', h, e_t) \in B, \\ 0, & \text{otherwise.} \end{cases}$$

In other words, the probability of going from state h to a subset of states B is zero if that set does not include the next period child human capital h', which is determined according to the given human capital production technology $h'(z', h, e_t) = z'[h^{\kappa}(\theta_t + e_t)^{1-\kappa}]^{\eta}$. If B includes h', then transition probability is fully determined by the stochastic process for abilities.

Given the definition of the Markov transition function, the next period's measures of individuals are given by:

$$\psi_{t+1}(B) = \frac{\int P_t(h, B) n_t d\psi_t}{\gamma}$$

where γ is equal to average fertility and shows the relative size of the next period generation to the current generation:

$$\gamma = \int n_t d\psi_t.$$

3.3 Politico-Economic equilibrium

Now assume that transfers T and education subsidies θ are endogenous and determined as outcomes of majority voting. That is, similar to Meltzer & Richard (1981) and Krusell &

Rios-Rull (1999), agents vote for the levels of transfers and education subsidies that maximise their equilibrium utility, and equilibrium policies coincide with those preferred by a median voter.

In order to derive individuals' preferences over transfers and education subsidies, I introduce the following assumptions. First, agents anticipate that the policies chosen in the current period will be in place forever. This assumption is quite realistic given that agents are likely to be myopic.[4] Second, as in Meltzer & Richard (1981) and Krusell & Rios-Rull (1999), agents correctly predict the general equilibrium effects of redistribution and education policies and calculate their utilities accordingly.

Given these assumptions, individuals' preferences over transfers and education subsidies are defined in the following way. Assume that given levels of redistribution and education policies (T, θ) were run forever so that the economy is in a steady state and at the beginning of the current (zero) period there is an occasional opportunity to re-vote on policies. The utility of an individual with human capital h associated with introduction of an alternative level of transfers T' and education subsidies θ' is given by:

$$W(h, \theta, T, \theta', T') = V_0(h) \text{ so that } T_{-1} = T,\ \theta_{-1} = \theta \text{ and } T_t = T',\ \theta_t = \theta' \ \forall\ t \geq 0.$$

$V_0(h)$ is the utility of an individual with productivity h, T_{-1}, θ_{-1} are policies at the beginning of the current period, T', θ' are alternative policies introduced in the current period and run forever.[5] Utility $W(h, \theta, T, \theta', T')$ depends on status quo policies (T, θ) since these policies determine current period distribution of individuals ψ_0 and, consequently, affect subsequent distributions $\{\psi_t\}_{t=0}^{\infty}$, which, in turn, influence individual utility through equilibrium tax rates.

[4]The current approach might be criticised from the position of the dynamic voting paradigm of Krusell & Rios-Rull's (1999) and subsequent literature. In this study, implementation of dynamic voting is not feasible due to uncertainty.

[5]When calculating their utilities, individuals take into consideration the transition path from the current steady state to the new stationary equilibrium under alternative policies (T', θ').

Since policy space is bi-dimensional, Nash equilibrium may not necessarily exist in a majority voting game. Therefore, following Conde-Ruiz & Galasso (2003) and Ono (2016), I use the so-called issue-by-issue voting concept formalised by Shepsle (1979). Under this concept, a sufficient condition for 2-tuple (T^*, θ^*) to constitute a politico-economic equilibrium of voting game is that T^* constitutes an majority-voting equilibrium, given that the other policy θ is fixed at the level θ^* and vice versa. Additionally, preferences must be single-peaked in each dimension of the policy space. In this study, I quantitatively verify that these conditions are satisfied.

According to the issue-by-issue voting concept, in this model majority-voting equilibrium is defined as follows. If a median voter prefers not to deviate from the current policy T, then T constitutes majority-voting equilibrium transfers given education subsidies θ:

$$T = T(T, \theta) = \underset{T'}{\text{argmax}}\, W(h_m(\theta, T), \theta, T, \theta' = \theta, T')$$

where $h_m(\theta, T)$ is the human capital of a median voter.

Similarly, if agents are voting on education subsidies, and a median voter prefers not to deviate from the current policy θ, then θ constitutes a majority-voting equilibrium education subsidisation policy given transfers T:

$$\theta = \theta(T, \theta) = \underset{\theta'}{\text{argmax}}\, W(h_m(\theta, T), \theta, T, \theta', T' = T)$$

Consequently, the fixed-point condition determining issue-by-issue voting equilibrium (T^*, θ_0^*) is determined by solving a two equation system:

$$T^* = T(\theta^*, T^*);\ \ \theta^* = \theta(\theta^*, T^*).$$

4 Calibration

This section describes estimation of the model parameters. The model is calibrated assuming that policies are set exogenously at the corresponding U.S. levels and the economy is in the steady state.

The following parameters take values which are standard for macroeconomic literature: $\beta = 0.366 = 0.99^{100}$ so that the quarter discount rate is 0.99, as in Aiyagari (1994). The share of parental time spent on children ϕ is equal to 0.09 as in De la Croix and Doepke (2003), who set an analogous time cost parameter equal to 0.075 in a model with a period of 30 years. Because in this current model, the period is 25 years, the parameter is adjusted to $0.09 = 0.075 * 30/25$. A government expenditure-to-GDP ratio of 0.165 is calculated as 0.19 (Krusell & Rios-Rull, 1999) less 0.025 corresponding to the ratio of expenditures on public primary education to GDP, which is endogenous in the current model.

The remaining parameters are jointly calibrated so that, given the redistribution and education policies set exogenously at the levels corresponding to the U.S. data, the steady state equilibrium replicates the relevant statistics of the U.S. economy described below.

4.1 Data

I begin by discussing the timing of the data used to evaluate characteristics of the U.S. economy. This study focuses on 1992-2002, because I use a cross-section of U.S. states to evaluate model performance. 1992 is the earliest date that Census data on state government finances is available, and 2002 is close to the year when the 1980-1982 cohort entered adulthood. This cohort is analysed in Chetty et al. (2014), which is apparently the only data source on intergenerational correlation of earnings across U.S. states.

4.1.1 Transfers

The distribution of transfers across individuals is exogenous and governed by the function $\lambda(i_t/\bar{i}_t)$. This study focuses on money transfers and does not consider population-based services and public goods. Money transfers in the U.S. consist of direct and means-tested benefits. Direct transfers include expenditures on Social Security, Medicare, Unemployment Insurance and Worker's Compensation. Payments for retirees are excluded from transfers, because old age is not analysed in the model. While direct transfers are not conditional on the income of recipients, means-tested transfers mostly benefit low income individuals. The largest means-tested programs are Medicaid, Earned Income Tax Credit (EITC), Food Stamps and Supplemental Security Income (SSI).

As in Krusell & Rios-Rull (1999), total expenditures on direct benefits are set at 1.7% of GDP (spending on pensions account for 5.1% GDP, according to the OECD Social Expenditure Statistics 1995). Means-tested transfers are set at 3.7% of GDP including payments from the federal budget (1.1% of GDP) and spendings from state and local budgets (2.6% of GDP).[6] Using estimates of aggregate expenditures on transfers and distribution of transfers across income groups from *The Redistributive State: The Allocation of Government Benefits, Services, and Taxes in the United States* report provided by the Heritage Foundation, I evaluate the distribution of total transfers across income quintiles (see table 1 below).[7]

Table 1: Distribution of transfers

Income quintile	First	Second	Third	Fourth	Fifth
Direct transfers	0.24	0.26	0.2	0.15	0.14
Means-tested transfers	0.46	0.29	0.15	0.08	0.04
Total transfers estimated	0.4	0.28	0.16	0.1	0.07

Notes. The first two rows are based on data from the Heritage Foundation. The last row shows the author's calculations.

As seen in table 1, the distribution of total benefits is skewed to the bottom of the income distribution. In order to replicate this property of distribution of transfers, I employ the following functional form:

$$\lambda(i/\bar{i}) = (i/\bar{i} + \lambda_1)^{-\lambda_2}$$

[6]Krusell & Rios-Rull use 1995 as an example year to estimate expenditures on transfers, while this study focuses on 1992-2002. However, the calculations based on the data from the *Statistical abstract of the United States* for the latter period are very close to those provided in Krusell & Rios-Rull's paper. Therefore, I use the estimates from this influential study to make the results of this paper more comparable to existing literature.

[7]http://www.heritage.org.

where $\lambda_1 > 0$ guarantees that transfers received by individuals with zero income is finite. Since the absolute level of λ is irrelevant, λ_1 could be normalised to 1 without loss of generality. Parameter $\lambda_2 > 0$ jointly calibrated with other parameters ensures that distribution of transfers is skewed to the bottom of the income distribution.[8]

4.1.2 Cost of children in terms of goods

This type of cost includes necessary expenditures on children of housing, food and clothing. According to data from *Expenditures on Children by Families* 1996 provided by the U.S. Department of Agriculture, expenditures on children in terms of goods are increasing with parental income. However, the share constituted by these costs to life-time parental income is decreasing with parental income. This finding is illustrated in table 2 below.

Table 2: Expenditures on children by husband-wife families

Income tertile	First	Second	Third
Before-tax mean annual income, in thousands of dollars	34.7	46.1	87.3
Expenditures on children, in thousands of dollars	66.75	86.4	126.96
Expenditures on children as a share of life-time income	0.24	0.15	0.12

In order to capture these properties of the costs of children in terms of goods, the following functional form is assumed:

$$g_t = g_1 {i_t}^{g_2}$$

where $i_t = wh(1 - \phi n_t)$, $g_1 > 0$, $0 < g_2 < 1$ are parameters to estimate. I choose income shares of expenditures on children for the first and second tertiles as target statistics. This

[8]Knowles (1999a), who also analyses a framework with endogenous fertility, approximates transfers by a second order polynomial. However, I do not follow his approach, because transfers may become non-monotone when the distribution of productivity types changes.

is because, for individuals with relatively low incomes, the costs of children are more likely to be interpreted as necessities than for families from the top of income distribution.

4.1.3 Education

The data on public and local investments in education are from the *Annual Survey of School System Finances* provided by the U.S. Census Bureau. For 1992-2002, public provision of primary education in the U.S. constituted 2.5% of GDP. Total expenditures on primary education from both public and local sources accounted for 4.5% of GDP.

4.1.4 Variance and intergenerational correlation of earnings

Variance of log earnings takes a value equal to 0.36, which is standard for macroeconomic literature (Mulligan, 1997); the estimate of intergenerational correlation of earnings is non-standard and taken from Chetty et al. (2014). Their study demonstrates that standard estimates based on intergenerational correlations of log earnings provided by existing literature including Solon (1992) and Corak (2006) may be biased due to non-linearities of intergenerational earnings elasticity.

In order to avoid this bias, Chetty et al. use an alternative approach based on the correlation between the rank of child income in the income distribution of children and the rank of parental income in the income distribution of parents. This type of estimate has been shown to be substantially more robust than intergenerational earnings elasticity estimates. Additionally, this study follows Chetty et al. because, to the best of my knowledge, this is the only data source for intergenerational correlation of earnings across U.S. states. Based on Chetty et al., the estimated national level of intergenerational earnings correlation is 0.33.[9]

[9] This estimate is below standard evaluations equal to 0.4 (Solon, 1992) and 0.47 (Corak, 2006). However, as the sensitivity analysis presented in Appendix demonstrates, the main results of this study are robust to consideration of standard estimates.

4.1.5 Demographics

To estimate average fertility rates and fertility-income profiles, I use data on the number of Children Ever Born from the 1990 U.S. Census. In the case of women aged 40-49, this variable may serve as an appropriate proxy for life-time fertility, since women are very likely to complete their child birth processes by that age. For the purpose of comparability of estimates of different statistics, I use 1990 data and restrict the sample to women aged 40-45, because this cohort is closest to the cohort of mothers of children born in 1980-1982.[10]

Household income is proxied by total family income per adult family member. Since incomes of individuals stabilise after the age of roughly 40, the annual income of individuals in that age group may serve as an appropriate proxy of life-time incomes. Jones & Tertilt (2008) offer an alternative proxy based on an occupational income score.[11]

I evaluate fertility differentials using both total annual total family income and occupational income scores. Fertility differentials are measured as a ratio of the average fertilities of the bottom income quintile over average fertilities of the top quintile. Average fertility rates and fertility-income profiles for both methodologies are presented in table 3 below. Because there are only minor differences between the two, family income methodology is used for the calibration exercise, due to its larger sample size.

Table 3: Fertility-Income profiles

		Income quintiles				
Methodology	Average	First	Second	Third	Fourth	Fifth
Income	1.13	1.31	1.16	1.11	1.06	0.99
Occupation score	1.11	1.29	1.14	1.10	1.04	0.97

[10] As in Jones & Tertilt (2008), I restrict the sample to married women.

[11] According to the U.S. Census definition, the occupation income score is a constructed variable that assigns a measure of the median earned income for each occupation. This study uses a variable based on the 1990 occupational classification scheme.

4.2 Jointly calibrated parameters

The parameters $\xi, \sigma, \theta_0, \eta, \kappa, \sigma_z, \lambda_0, \lambda_2, g_1, g_2$ are calibrated to match the statistics of the U.S. economy described above. While there is no one-to-one correspondence between parameters and target statistics, parameters are assigned based on the principle of sensitivity. Higher values of σ increase the curvature of the utility function. Consequently, as Knowles (1999a) suggests, number of children increases. Therefore, σ is assigned to average fertility.[12] Parameter ξ affects the marginal utility of an additional child. I assign ξ to the fertility differential between low and high income individuals. Investments in education are governed by the parameters of the human capital production function. Parameter θ denotes government subsidisation of primary education as a share of GDP. Parameter η reflects returns on education and, therefore, corresponds to total investments in education. I assign κ to the intergenerational correlation of earnings because this parameter influences the relative importance of parental human capital for the future human capital of a child. The variance of ability shock σ_z is assigned to the variance of log earnings.

The parameter of transfer function λ_0 affects an aggregate level of transfers as a share of GDP. Parameter λ_2 influences the curvature of the transfer function and, therefore, corresponding target statistics is a share of transfers paid to middle quintile of the income distribution. Clearly, one parameter is not enough to match the whole distribution of transfers. However, as I demonstrate later in the text, the resulting distribution of transfers in the equilibrium is very close to that in the data. Parameters g_1 and g_2 of the function $\bar{g}$ are responsible for expenditures on children in terms of goods for the bottom and middle tertiles of the income distribution. The estimates of calibrated parameters are presented in table 4 below. Columns "U.S." and "Model" demonstrate that the model replicates target statistics of the U.S. economy quite well.

[12] Note that, due to endogenous fertility, $1 > \sigma > 0$.

Table 4: Estimates of jointly calibrated parameters

Description	Parameter	Value	Target	U.S.	Model
Risk aversion parameter	σ	0.41	Average fertility rate	1.13	1.128
Curvature of altruism factor	ξ	0.42	Fertility differential	1.31	1.31
Std dev of noise in z	σ_z	0.56	Variance of log earnings	0.36	0.362
Education subsidy	θ	0.009	Public education, % GDP	2.5	2.5
Elasticity of HC w.r.t. inputs	η	0.39	Total education, % GDP	4.5	4.6
Exponent on parental HC	κ	0.54	Persistence of earnings	0.33	0.33
Generosity of transfers	λ_0	0.27	Total transfers, % GDP	5.4	5.4
Slope of $\lambda(i/\bar{i})$	λ_2	2.9	Transfers, middle tertile	0.16	0.16
Generosity of child cost	g_1	0.07	Child cost, bottom tertile	0.24	0.237
Slope of child cost	g_2	0.32	Child cost, middle tertile	0.15	0.148

4.3 Benchmark model fit

In this subsection I evaluate the performance of the calibrated model in replicating characteristics of the U.S. economy, which are important for the results but not directly targeted in the calibration.

The distribution of transfers across income groups is important because it affects demand for redistribution. Table 5 below demonstrates that the distribution of transfers generated by the model is very close to the data. Therefore, the choice of the functional form of λ is reasonable. The distribution of earnings is another important characteristic of the economy because it affects the median voter's demand for insurance. In the calibration exercise, the target parameter is the variance of log earnings. However, as the table above shows, the calibrated model is capable of replicating the whole distribution of earnings. The relative position of the median voter determined by the median-to-mean income ratio is matched very closely: 0.837 versus 0.835 in the data.[13]

[13]Data source: U.S. Census 1990.

Table 5: Distribution of transfers

Income quintile		First	Second	Third	Fourth	Fifth
Distribution of transfers	Benchmark	0.41	0.26	0.16	0.11	0.06
	U.S.	0.40	0.27	0.16	0.10	0.07
Distribution of earnings	Benchmark	0.37	0.64	0.84	1.13	2.01
	U.S.	0.36	0.66	0.85	1.11	2.01

Additionally, the model replicates negative/positive relations between the number of children/expenditures on education per child and parental incomes (see figure 1 below)[14]. Although, in general, the Barro-Becker model does not guarantee reproduction of these properties.

The results presented above demonstrate that the model is able to account for the salient features of the U.S. economy and, therefore, may serve as a proper laboratory for quantitative investigation of the role of endogenous fertility in explaining redistribution and education policies in the U.S.

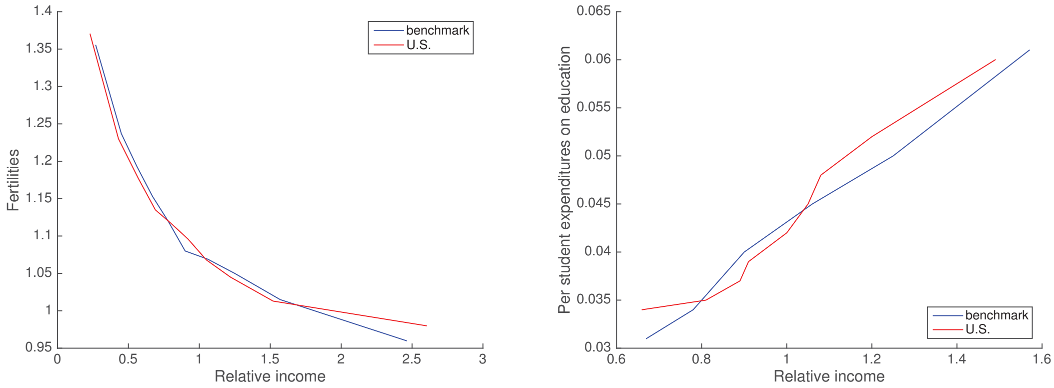
5 Results

5.1 Politico-economic equilibrium: education and redistribution policies in the U.S.

In this section I analyse whether distribution and education policies observed in the U.S. can be rationalised as outcomes of the politico-economic equilibrium defined in the section 3

[14]The fertility-income profile is estimated from U.S. 1990 Census data. The relation between investments in education per child and parental income is evaluated based on data on per student expenditures on primary education provided by the Census's *Annual Survey of School System Finances* report, and the data on local incomes provided by the Bureau of Economic Analysis.

Figure 1: Fertility-income and education-income profiles



A: Fertilities

B: Investments in education

above. For this purpose, relying on estimates of parameters σ, ξ, η, κ, σ_z, g_1, g_2, λ_2, I solve numerically for politico-economic equilibrium redistribution and education policies.[15]

In order to quantify the role of endogenous fertility in determining redistribution and education policies, I compare the benchmark model (with endogenous fertility) with the model in which fertility is exogenous. The latter model assumes that fertilities are homogeneous across individuals and are set equal to the average number of children in the benchmark economy.[16]

Since this study employs the concept of issue-by-issue voting, this implies that, practically, the politico-economic equilibrium can be found by first solving for the majority-voting equilibrium level of transfers given education subsidies $T(\theta)$ and second, by solving for equilibrium education subsidies given transfers $\theta(T)$. Generally, there is no guarantee of the existence and uniqueness of a politico-economic equilibrium in the model. However, it can

[15]The procedure of calibrating the model assuming that policies are exogenous and then employing a calibrated model to analyze whether policies observed in the data can be rationalised as outcomes of politico-economic equilibrium is similar to that employed by Krusell & Rios-Rull (1999).

[16]The elimination of endogenous fertility from the model does not substantially change its ability to replicate the key characteristics of the U.S. economy; see table 8 in Appendix A.

be quantitatively verified that functions $T(\theta)$ and $\theta(T)$ are well behaved and that the resulting politico-economic equilibrium is unique. Before turning to the main results of the paper, I discuss the complementarity between redistribution and education policies demonstrated by the model, and differences in the slopes of response functions $T(\theta)$ and $\theta(T)$.

5.1.1 Complementarity between policies

As can be seen from figure 2 below, both $T(\theta)$ and $\theta(T)$ are increasing functions of their arguments. Note that assumption of endogenous fertility is not essential for complementarity between policies.

The intuition for this result is as follows. A redistribution policy impedes individuals' incentives to invest in educating their children. Education subsidies may mitigate this adverse effect of transfers by improving average productivity. Therefore, the given level of transfers may be financed by lower equilibrium tax rates. Consequently, when transfers become more generous, a median voter would support more generous education subsidies, and vice versa. In other words, the policies are complements. This result is in line with the findings of existing literature including Bovenberg & Jacobs (2005) and Krueger & Ludwig (2013), although, these studies analyse policies from the social planner's perspective as opposed to the political economy paradigm employed in this paper.

Additionally, response function $\theta(T)$ corresponding to equilibrium education subsidies is steeper than response function $T(\theta)$ corresponding to equilibrium transfers. Similarly to the property of complementarity, an assumption of endogenous fertility is not crucial for this result. To see the intuition, consider the cases of voting on each of two policies separately. If redistribution policy is a given and individuals vote on education policy, more generous transfers discourage parents from investing in educating their children. Consequently, in an economy with higher levels of transfers, the median voter is poorer compared to a mean-income individual and supports more generous redistribution through education subsidies. This median-voter effect amplifies the effect of complementarity discussed above.

In contrast, when education policy is a given and agents vote on redistribution, more generous education subsidies improve productivity and reduce inequality due to crowding-out of private investments in education. Consequently, in an economy with higher education subsidisation, the median voter is richer than the mean-income individual and prefers less generous redistribution through transfers.In this case, the median-voter effect acts in the opposite direction to the complementarity effect.[17] Therefore, the slope of the response function $T(\theta)$ is lower than the slope of $\theta(T)$.

5.1.2 Equilibrium policies and endogenous fertility

The benchmark model predicts equilibrium transfers and education subsidies equal to 5.5% and 2.9% of GDP respectively (see column "Benchmark", table 6). This is close to the U.S. data (column "Calibrated model"). Given that equilibrium policies are quite close to the U.S. data, the statistics of the U.S. economy predicted by the benchmark model are close to the data as well (see table 8, Appendix A).

This study demonstrates that assumption of endogenous fertility is important for the ability of the model to perform well in replicating U.S. data. Once endogenous fertility is eliminated from the framework, equilibrium levels of both transfers and education subsidies increase substantially. Transfers increase by 53%, while education subsidies increase by 31% compared to the benchmark (see column "Exogenous fertility").

Endogenous fertility is important because it increases the costs of transfers and education subsidies, since both policies positively affect fertility differentials between low and high income parents and the average number of children.

In contrast to low income individuals, for high income parents, income and substitution effects act in the opposite directions.[18] Therefore, transfers and education subsidies positively

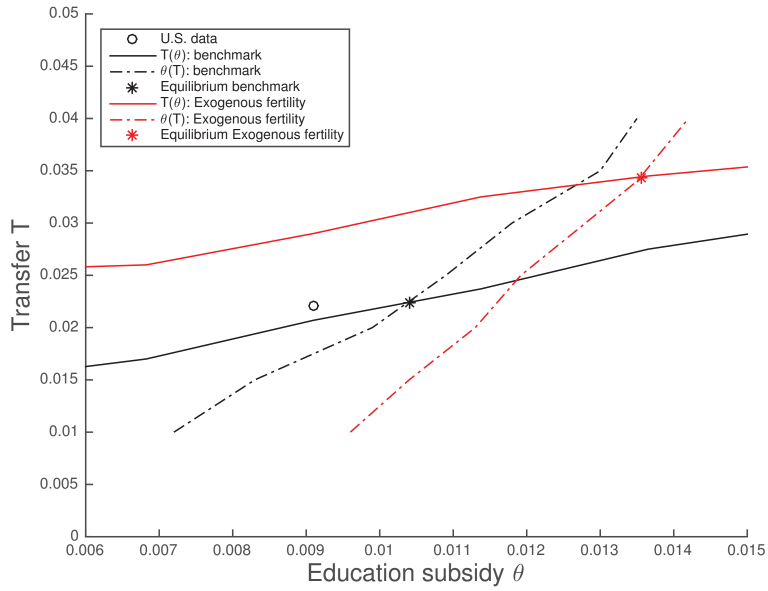
[17]However, the equilibrium level of transfers is increasing with education subsidisation, because the complementarity effect is quantitatively more important than the median-voter effect.

[18]Since both transfers and education subsidies imply redistribution of resources from rich to poor agents, the income effect of policies on fertilities is positive for low income parents and negative for high income

Table 6: Politico-economic equilibria

Statistics	Calibrated model	Benchmark	Exogenous fertility
Education subsidisation per child θ	0.0091	0.0104	0.0136
Education subsidisation, % of GDP	2.5	2.9	4.7
Transfers per capita T	0.0221	0.0224	0.0343
Transfers, % of GDP	5.4	5.5	8.3

Figure 2: Politico-economic equilibrium



Notes. Black and red colours correspond to endogenous fertility (benchmark) and exogenous fertility models, respectively. Solid lines correspond to equilibrium transfers $T(\theta)$ given an education policy. Dashed lines correspond to equilibrium education subsidies $\theta(T)$ given transfers. The interceptions of response functions $T(\theta)$ and $\theta(T)$ correspond to politico-economic equilibrium in each case.

affect fertility differentials.[19] Increases in fertility differentials, in turn, lead to a higher share

parents. In contrast, since both policies lead to declines in the opportunity costs of children and investments in education per child, the substitution effect increases incentives to have children for both types of parents.

[19]See examples in subfigures A and B, figure 3, in Appendix A, illustrating adjustments in fertility differ-

of low productive individuals and declines in average productivity. Consequently, one would need a higher budget-balancing tax rate to finance the given levels of public policies.

Similarly to fertility differentials, the average number of children is positively affected by transfers and education subsidies, because the substitution effect quantitatively dominates income effect for high income parents and fertilities of both productivity types increase (see the example in figure 3, subfigure C, in Appendix A). Increases in the average number of children positively affect equilibrium tax rates as well, due to their negative impact on aggregate labor supply and positive impact on aggregate expenditures on education subsidies.

Consequently, due to higher equilibrium tax rates, the costs of transfers are more substantial when fertility is endogenous and the median voter would support lower levels of transfers and education subsidies, which are much close to the U.S. data than in the absence of endogenous fertility (see figure 2 above).

Additionally, a concern that may arise is whether the results presented above are driven by the impact of fertility decisions on the labor supply (due to time costs of raising children) or by the impact of fertility and child education decisions on the distribution of productivity types. In order to shed some light on this question, I compare equilibria in the benchmark and exogenous fertility models with an Exogenous Fertility - Benchmark Labor (ExF-BL) model (see subfigure D, figure 3, in Appendix A). In the latter framework, fertilities are exogenous, and the labor supply is fixed and corresponds to that in the benchmark model with endogenous fertility. This setup preserves labor supply responses as in the model with endogenous fertility, but eliminates the impact of fertility decisions on the distribution of productivities from the analysis, because individuals are not choosing the number of their children.

As subfigure D, figure 3, in Appendix A demonstrates, the equilibrium in the ExF-BL model is very close to that in the model with exogenous fertility. Therefore, the impact of

entials on the transition path from the equilibrium corresponding to the current U.S. policies to equilibria under alternative policies.

fertility and child education decisions on the distribution of productivities is quantitatively more important than the impact of fertility decisions on the labor supply. Consequently, the assumptions of both endogenous fertility and human capital introduce a significant element into the model which is unlikely to be mimicked by assumptions of endogenous labor supply and human capital.

Finally, the main results of this paper are robust to small variations in the parameters of the model (see table 9 in Appendix A).

5.2 Model validation based on a cross-section of U.S. states

The credibility of the results presented above crucially depends on the plausibility of fertility elasticities with respect to redistribution and education policies predicted by the model. There are a number of empirical studies including Georgellis & Wall (1992), and Whittington et al. (1990) confirming positive effects of transfers on fertilities in the U.S. However, the estimates obtained in these studies cannot be used to discipline the current model due to a lack of information regarding the elasticities of completed fertilities. In addition, apparently there is no empirical evidence on the impact of expansion of public schooling subsidies on fertilities in the U.S.

In order to circumvent these difficulties, I validate the model based on a cross-section of U.S. states. This setting can serve as an excellent case study, because all states operate within a similar political system while exhibiting substantial variations in the levels of transfers, tax rates and public subsidies for schooling. Transfers are financed mostly from the federal budget. According to data from the *Federal Expenditures by State* and *Census Annual State Government Finance* reports provided by the 1990 U.S. Census, only 20% of total expenditures on transfers are financed by state and local governments.[20] Therefore, this variable is treated as exogenous at the state level. In contrast, expenditures on primarily education are

[20]In the states with the highest levels of funding from their own resources (Minnesota and New Hampshire) contributions from state and local governments account for at most 36% of total expenditures.

determined mostly at the state and local levels. According to the 1990 U.S. *Census Annual Survey of School System Finances* report, only 7% of expenditures are financed from the federal budget, while the rest is financed from state and local budgets.[21] Therefore, education policy is treated as endogenous at the state level and determined through majority voting.

Federal expenditures on transfers are divided into two groups. The first is direct payments from the federal budget to individuals in the form of direct benefits and means-tested transfers. The second is federal payments to state and local governments in the form of aid for financing means-tested transfers. Both types of federal payments vary across states for various reasons.

First, since U.S. states form a federal fiscal union, the federal government may transfer relatively more resources in the form of transfers to states with relatively low incomes. According to the 1999 *Congressional Research Service* report, federal financing of certain types of transfers is an inverse function of per capita state income. One example is the Federal Medical Assistance Percentage Program used to finance Medicaid, which accounts for near half of all spending on means-tested transfers. Second, political preferences vary across states. More democratic-leaning states may lobby for higher expenditures on transfers from the federal budget. Third, as pointed out by Serrato & Wingender (2016), allocation of a wide range of federal spending programs depends on local population measurements. Discrepancies in methodologies used to assess population in different years (Census and non-Census) lead to measurement errors and, consequently, to substantial variations in the allocation of federal expenditures on transfers across states.

Finally, though the greatest portion of funding comes from the federal budget, state and local governments have a certain degree of freedom to decide on eligibility requirements and benefits amounts for various welfare programs. Medicaid and TANF (Temporary Aid to Needy Families) are among these programs.[22] For example, in 2000, Medicaid expenditures

[21]The highest level of federal budget contribution is 13% among all states.

[22]Additionally, states may receive bonuses from the federal government for high performance in meeting program goals. One example is TANF (Temporary Aid to Needy Families).

per enrollee varied between \$ 3043 and \$ 7825, and TANF (Temporary Aid to Needy Families) varied between \$ 3879 and \$ 11877 for families of three with no income.[23]

5.2.1 Empirical evidence

I start with a description of the data sources on public policies, fertilities and intergenerational correlation of earnings across U.S. states. The 1992-2002 time period considered for a cross-section of U.S. states is the same as for the "national" model discussed above.

Transfers. I use data on direct payments to individuals financed by the federal budget from the *Federal Expenditures by State* reports provided by the 1999 Census. The data on state and local expenditures on transfers including aid from the federal budget is from the 1999 *Census Annual State Government Finance*. In order to eliminate variations in the size of transfers due to differences in demographic and population characteristics across states, I adjust expenditures on transfers by the number of recipients using the data on the number of beneficiaries for major programs including Unemployment Insurance, Supplemental Security Income, TANF and Food Stamps programs provided by the 1997 Census.[24]

Taxes. Following Armenter & Ortega (2007), I use federal and state personal current taxes as empirical counterparts for income tax rates in the model. The data is provided by the *Bureau of Economic Research*, regional accounts. The tax rates are evaluated as an average ratio of total personal current tax revenue over total personal income for 1992-2002.

It is important to account for tax rates variation across states, because expenditures on transfers are budget-balanced in the model. In contrast, in the U.S. economy expenditures on transfers are not balanced by tax revenue, since the greatest part of transfers is financed from federal budget. Therefore, in order to assess the credibility of the assumption of budget-balancing transfers, it is useful to check whether more generous expenditures on transfers are

[23]Sources: U.S. Department of Health and Human Services and the *Kaiser Family Foundation*, www.kff.org

[24]Specifically, first I calculate transfers (financed from both federal, state and local sources) per recipient, which I then premultiply by the average share of transfer recipients in a population across states. The data on recipients can be found via https://www.census.gov/prod/99pubs/99statab/sec12.pdf.

associated with higher tax rates. Below I demonstrate that this is indeed the case.

Other variables. The sources of the data on primary education, intergenerational mobility and demographic variables are the same as in the calibration section above.

Table 7 presents the correlations between key economic variables. All correlations are significant at least at a 10 per cent level (the notations of the variables are provided in table 10, Appendix B). States with more generous transfers have more generous public subsidies for primary schooling, higher tax rates and lower intergenerational correlation of earnings. Additionally, these states are characterised by higher fertilities and fertility differentials.

Notably, positive correlation between transfers and tax rates cannot be explained by more generous public subsidies for primary education. In order to demonstrate this, I introduce a so-called net tax measure equal to the tax rate less the ratio of public subsidies for primary schooling to aggregate state incomes. As can be seen from table 7, the correlation between net tax and transfers is positive. The relationships between variables are preserved in the case of alternative measures of fertility differentials, transfers adjusted by the costs of living and transfers and education subsidies measured as a share of state GDP (see table 11, Appendix B). Additionally, the results are robust to controlling for a number of factors which are beyond the scope of the current model (see table 12, Appendix B).

5.2.2 Policy experiments

In this subsection I evaluate the accuracy of the model's predictions for a cross-section of U.S. states. I solve for majority-voting equilibrium education subsidies given transfers. The resulting equilibrium corresponds to $\theta(T)$ response function in the benchmark. Additionally, I solve for corresponding fertilities, fertility differentials and intergenerational correlation of earnings. The results are depicted in figure 4 in Appendix B. As subfigure A shows, the model predicts a positive relationship between the levels of transfers and public subsidies for education as in the data (though the model slightly overestimates the generosity of education subsidies).

Table 7: Correlations of key economic variables

Variable	TR	TAX	NETTAX	ED	RM	FERT	FERTDIFF
TR	1						
TAX	0.62***	1					
	(0.000)						
NETTAX	0.57***	0.91***	1				
	(0.000)	(0.000)					
ED	0.46**	0.57***	0.28*	1			
	(0.001)	(0.000)	(0.04)				
RM	-0.35*	-0.46**	-0.34*	-0.38*	1		
	(0.01)	(0.001)	(0.01)	(0.07)			
FERT	0.32*	0.46**	0.24	0.27	-0.4**	1	
	(0.02)	(0.001)	(0.1)	(0.06)	(0.004)		
FERTDIFF	0.41***	0.48*	0.27*	0.45**	-0.26*	0.32*	1
	(0.003)	(0.001)	(0.06)	(0.001)	(0.07)	(0.02)	

*Note *p<.05, **p<.01, ***p<.001

Additionally, the model predicts that states with more generous transfers will have higher fertilities and fertility differentials (see subfigures B and C, figure 4 in Appendix B). While the relations between transfers and the average number of children is a bit steeper than that in the data, the fertility differentials predicted by the model are remarkably close to the data.

Moreover, the model correctly predicts lower intergenerational correlation of earnings in states with more generous redistribution policies (see subfigure D, figure 2). The mechanism driving this result is as follows. More generous transfers discourage parents from investing in educating their children. Therefore, education becomes less correlated with parental income and intergenerational correlation of earnings declines. Additionally, more generous subsidies for public education crowd out parental investments in children's education and, consequently, contributes to further decreases in the intergenerational correlation of earnings.

Finally, the model delivers a relatively accurate prediction of the data in the case of transfer and education subsidies measured as a share of state GDP (see figure 5 in Appendix B). The results above demonstrate that, given redistribution policy, the model delivers relatively accurate predictions of politico-economic equilibrium education policies and corresponding fertilities, fertility differentials and intergenerational correlation of earnings. This confirms that the model can serve as a reliable tool for quantitative analysis of the role of endogenous fertility in explaining the outcomes of generosity of both redistribution and education policies at the U.S. national level presented in the subsection 5.2.

6 Conclusion

This study demonstrates that assumption of endogenous fertility is quantitatively important for explaining the levels of redistribution and education policies in the U.S. The analysis builds on a political economy extension of a dynamic general equilibrium model in the style of Barro & Becker (1989). The model is calibrated to the U.S. economy. Redistribution and education policies are endogenised as outcomes of majority voting.

The study demonstrates that the model with endogenous fertility predicts political equilibrium levels of redistribution and education policies that are quite close to the U.S. data. However, elimination of endogenous fertility from the analysis leads to substantially higher equilibrium levels of both redistribution and education policies. This is because an assumption of endogenous fertility adds costs of transfers and education subsidies, since both policies positively affect fertility differentials and the average number of children. The validation of the model based on a cross-section of U.S. states demonstrates the plausibility of fertility decisions responses and, consequently, the credibility of the main result of this study.

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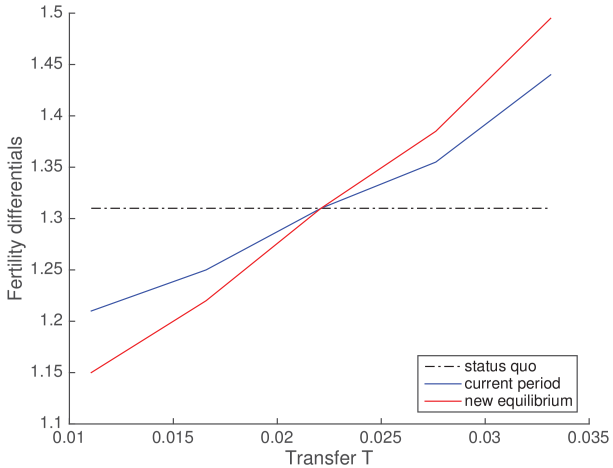
Appendix A

This section presents key statistics predicted by different settings, depicts fertilities and fertility differentials on a transition path including initial stationary equilibrium (U.S. status quo), a current period in which alternative policies are introduced, and a new stationary equilibrium. This section concludes by evaluating the sensitivity of the main results with respect to small changes in parameter values.

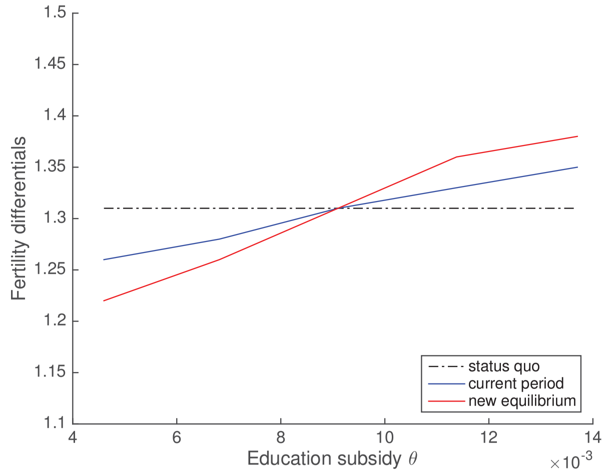
Table 8: Replication of the key statistics by different models

Statistics	U.S.	Calibrated model	Benchmark	Exogenous fertility
Average fertility rate	1.13	1.128	1.148	1.13
Fertility differential	1.31	1.31	1.34	1
Variance of log earnings	0.36	0.362	0.358	0.35
Public education, % GDP	2.5	2.5	2.9	2.47
Total education, % GDP	4.5	4.6	4.7	4.6
Intergenerational correlation of earnings	0.33	0.33	0.32	0.31
Total transfers, % GDP	5.4	5.4	5.5	5.3
Transfers, middle tertile	0.16	0.16	0.162	0.161
Cost of children, bottom tertile	0.24	0.237	0.236	0.233
Cost of children, middle tertile	0.15	0.148	0.148	0.147

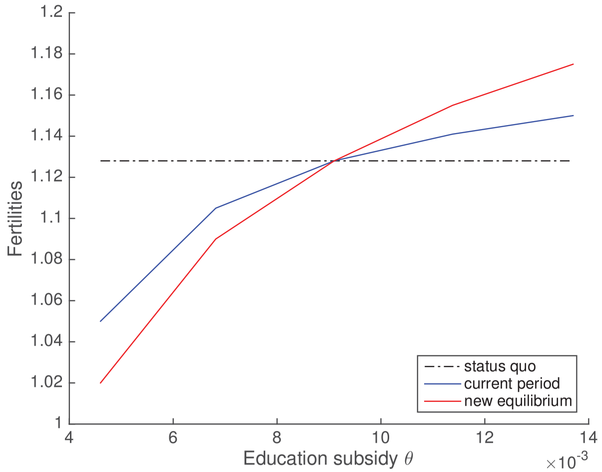
Figure 3: Fertilities, fertility differentials and decomposition of results



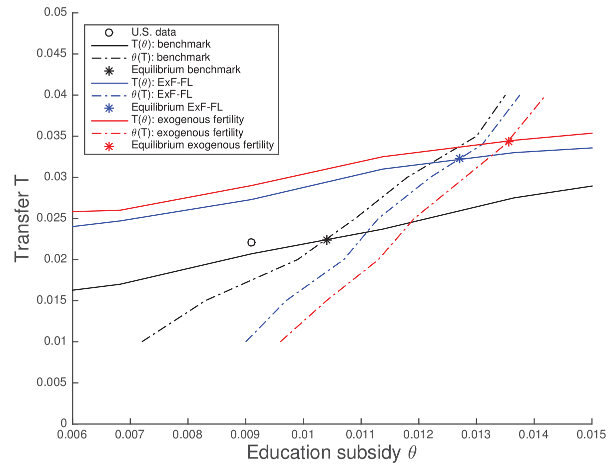
A: Fertility differentials. Education = U.S. level



B: Fertility differentials. Transfers = U.S. level



C: Fertilities. Transfers = U.S. level



D: Decomposition of results

Sensitivity analysis. In this section of Appendix, I demonstrate that the main results are robust to small variations in the values of model parameters.

Table 9: Sensitivity analysis

Parameters	Endogenous fertility		Exogenous fertility	
	Transfers	Education	Transfers	Education
Benchmark calibration	5.49	2.91	8.30	4.70
5-percent increase in σ	5.43	2.85	8.15	4.62
5-percent increase in ξ	5.41	2.83	8.08	4.65
5-percent increase in η	5.45	2.85	8.09	4.63
IEE = 0.4	5.38	2.79	8.65	4.95
IEE = 0.47	5.29	2.71	8.81	5.00
5-percent increase in λ_2	5.41	2.95	7.98	4.81
5-percent increase in σ_z	5.57	2.93	8.03	4.84

Notes. In the U.S. data transfers and education subsidies account for 5.4% and 2.5 % of GDP respectively. As the results in table 2 demonstrate, the model with endogenous fertility performs much better in replicating the levels of public policies observed in the U.S. data than the counterpart model with exogenous fertility for various alternative parameter values. In the case of IEE (intergenerational earnings elasticity) the model is recalibrated so that it matches alternative estimates of intergenerational earnings correlation, which are standard in macroeconomic literature (0.4 Solon, 1992; 0.47 Corak, 2006). As table 2 shows, higher intergenerational correlation of earnings makes the assumption of endogenous fertility even more important. Consequently, differences in equilibrium levels of policies predicted by the models with and without endogenous fertility become more substantial than in the case of benchmark calibration implying IEE equal to 0.33.

Appendix B

This section introduces notations, presents a robustness check of the relationships between variables in table 7 and presents model predictions regarding a cross-section of U.S. states.

Table 10: Key notations

Variable	Notation
Transfers	TR
Transfers adjusted by costs of living	TRCL
Labor income tax %	TAX
Labor income tax less state expenditures on public education	NETTAX
Expenditures on public education	ED
Intergenerational correlation of earnings	RM
Average fertility rates	FERT
Fertility differentials between bottom and top quintiles of income distribution	FERTDIFF
Fertility differentials between below- and above-median income groups	FERTDIFF50
Fertility differentials between no-college and college individuals	FERTDIFFED
Fertility differentials between bottom and top quintiles of occupation scores distribution	FERTDIFFSC
State government ideology	IDEOL
Student enrollment	SHARESTUD
Percentage of Black	BLACK
Percentage of Hispanic or Latino	HISP
Income Gini	GINI
Percentage of children in single-parent household	FRACCHILD
Percentage of individuals who commute less than 15 minutes to work	FRACCOMMUT
Social capital index	SOCIALCAP
Test scores adjusted by parental income	TESTSC
High school dropout rates	HSDROP

Table 11: Robustness check

Variable	FERTDIFF50	FERTDIFFED	FERTDIFFSC	TRCL	TRSH	EDSH
TR	0.35*	0.31*	0.39**	0.95***	0.79***	0.34*
	(0.01)	(0.02)	(0.005)	(0.000)	(0.000)	(0.016)
TAX	0.4**	0.43**	0.5***	0.64***	0.42**	0.37**
	(0.004)	(0.002)	(0.000)	(0.000)	(0.002)	(0.009)
NETTAX	0.26*	0.27*	0.36*	0.64***	0.33*	0.3*
	(0.06)	(0.05)	(0.01)	(0.000)	(0.018)	(0.029)
ED	0.35*	0.46***	0.50***	0.52***	0.3*	0.8***
	(0.01)	(0.000)	(0.000)	(0.000)	(0.03)	(0.000)
RM	-0.32*	-0.35*	-0.34*	-0.37**	-0.24	-0.27
	(0.02)	(0.01)	(0.01)	(0.009)	(0.09)	(0.06)
FERT	0.26	0.23	0.27	0.28*	0.58***	0.51***
	(0.06)	(0.1)	(0.05)	(0.04)	(0.000)	(0.000)
FERTDIFF	0.67***	0.58***	0.73***	0.33*	0.51***	0.53***
	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)	(0.000)

*Note *p<.05, **p<.01, ***p<.001

Notes. The correlations are evaluated in the case of alternative measures of fertility differentials. Additionally, the robustness of correlations is checked in the case of transfers adjusted by costs of living (TRCL) as well as transfers (TRSH) and education subsidies (EDSH) measured as a share of state GDP. Costs of living are proxied using the index estimated in Berry et al. (2000).

Table 12: Robustness check of correlations

Dependant variable	ED		FERT		FERTDIFF		RM	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
TR	1.21***	1.29***	0.063*	0.040	0.099**	0.114***	-0.06**	-0.06**
	(0.33)	(0.30)	(0.027)	(0.028)	(0.031)	(0.033)		(0.019)
IDEOL		0.014***						
		(0.004)						
SHARESTUD		0.166*						
		(0.063)						
BLACK				-0.001		0.001		
				(0.001)		(0.002)		
HISP				0.002		0.001		
				(0.001)		(0.002)		
GINI				-0.177		0.265		0.015
				(0.237)		(0.282)		(0.16)
FRACCHILD								0.93
								(0.25)
FRACCOMMUT								-0.27
								(0.08)
SOCIALCAP								0.03
								(0.012)
TESTSC								0.0007
								(0.001)
HSDROP								0.19
								(0.5)

Notes. The columns correspond to dependant variables. The rows correspond to regressors. The regression coefficients presented above serve solely for evaluation of conditional correlations and should not be interpreted as estimates of causal links between variables.

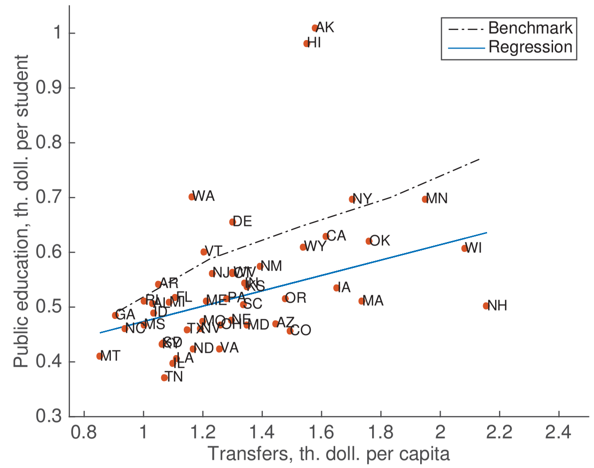
Table 12. Comments. As table 11 shows, correlations are robust to controlling for a number of factors.

Transfers and education subsidies. Positive relationships between levels of transfers, public schooling and taxes might be explained by the fact that the size of government is likely to be positively correlated across different dimensions. Therefore, more liberal states may support more generous transfers and education subsidies. Below I add a measure of state government ideology (I chose 1996 as an example year) provided by Berry et al.'s (1998) study as a control variable. Additionally, the positive link between per student expenditures on public schooling might be explained by the relatively low share of school-age children as a proportion of the population. The results demonstrate that positive relationships between levels of transfers and public schooling is preserved and highly significant after controlling for political preferences and the share of school-age individuals in a population (see columns "ED 1" and "ED 2").

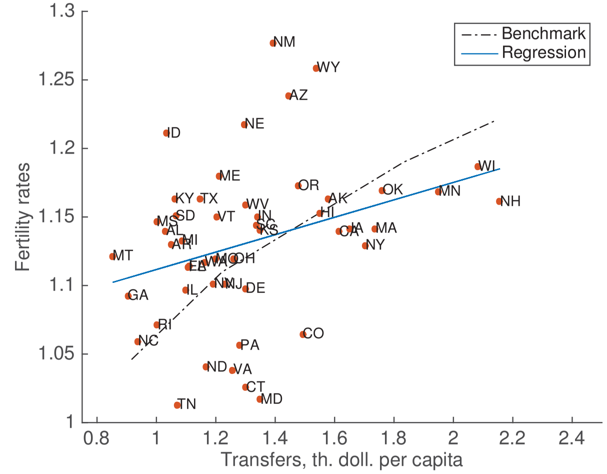
Transfers, fertilities and fertility differentials. The variation of fertilities and fertility differentials across states may be explained by variations in income inequality and the racial composition of population. In the case of fertilities and transfers, introduction of the Gini coefficient and percentage of Black and Hispanic populations to the regression leads to insignificance of the level of transfers, although, the proportion of variance in fertilities explained by inequality and racial composition is low as well. This indicates that positive connections between the generosity of transfers and fertility rates is moderate. However, positive relationships between transfers and fertility differentials remain highly significant after controlling for inequality and racial compositions across states (see columns "FERT 1, 2" and "FERTDIFF 1, 2").

Transfers and intergenerational correlation of earnings. Finally, I evaluate whether negative correlations between transfers and intergenerational correlation of earnings is robust to controlling for factors which are found to be important in Chetty et al. (2014). These factors include the percentage of the Black population, income inequality, spatial segregation, school quality proxied by test scores and high school dropout rates, social capital and the percentage of children living in single-parent households. Correlation between intergenerational earnings persistence and transfers remains negative and highly significant after controlling for these factors (see columns "RM 1, 2").

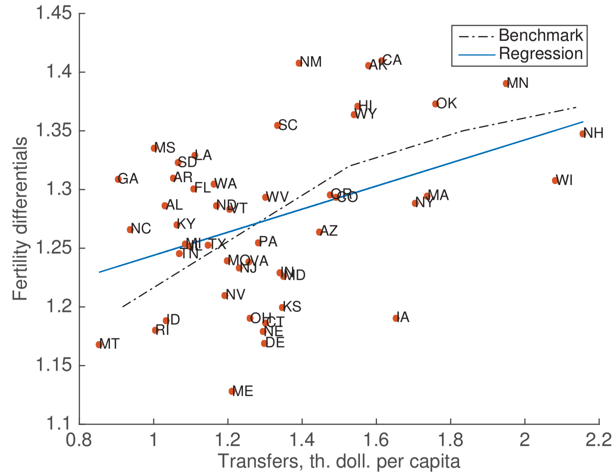
Figure 4: Model predictions for a cross-section of U.S. states: transfers and education subsidies are measured in per capita/ per student terms



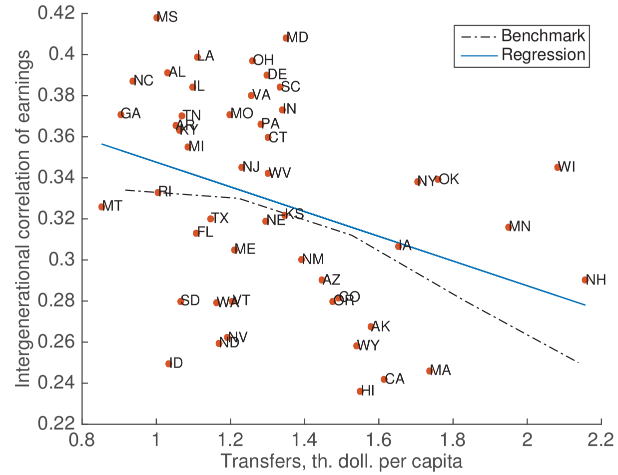
A: Education subsidies



B: Fertilities

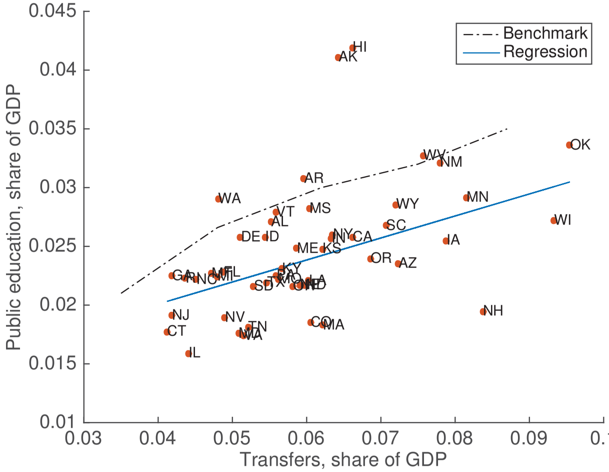


C: Fertility differentials

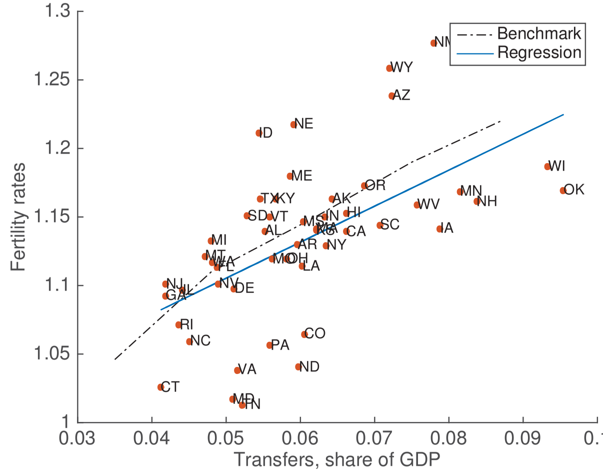


D: Intergenerational correlation of earnings

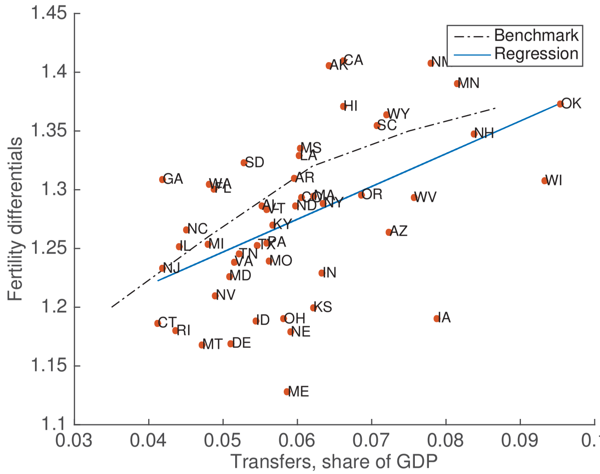
Figure 5: Model predictions for a cross-section of U.S. states: transfers and education subsidies are measured as a share of state GDP



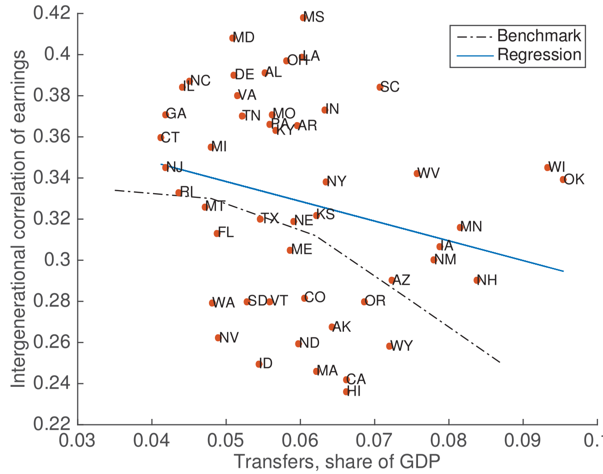
A: Education subsidies



B: Fertilities



C: Fertility differentials



D: Intergenerational correlation of earnings

Abstrakt

Tento článek využívá politicko-ekonomický dynamický model všeobecné tržní rovnováhy ke kvantifikaci důležitosti endogenní fertility pro vysvětlení štědrosti přerozdělování a podob vzdělávacích politik v USA. Vzdělávací politiky jsou určeny vnitřně jako výsledek hlasování většiny. Zjišťuji, že započítání endogenní fertility je nezbytné pro schopnost modelu dobře popsat úrovně transferů i dotování vzdělání v USA. Predikce modelu ohledně průřezu napříč státy USA jsou použity k ověření možných reakcí fertility na politiky vzdělávání a v konečném důsledku i kredibility mých výsledku.

Klíčová slova: volba, endogenní plodnost, přerozdělování, vzdělání

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